Federal Democratic Republic of Ethiopia
Ethiopia Electric Power
Ethiopia Electric Utility

DATA COLLECTION SURVEY ON ADDIS ABABA TRANSMISSION AND DISTRIBUTION SYSTEM

FINAL REPORT

August 2017

Japan International Cooperation Agency

NEWJEC Inc.

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Data Collection Survey on Addis Abba Transmission and Distribution System
Final Report

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Abbreviations

AADMP	Addis Ababa Distribution Master Plan Study, Final Report
AADMP Ic/R	Addis Ababa Distribution Master Plan Study, Amendment One Inception Report – Final
AADMP IT/R	Addis Ababa Distribution Master Plan Study, Interim Report
AADRUP	Addis Ababa Distribution Rehabilitation and Upgrade Project
AAHVRUP	Addis Ababa High Voltage Rehabilitation and Upgrading Project
ADC	Addis Centre (Substation)
ADE	Addis East (Substation)
AfDB	African Development Bank
AIC	Average Incremental Cost
AIS	Air Insulated Switchgear
AMT	Amorphous Alloy Core Transformers
BLL	Black Lion (Substation)
BSP	Bulk Supply Points
CRGOT	Cold Rolled Grain Oriented Electrical Steel Transformer
DCC	Distribution Control Center
DMS	Distribution Management System
EEA	Ethiopian electricity Agensy
EEP	Ethiopia Electric Power
EEU	Ethiopia Electric Utility
EPC	Engineering Procurement and Construction
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GIS	Gas Insulated Switchgear
GTP	Growth and Transformation Plan
HI	Health Index
HV	High Voltage
JICA	Japan International Cooperation Agency
LRT	The Light Rail Transit
LV	Low Voltage
MoWIE	Ministry of Water, Irrigation and Energy
MV	Medium Voltage
NDC	National Dispatch Center
P/B	Parsons Brinckerhoff
RAP	Resettlement Action Plan
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control And Data Acquisition
Sw/St	Switching Station
TSRUP	Transmission and Substations Rehabilitation and Upgrading Project

Chapter 1 POWER SECTOR SITUATION IN ADDIS ABABA CAPITAL REGION

1.1 Background of the Study

Federal Democratic Republic of Ethiopia (hereinafter called "Ethiopia") has the second largest population in Africa (99.4 million people, according to World Bank Report of 2015) and high population growth rate (2.5% per annum, according to World Bank Report of 2014).

Average GDP growth rate in the last 10 years is maintaining higher economic growth at the rate of 10.9%.

With such a smooth economic growth, construction of industrial sector and housing are developing rapidly and the power demand in Addis Ababa administration area and an approximate 50km radius area around the city (hereinafter called "Addis Ababa Capital Region") is expected to increase from 800MW in 2014 to 3,576MW in 2034 continuously[1]. Trend of maximum power demand is shown in Figure 1-1.

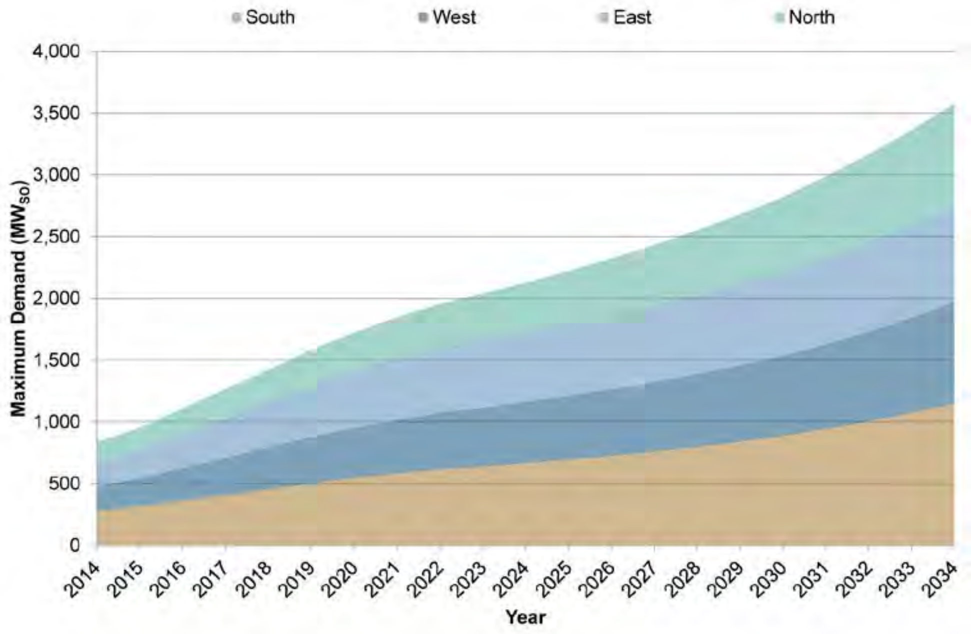

Figure 1-1 Trend of Maximum Power Demand in Each Area

Source: AADMP Volume 1 Part 2

Africa Union (AU) and Economic Commission for Africa (ECA) are located in Addis Ababa, therefore, Addis Ababa is not only the capital of Ethiopia but also the diplomatic center in Africa. For these reasons Addis Ababa needs to supply high quality of electricity with no outage and stable voltage.

On the other hand, there are so many overload and excess of voltage drop limit in distribution line in Addis Ababa described in Table 1-1.

The capacity of existing transmission and distribution network is becoming overloaded because of high growth demand rate.

1 AADMP Volume 1 Part 2

Table 1-1 Addis Ababa Capital Region Extract Case of Condition

Substation	Feeder	Voltage Issues	Loading Issues	Minimum Voltage (pu)	Loading Issues (% of Conductor Rating)
Addis Alem	ALM-15-01	✓	X	91.48	-
Addis Alem	ALM-15-02	✓	X	91.49	-
Addis Center	ADC-15-04	✓	✓	91.18	179.6
Addis Center	ADC-15-07	✓	✓	94.38	173.8
Addis Center	ADC-15-10	X	✓	-	181.1
Addis Center	ADC-15-14	X	✓	-	111.7
Addis East	ADE-15-02	X	✓	-	143
Addis North	ADN-15EW-04	✓	✓	94.61	174.2
Addis West	ADW-15-01	X	✓	-	116
Addis West	ADW-15-02	X	✓	-	149.6
Addis West	ADW-15-04	X	✓	-	108.9
Bella	BEL-15-04	✓	✓	91.55	290.5

Source: AADMP IT/R Volume 4 Part 2

Distribution network in Addis Ababa Capital Region has the following problems:

- Lack of capacity:
  Capacity of transformer and distribution line is becoming overloaded because of rapid demand increase

- Poor reliability and quality of supply:
  There are so many aged equipment and some devices are excessing standard lifespan. Maintenance is not properly done for many facilities.
  Frequent power outage and supply voltage drop occur due to deterioration of equipment.

- High losses:
  Approximately 19% loss in distribution system occurs due to lack of capacity and equipment deterioration[2].

Addis Ababa would be a model case by improving current power situation in distribution system It is important for continuous economic growth in Ethiopia, and also Addis Ababa will take initiative for improvement of power sector situation in Ethiopia.

1.2 Basic Indicators Related to Transmission and Distribution Network

1.2.1 Voltage Composition of Transmission and Distribution System

Transmission network supplying power to Addis Ababa Capital Region consists of 400kV, 230kV, 132kV and 45kV.

Distribution network consists of 33kV and 15kV middle voltage distribution line by step down transformer rated at 132/33kV, 132/15kV and 45/15kV.

Electricity of low voltage customers are supplied by 433V or 250V with frequency of 50 Hz using 3-phase 4-wire distribution line. (Figure 1-2)

2 AADMP Volume 1 Part 2

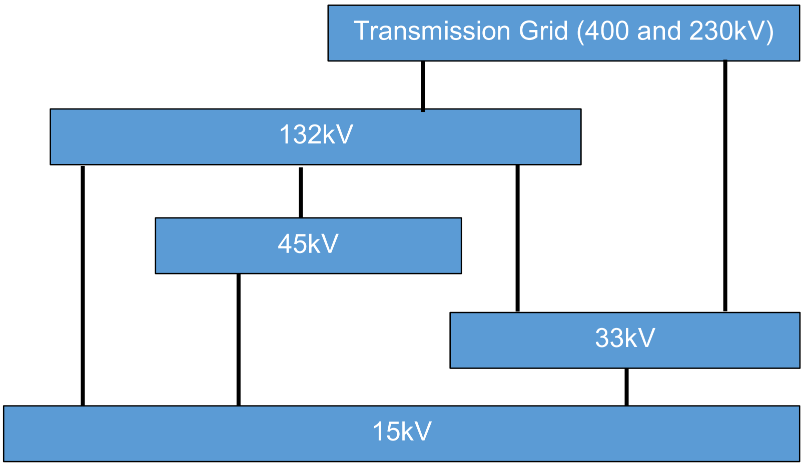

Figure 1-2 Voltage Composition of Transmission and Distribution System

Source: AADMP Volume 2 Part 2

1.2.2 Reliability of Power Supply

Trend of reliability of power supply in Ethiopia is shown in Table 1-2. This value is quite low compared with Japan's reliability level[3].

Table 1-2 Trend of Main Indicator of Reliability of Power Supply

Parameter	Unite of measure	2007	2008	2009
Frequency of Outage / planned	Freq/customer/year (times)	20	10	5
Duration of Outage / planned	Dur./customer/year (hours)	10	7	5
Frequency of Outage / forced	Per cust./year (times)	50	25	15
Duration of Outage / forced	Per cust./year (hours)	22	21	20

Source: "Electricity sector regulation ETHIOPIA", East Africa Power Industry Convention 2007, Addis Ababa, ETHIOPIA

1.2.3 Service Quality

Qualities of service set in Ethiopia are shown in Table 1-3. According to this Table, recovery time in fault is within 2 hours. This level affects Indicator of Reliability of Power Supply described in Table 1-2, and depends on system configuration and operation method.

Primary voltage (MV) of distribution system permits ±10 % variation of nominal voltage. By contrast, service quality of AADMP is examined by ±5 % variation of nominal voltage with considering voltage supply in fault[4].

Tolerance of supply voltage to customer (LV) needs to investigate in this survey. AADMP recommends the value described in Table 1-4.

3 RENCANA PENYEDIAAN TENAGA LISRIK 2004-2013 Project Report: THA 26371, ADB
4 AADMP Volume 2 Part 1

Table 1-3 Standard Value of Service Quality Indicator

Service Quality Standards: Distribution & Sales, March 2006

Restoring a supply following a distribution system failure	2 hours
Providing an estimate of charges	3 days
Giving notice of supply interruption	24 hours
Voltage problems:	
✓ Investigate & replay	15 days
✓ Solution	
Simple work	3 months
Complex work	1year
Responding to queries about meter accuracy	15 days
Responding to queries from customers	5 days
Providing a new supply, improving or relocating existing supply installation	
✓ Single phase	4 days
✓ Three phase	13 days
Reconnecting meters following payment	24 hours
Meter reading	Every month
Responding to customer complaints	10 days

Source: "Electricity sector regulation ETHIOPIA", East Africa Power Industry Convention 2007, Addis Ababa, ETHIOPIA

Table 1-4 Tolerance of Voltage Range

Nominal Voltage	Lowest Service Voltage	Highest Service Voltage
400V	360V (-10%)	440V (+10%)
240V	216V (-10%)	264V (+10%)
15kV	13.5kV (-10%)	16.5kV (+10%)
33kV	29.7kV (-10%)	36.3kV (+10%)

Source: AADMP IT/R Volume 3 Part 1

1.2.4 Distribution Loss

Distribution loss in Addis Ababa is assumed to be 20% to 22.7%. This value is quite high compared to international level of 12% to 13%[5,6].

On the other hand, EEP has a plan to improve distribution loss described in Table 1-5 through AADMP project.

Table 1-5 Improvement Objective of Distribution Loss

Year	Technical Loss (%)	Non- Technical Loss (%)	Total (%)
2017	12.9	3.0	15.9
2034	8.0	1.0	9.0

Source: Prepared by JICA Study Team based on AADMP Volume 1 Part 2

5 Addis Ababa, Ethiopia Enhancing Urban Resilience, July, 2015 - GFDRR
6 AADMP Volume 1 Part 1

The unit price of loss which is a basis of the economic evaluation of power distribution loss is considered to be USD 0.06. This tariff is for LV customer however, it includes subsidy from Ethiopia government. Therefore AADMP applied USD 0.09 considering unit price at generating end[7].

1.2.5 Current Condition of Transmission and Distribution Network

As mentioned before, power demand in Addis Ababa Capital Region is expected to increase from 835MW in 2014 to 3,576MW in 2034 due mainly to population increase and development plan. To cope with the soaring, recently there are so many investments in power sector. As a result of such investment, a lot of new power plants have started operation, and currently power generation capacity is considered much enough. Furthermore, power developments utilizing hydropower potential, result in earning foreign currency by power export to neighbor countries.

On the other hand, in response to rapid economic growth as mentioned above, development of transmission and distribution network including substations are insufficient. There are some customers that wait for electricity connection because the power supply cannot cope with an increase of power demand. To cope with further economic growth, improvement of distribution and transmission network in Addis Ababa Capital Region is urgent issue of power sector in Ethiopia.

By contrast, some substation and distribution equipment in Addis Ababa are aged over 30 to 40 years from commissioning, and those are deteriorated and overloaded. Therefore, it is impossible to supply efficient and highly reliable power.

For example, an average of 42 times power outage occurs per week because of cable disconnection of 15kV distribution line and operation of substation's circuit breaker according to the data after January 2015. Control system of distribution network for recovering properly such a distribution fault has not been improved yet.

For such a situation, urgent rehabilitation is required for transmission, distribution and substation equipment. Moreover, urgent upgrade is required to cope with power demand growth in the future.

1.2.6 Assistance for Improvement of Network by Other Donor

Some donors have been providing finance in Ethiopia to solve those problems described above in Addis Ababa Capital Region. Some examples are shown in Table 1-6.

Table 1-6 Development Activity by Respective Donors

Type	Title	Sponsor	Partners	Primary Government Counterpart	Time Period
Technical Assistance	Ethiopia Urbanization Review	World Bank		Ministry of Urban Development, Housing and Construction	2015
Technical Assistance	Ethiopia Energy Sector Review and Strategy	World Bank		Ministry of Water and Energy	Forthcoming
Strategy Document	Development of Energy Efficiency in Three Pilot Cities in Sub-Saharan Africa-Addis Ababa	World Bank	Camco-Clean Energy, Verco	Addis Ababa City Council	2014
Infrastructure Project	Ethiopia Electricity Network Reinforcement and Expansion Project (EENRP)	World Bank		Ministry of Water and Energy, Ethiopian Electric Power (EEP) Development Bank of Ethiopia	Approved 2012
Technical Assistance	Ethiopia: Addis Ababa Urban Profile	UN-Habitat		Ministry of Finance and Economic Development	2008

Source: Addis Ababa, Ethiopia Enhancing Urban Resilience, July 2015: GFDRR

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As part of the above support activities, the following projects are undergoing prior to AADMP as an extended network of transmission and distribution network in the Addis Ababa Capital Region, which are called "Planned and Committed Project" in AADMP.

-Addis Ababa Distribution Rehabilitation & Upgrading Project (AADRUP)
-Addis Ababa High Voltage Rehabilitation & Upgrading Project (AAHVRUP)
-Transmission and Substations Rehabilitation and Upgrading Project (TSRUP), etc.

With respect to the issues relating to AADMP, recommendation and/or proposal are presented in cooperation with the above projects.

In addition, the recent assistance situations other than the above projects are shown below.

・ May 27, 2016: World Bank approved to finance USD 2 million for upgrading power system in Ethiopia. Scope of works is to construct new 230kV transmission line, new three substations, new MV/LV distribution line, etc.

・ July 15, 2016: African Development Bank (AfDB) approved to finance USD 1.05 million to Ethiopia. Scope of works is to construct new 230kV transmission line, upgrade two substations, MV/LV distribution line, etc.

Chapter 2 POLICY RELEVANT TO IMPROVEMENT OF NETWORK IN ETHIOPIA

2.1 Improvement of Network in National Policy and Plan

In Ethiopia, the electricity law (Electricity Proclamation No.86) was amended in 1997. As the result, power utility was privatized as Ethiopia Electric Power Corporation (hereinafter called "EEPCo") and the power generation sector was liberalized. In addition, Ethiopia Electricity Agency (hereinafter called "EEA") was established as regulatory authority of electric power business. EEA is conducting regulation relevant to business license, investment license and grid access[8]. Afterwards EEPCo was divided into two organizations in December 2013, i.e. Ethiopian Electric Power (hereinafter called "EEP") which is responsible for power generation and transmission, and Ethiopian Electricity Utility (hereinafter called "EEU") which is responsible for distribution.

Organization chart of EEP are shown in Figure 2-1.

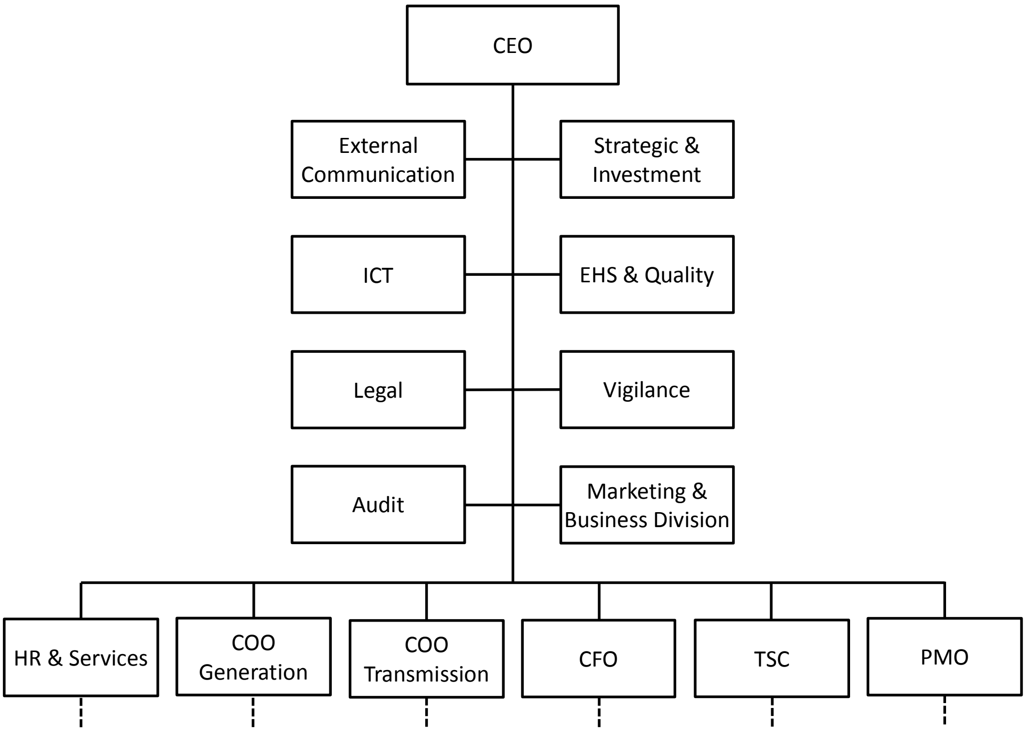

Figure 2-1 EEP Organization Chart

Source: EEP

Ethiopia was acknowledged as Heavily Indebted Poor Countries (HIPC) in 2002. Ethiopia has formulated a national development plan for poverty reduction.

Ministry of Finance and Economic Development (MoFED) responsible for formulation of national development plan announced multiple field development plan such as transportation, energy and communication in September 2010, which is called 5 year Growth and Transformation Plan (hereinafter called "GTP")

The first 5 year period in GTP (11/2010 ~ 2014/2015) focused on improving quality of public

8 Japan Electric Power Information Center Power Industry of oversea countries Chapter 2 Federal Democratic Republic of Ethiopia

service, especially infrastructure development, social improvement and human resource development for education.

In the power sector GTP decided main objectives to supply electricity which is matching with the international standard and reliable. GTP kept trying to construct new hydro power plant and geothermal power plant, and expand existing transmission network to boost rural electrification, and modernize transmission and distribution network to reduce power loss.

In particular, upgrading of power facility during the first period in of GTP was conducted as shown in Table 2-1.

Currently, GTP proceeds to the second 5 year period (GTPII: 2015/15～2019/20). However, as an important issue, expansion of transmission and distribution network is still continued.

Table 2-1 Development Objectives of Power Sector in GTP

Description of Target		2009/10	2014/15
1. Hydroelectric power generating capacity	(MW)	2,000	10,000
2. Total length of distribution lines	(km)	126,038	258,000
3. Total length of rehabilitated distribution lines	(km)	450	8,130
4. Number of consumers with access to electricity		2,000,000	4,000,000
5. Coverage of electricity services	(%)	41	75
6. Total underground power distribution system	(km)	97	150

Source: Japan Electric Power Information Center Power Industry of oversea countries Chapter 2 in 2015

As mentioned in the previous section, Addis Ababa Capital Region is maintaining high population growth and economic growth. To support continuous growth, Federal Urban Planning Institute formulated policies of urban development at nationwide which are called Integrated Development Plan (hereinafter called “IDP”), Oromia Special Zone Development Plan (hereinafter called “OSZP”), etc.

Currently, there are so many developing plans under consideration, especially Addis Ababa Capital Region as target area in this survey is expected to be developed in housing and industry sector.

Power demand in Addis Ababa Capital Region accounts for 42% (as peak demand) of the total demand in Ethiopia[9]. Therefore, improvement of transmission and distribution network is expected to focus on Addis Ababa Capital Region from now on.

9 AADMP Ic/R

2.2 Regulations Relevant to Improvement of Network

Regulations relevant to improvement of transmission and distribution network in Ethiopia are described below.

2.2.1 Grid Code

Grid Code was issued by EEA on August 2016 as draft version.

The contents are widely covered and are explained about connection voltage to system, frequency and even cyber security. As one case, tolerance of frequency is shown in Figure 2-2.

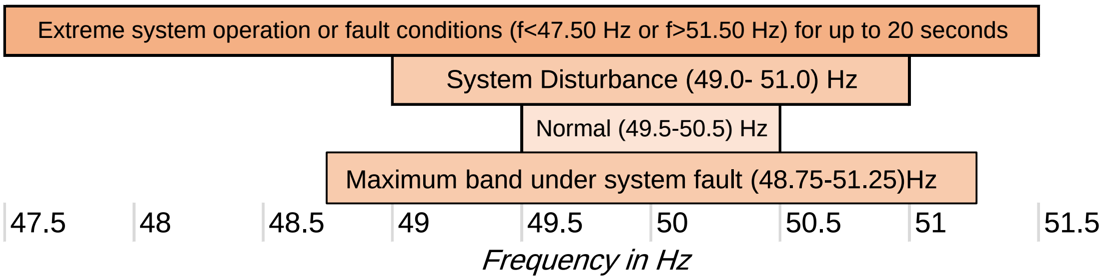

Figure 2-2 Tolerance of Frequency at Transmission System

Source: Ethiopia Nationality Electricity Transmission Grid Code (Draft) EEA August 2016

2.2.2 Environmental Guideline

Ethiopia enacted the constitution of the Federal Democratic Republic of Ethiopia on August 21, 1995. The law provides the framework relevant to health and environmental preservation of people in Ethiopia. Moreover the law specifies about the rights of land use and ownership. The policy and proclamation about environment are widely covered. Therefore, it is important to check adequate environmental guideline and policy from time to time. One case of proclamations is shown below.

- Environmental Impact Assessment Proclamation (Proc. No 299/2002)[10]

The objective of this proclamation is to make necessary Environmental Impact Assessment (hereinafter called "EIA") which is classified by Environmental Protection Authority. Therefore, it is necessary to check classification of the project based on this proclamation when the new project launches.

The Law of Federal Democratic Republic of Ethiopia which was established in 1995 has not assured land ownership. As to resettlement and land acquisition, the law formulates principle of land acquisition about public purpose. Detailed procedure and compensation is formulated by "The Expropriation of Landholding for Public Purpose and Payment of Compensation Proclamation (Proc No 455/2005)" and "Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purpose, Council Ministers Regulation No. 135/2007". According to regulation of No. 135/2007, land acquisition related to public purpose is implemented by local administration, government, etc. Therefore, land acquisition related to construction of substation, transmission tower, etc. will be expected to implement by each administration.

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2.2.3 Equipment Planning / Installation Criteria

Equipment planning and Installation criteria descried in AADMP are based on international standards such as International Electrotechnical Commission (hereinafter called "IEC") and Institute of Electrical and Electronics Engineers (hereinafter called "IEEE"), etc. There is no big difference between AADMP and international standards. Equipment planning process is shown in Figure 2-3.

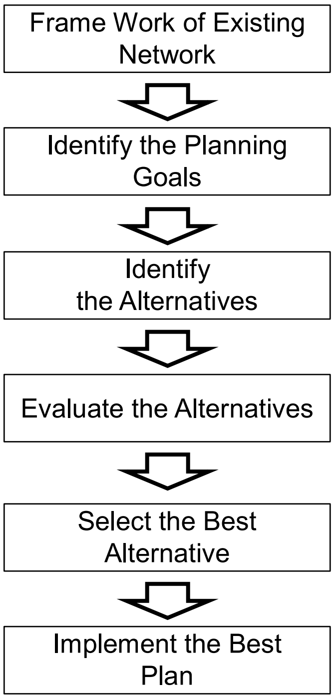

Figure 2-3 Equipment Planning Process

Source: AADMP IT/R Volume 3 Part 1

Chapter 3 PROPOSED CONTENTS IN THE AADMP

3.1 Objective of AADMP

As mentioned in Section 1, government of Ethiopia shows necessity of investment in transmission and distribution sectors to cope with the rapidly increased power demand in Addis Ababa Capital Region from now on. As specific objective, government of Ethiopia presented the main target to expand transmission and distribution network from 16,018km in 2014/15 to 21,728km in 2019/20. Under this policy, Parsons Brinckerhoff (hereinafter called "P/B") which is a consulting company, of which its headquarters is in USA, conducted study from February 2014 for upgrading of transmission and distribution network in Addis Ababa Capital Region. As the result of study, P/B prepared AADMP in September 2015.

The main objective preparing AADMP are shown below.

- Upgrading power facilities for stable power supply from the viewpoint of the next 20 years
- Conduct Strategic Environmental and Social Assessment Study
- Training and guidance on knowledge and skill to EEP
- Improvement of business management in distribution division

As AADMP related reports, there are Interim Report (hereinafter called "AADMP IT/R") issued in December 2014 as an interim progress report, Final Report issued in September 2015 as Final Report, and Executive Summary as summery of Final Report. Moreover, three months after AADMP were issued, P/B issued Amendment One Inception Report - Final (hereinafter called "AADMP Ic/R") to make scope of works and procurement method clear. There are a few difference of construction cost, scope of works and respective names between each report. However, they did not have an intent to change a concept of AADMP, therefore, JICA Study Team has reviewed relevant documents including AADMP and AADMP Ic/R as the main documents. The relationship of each document is shown in Figure 3-1.

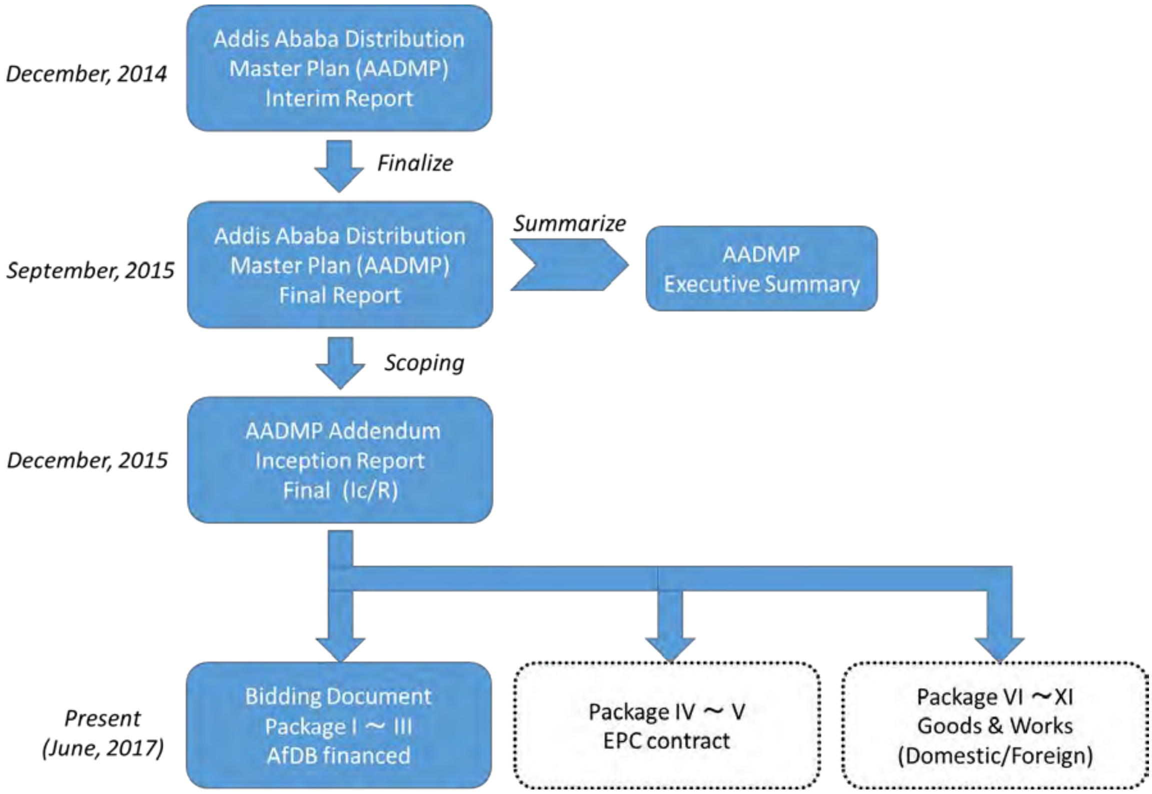

Figure 3-1 Relationship Diagram of Each Documents in AADMP

Source: Prepared by JICA Study Team

3.2 Data and Existing Facilities

3.2.1 General Information on Addis Ababa Capital Region

AADMP's study area covers the city of Addis Ababa and an approximately 50km radius around the city. AADMP's study area also includes Addis Ababa administration area as capital city in Ethiopia and parts of the surrounding area of Oromia which is the largest area and population in Ethiopia. The study area is shown in Figure 3-2[11].

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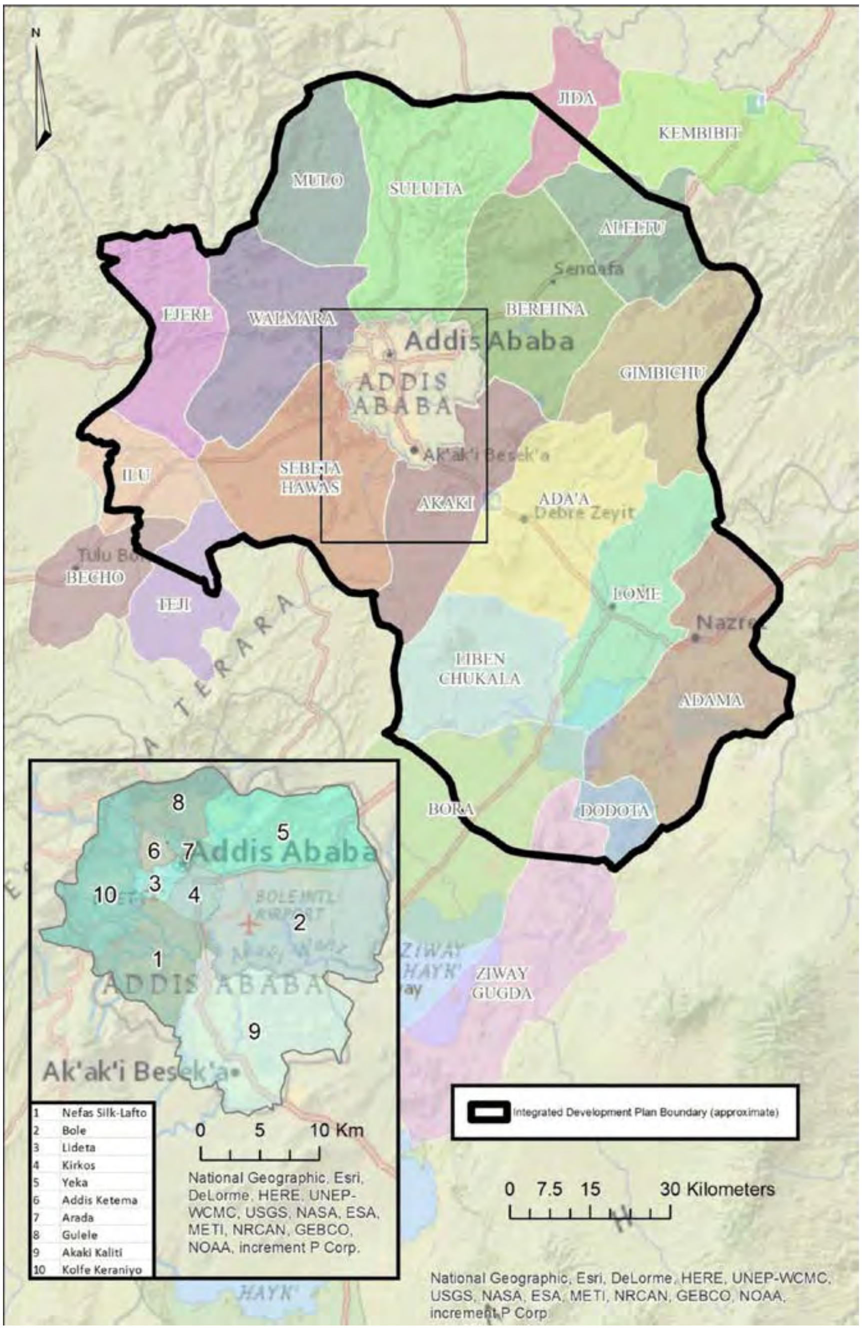

Figure 3-2 Study Area

Source: AADMP Volume 1 Part 1

As mentioned in Section 1, in Addis Ababa Capital Region is rapid population increase is forecasted. Population growth in the period of 30 years from 2007 to 2037 in AADMP will reach almost four million in medium case[12]. In addition, maximum power demand in Addis Ababa Capital Region is estimated to increase from 835MW in 2014 to 3,576MW in 2034 because of demand growth by household and industrial sector which are caused by such an increase of population.

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3.2.2 Transmission and Substation Facilities in Addis Ababa Capital Region

There are 29 Bulk Supply Points (hereinafter called "BSP") and primary substations in total in the study area. The main transmission network of Addis Ababa Capital Region is as shown in Figure 3-3. The transmission line consists of ring shape surrounding center of the city. However, Addis Centre substation (hereinafter called "ADC substation"), Addis West substation (hereinafter called "ADW substation"), Addis East substation (hereinafter called "ADE substation"), etc. as important feeding points for power demand are supplied as radial line from 132kV ring network. Therefore, these substations do not satisfy N-1 criteria.

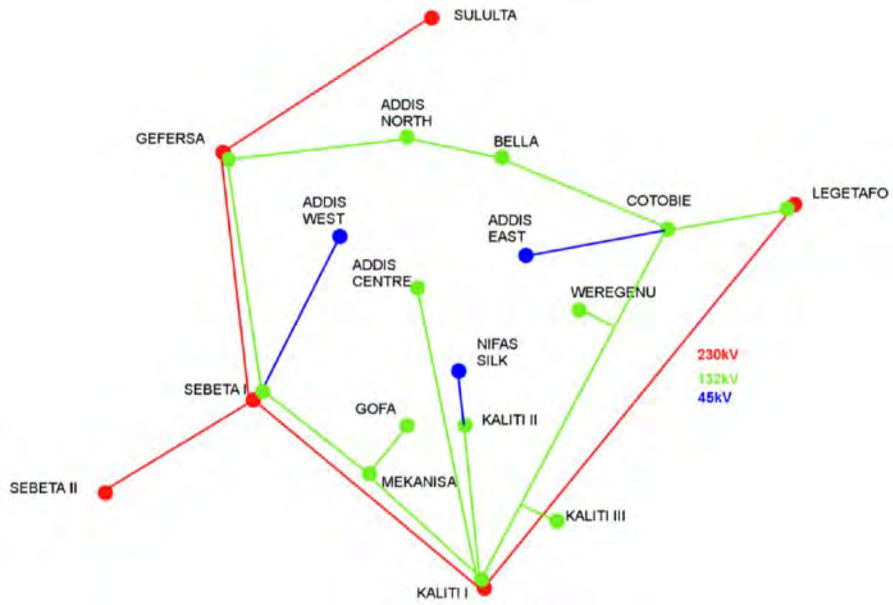

Figure 3-3 Outline of Transmission Network around Capital Region

Source: AADMP Volume 2 Part 2

There are 57 units of transformers at BSP and primary substations in the study area[13]. 32% of those transformers are in very poor condition or poor condition. Most transformers are very close to equipment lifespan or going beyond lifespan. One case of transformer condition in Addis Ababa Capital Region is shown in Table 3-1.

P/B conducted study of these equipment conditions based on Health Index (hereinafter called "HI"). Concept of HI is mainly used in Western countries and as index of equipment replacement. HI is described in (d) of this section.

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Table 3-1 An Example of Transformer HI

Trans-ID	Substation Name	Trafo Name	Weighted Condition Score	Year Manufactured	Expected Asset Life	Remaining Life	Maintenance Quality	Failure Rate Multiplier	Adjusted Remaining Life	Optimised Intervention
1	Aba Samuel	T1	4.00	1956	50	-8	Very Poor	1.51	-25	YES
2	Addis Alem	T1	1.17	2005	50	41	Excellent	0.89	47	NO
3	AddisCentre	T1	1.42	1999	50	35	Excellent	0.89	41	NO
		T2	1.42	1999	50	35	Excellent	0.89	41	NO
		T3	2.17	Missing Nameplate	50	Missing Nameplate	Fair	0.95	Missing Nameplate	NO
4	Addis East I	T1	3.33	1966	50	2	Very Poor	1.51	-15	YES
		T2	3.33	1966	50	2	Very Poor	1.51	-15	YES
5	Addis North	T1	1.75	1998	50	34	Good	0.95	37	NO
		T2	1.75	1998	50	34	Good	0.95	37	NO
6	Addis South II (Gofa)	T1	1.33	2005	50	41	Excellent	0.89	47	NO
		T2	1.33	2005	50	41	Excellent	0.89	47	NO
7	Addis West	T1	2.08	1979	50	15	Fair	0.95	18	NO
		T2	2.08	1998	50	34	Fair	0.95	37	NO
8	Akaki I	T1	1.75	1998	50	34	Good	0.95	37	NO
9	Akaki II	T1	2.50	1987	50	23	Poor	0.95	26	YES
		T2	2.25	1987	50	23	Fair	0.95	26	NO
		T3	2.17	1988	50	24	Fair	0.95	27	NO
10	Bella (Addis East II)	T1	1.25	2003	50	39	Excellent	0.89	45	NO
		T2	1.25	2003	50	39	Excellent	0.89	45	NO

Source: AADMP IT/R Volume 4 Part 1

3.2.3 Distribution network in Addis Ababa Capital Region

The distribution network is generally radial type, it has main backbone and a number of spurs. Some of spurs have no connection with other feeders. Therefore, if fault occurs, the effect of outage might expand widely.

Although π-loop type with ring main unit, called expressway system, are installed under the Urban Distribution Rehabilitation and Expansion Project in urban area, many of them are out of service due to damage during the Light Rail Transit (hereinafter called “LRT”) construction. Due to the damage of network, performances of distribution network are restricted. These situations have caused many network issues i.e. feeder overload and excess of limitation of voltage drop. On the other hand, these damage of expressway are planned to reinstate under the AADRUP and other projects, therefore they are excluded from AADMP.

Most of the distribution network is operated by 15 kV, however regions with low demand density in rural area are operated by 33kV because the distribution lines in rural area tend to be longer than urban area. Both distribution lines are stepped down to 433V or 250V by transformer mounted on pole or on the ground to supply housing, commercial demand, etc.

In the data collection process of the AADMP, P/B made existing distribution network model based on EEP owned Distribution Management System (DMS). Typical amount of equipment obtained by the data collection process is shown in Table 3-2.

Table 3-2 Outline of Distribution Equipment in Study Area

Equipment	Total Quantity
MV feeders	
15kV feeders	2,342 km
33kV feeders	322 km
Distribution Transformer	
15kV/433V	5,413 units
33kV/433V	302 units
LV feeders	6,553 km

Source: Prepared by JICA Study Team based on AADMP Volume 2 Part 1

By the distribution network model prepared by distribution network mapping, the condition and performance of existing distribution network was assessed. As a result of the assessment, AADMP found that there are a lot of overloaded and excess of limitation of voltage drop in many distribution feeders. Table 3-3 shows an example of assessment results.

Table 3-3 An Example of Assessment Result of Distribution Network

Substation	Feeder	Voltage Issues	Loading Issues	Minimum Voltage (pu)	Loading Issues (% of Conductor Rating)
Addis Alem	ALM-15-01	✓	X	91.48	-
Addis Alem	ALM-15-02	✓	X	91.49	-
Addis Center	ADC-15-04	✓	✓	91.18	179.6
Addis Center	ADC-15-07	✓	✓	94.38	173.8
Addis Center	ADC-15-10	X	✓	-	181.1
Addis Center	ADC-15-14	X	✓	-	111.7
Addis East	ADE-15-02	X	✓	-	143
Addis North	ADN-15EW-04	✓	✓	94.61	174.2
Addis West	ADW-15-01	X	✓	-	116
Addis West	ADW-15-02	X	✓	-	149.6
Addis West	ADW-15-04	X	✓	-	108.9
Bella	BEL-15-04	✓	✓	91.55	290.5

Source: AADMP IT/R Volume 4 Part 2

In addition, as to the power transmission network, P/B conducted the investigation of equipment condition based on HI. As for the distribution network, estimation of the equipment condition of the whole distribution network is carried out by sample survey, due to the enormous amount of equipment and constraint of investigation time. An example of the survey results on distribution transformers is shown in Table 3-4.

Table 3-4 An Example of the Status Survey Result of Distribution Transformer

Site	Rating (kVA)	Poles	Corrosion	Oil Leaks	Damage / Theft	Comments
ADC04-T001	200	3	3	3	4	Inconsistent fuse sizes on the pole mounted LV circuit breakers. Moderate corrosion on double steep poles. Damaged pole mounted fuse boxes with exposed live contacts.
ADC04-T077	315	1	2	1	2	Transformer "ADC04-T077" is rated as 200kVA on DMS but 315kVA on nameplate. Absence of transformer mounting brackets, lightning arresters, and deteriorated transformerbushings. Poor clearance from private fencing.
ADC04-78	200	4	3	2	4	Wood pole split from top to bottom. Moderate corrosion on transformer and base. Shrubs growing into transformer. Missing lightning arresters, and poor LV winding side installations.
ADC04-73	315	2	1	1	4	Wood pole split at the top.
ADC05-T097	200	1	2	3	4	Moderate oil leaks on transformer. Missing lightning arrester, damaged earthing, damaged pole mounted fuse breakers with exposed contacts. Poor clearances of transformer pole from adjacent fence. Tree growing into transformer.
ADC09-T009	630	1	2	4	4	Transformer is sited within integral substation. Live busbars within reaching distance. Poorly insulated busbars. Cooper wire improvised fusing on LV board. Complete deterioration of silicon breather. Excessive oil leak at base of transformer.
BEL02 - T013	315	1	4	4	4	Transformer and support base severely corroded. Excessive oil leak from tank and damage earthing. Broken pole mounted fuse boxes with expose live contacts.
WER01-T	200					

Source: AADMP IT/R Volume 4 Part 1

As a result of the sample survey, it was indicated that 53% of MV feeders, 58% of distribution transformers and 82% of LV feeders need for some rehabilitations.

Proposals on expansion / rehabilitation were implemented in AADMP based on the result of state evaluation of distribution network.

3.2.4 Health Index (HI)

HI is to assess equipment condition based on a certain criteria. HI expresses equipment deterioration by numerical value that is marked from zero point to four point. Many utility companies in Western countries introduce this concept. IEEE also specifies how to determine HI. It is becoming more common. HI means that the lower HI score, the better equipment condition, on the other hand, the higher HI score, worse equipment condition. An example of HI is shown in Table 3-5. In the case of evaluation of distribution transformer's pole deterioration, HI is assessed based on the following criteria:

- If distribution transformer is mounted on ground, it is zero point,
- If pole is relatively new, it is one point,
- If pole is excess of equipment life, it is four point, etc.

HI has a scoring system which adds points as to the worse condition. As described in Table 3-5, in the case of distribution transformer, evaluation items consist of defacement of transformer, deterioration of support frame, oil leakage condition, installed earth condition, etc. Moreover, HI multiplies weighting coping with the importance by each evaluation item, sums up all evaluation items and divide it by the total sum of weighing. The calculation equation is shown below. An example of weighting index is shown in Table 3-6.

$$\text{Normalised Score} = \frac{\sum_{i=0}^{n}(si \cdot wi)}{\sum_{i=0}^{n}(wi)}$$

si = Condition Score
wi = Weighting Factor
si .wi = Weighted Score

Source: AADMP IT/R Volume 4 Part 1

Table 3-5 Inspection Table for Distribution Transformer HI (Distribution Transformer)

Distribution Transformer Condition Assessment

1. Assess condition of pole/s. Take into account: termites, split tops, lightning damage, fire damage, insect infestation, rust (steel or concrete), alignment, stay wires.

Criteria Name	Score Description	Score
Poles	0. N/A (not pole mounted)	0
Poles	1. New or as new	1
Poles	2.Good or serviceable condition	2
Poles	3. Material deterioration, intervention requires consideration.	3
Poles	4. End of serviceable life, intervention required	4

2. Assess general wear of transformer coating, corrosion on housing, support structures, bases and locks.

Criteria Name	Score Description	Score
Corrosion	1. None	1
Corrosion	2. Slight	2
Corrosion	3. Moderate	3
Corrosion	4. Severe	4

3. Assess the amount of oil or compound leaks.

Criteria Name	Score Description	Score
Oil Leaks	1. None	1
Oil Leaks	2. Slight	2
Oil Leaks	3. Moderate	3
Oil Leaks	4. Severe	4

4. Assess damage and theft of equipment, including (where applicable): support structures, earthing, enclosure, padlocks and control gear; absence of surge arresters and fuse switch

Criteria Name	Score Description	Score
Safety / Damage / Theft	1. None	1
Safety / Damage / Theft	2. Slight	2
Safety/ Damage / Theft	3. Moderate	3
Safety / Damage / Theft	4. Severe	4

Source: AADMP IT/R Volume 4 Part 1

Table 3-6 An Example of Weighting Index (Power Transformer)

Weighted Factors

Power Transformers

Criterion		Description	Weighting	Contribution
1	Terminals/Bushings	Inspect terminals and bushings external condition, oil levels and gaskets.	2	16.7%
2	Cooling System	Assess cooling system radiators/coolers, gaskets, fans and pumps.	1	8.3%
3	Tank	Inspect oil conservator, oil level, tank external condition, gaskets and oil sampling valves.	2	16.7%
4	Oil Leaks	Assess amount and severity of oil leaks on transformer.	2	16.7%
5	Damage / Theft	Assess damage and theft on the transformer, including support structures.	2	16.7%
6	Earthing	Inspect transformer earthing, connections to transformer and earth.	2	16.7%
7	Silicon breather	Check condition of silicon breather.	1	8.3%
8	Oil Bund	Check for presence of suitable oil bund	NA	
9	Foundations	Inspect transformer foundation and any fractures or deterioration.	NA	

Source: AADMP IT/R Volume 4 Part 1

3.2.5 Contents of Proposed Projects

AADMP specifies related prior projects, proposals for three construction plans and specification proposals on automation of distribution network (SCADA) as shown below.

a) Planned and Committed Projects
b) Rehabilitation and Short Term Expansion Plan
c) Medium Term Expansion Plan
d) Long Term Expansion Plan
e) SCADA and Telecommunications

Respective construction plans are described below.

a) Planned and Committed Projects

The main concept of Planned and Committed Projects is shown in Figure 3-4. This projects aim to secure the supply in respective substations which are short of supply caused by demand increase, by constructing substations (including transmission line) at neighbor area.

The outline of Planned and Committed Projects is shown in Table 3-7.

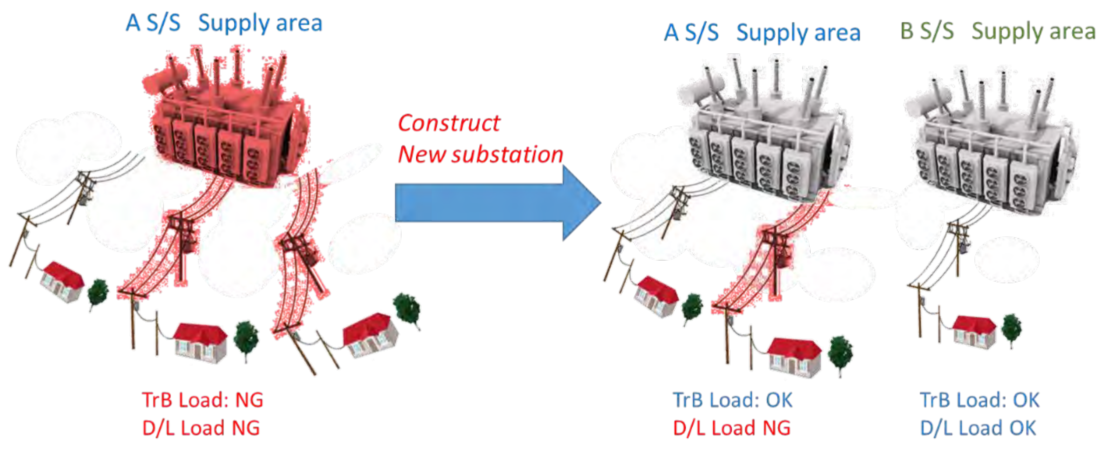

Figure 3-4 Concept for Planned and Committed Projects

Source: Prepared by JICA Study Team

Table 3-7 Outline of Planned and Committed Projects

Project	Number of work	Estimated Capital Cost (Million USD)
Addis Ababa Distribution Rehabilitation & Upgrading Project (AADRUP)	59	210
Addis Ababa High Voltage Rehabilitation & Upgrading Project (AAHVRUP)	11	63
Transmission and Substations Rehabilitation and Upgrading Project (TSRUP)	18	174
Reinforcement of the Transmission Network Project (RTNP)	2	28
Various other distribution projects within the Study Area	—	155
Total	**103**	**630**

Source: AADMP Volume 2 Part 1, Volume 4 Part 1

b) Rehabilitation and Short Term Expansion Plan

Rehabilitation and Short Term Expansion Plan are divided into two schemes, which are Key Project and Key Program. Key Project is composed of rehabilitation and expansion plan which are to cope with tasks extracted from health index of substation facility, overloaded data of distribution line, evaluation of voltage drop, and demand increase for short term (about three years). The scheme is shown in Figure 3-5.

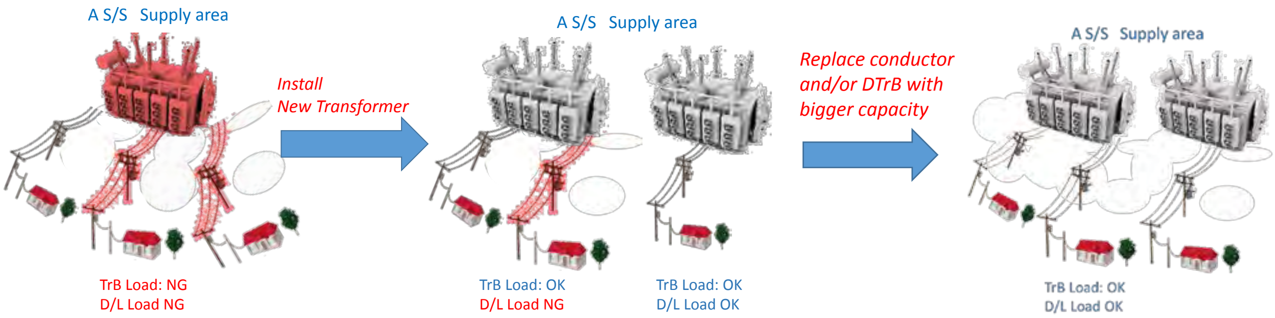

Figure 3-5 Concept for Rehabilitation and Short Term Expansion Plan

Source: Prepared by JICA Study Team

The concept is to satisfy the demand by upgrading and replacing transformer and distribution line. This plan is based on situation after completion of Planned and Committed Projects. Therefore, depending on the progress of Planned and Committed Projects, there is a possibility to delay the construction timing, however, there would be no big change of construction schemes.

On the other hand, Key Program is to conduct full rehabilitation in the whole study area based on health index conclusion of sample survey of distribution facility.

c) Medium Term Expansion Plan

The main concept of Medium Term Expansion Plan is shown in Figure 3-6 and Figure 3-7. Rehabilitation and Short Term Expansion Plan is scheduled to be completed in 2017. Therefore, Medium Term Expansion Plan is planned considering the contents of construction and assuming the increase of demand in the future.

Moreover, Medium Term Expansion Plan aims to fade out from 45kV to unify 33kV. According to AADMP, in the future, it is planned that the urban area will supply by 15kV middle distribution line and the rural area will supply by 33kV middle distribution line. Therefore, the construction plan unifying 33kV in rural area matches with AADMP.

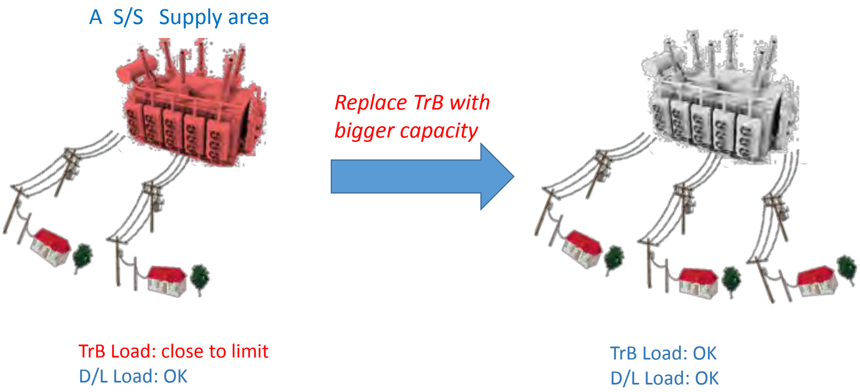

Figure 3-6 An Example of Concept for Medium Term Expansion Plan

Source: Prepared by JICA Study Team

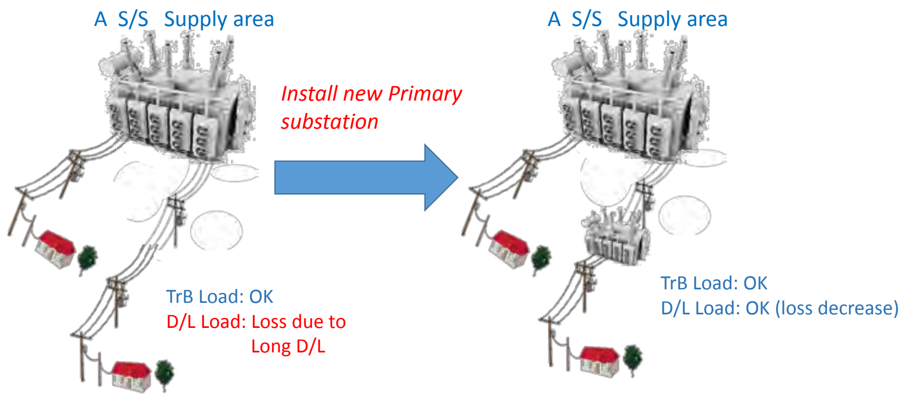

Figure 3-7 An Example of Concept for Medium Term Expansion Plan

Source: Prepared by JICA Study Team

d) Long Term Expansion Plan

In the AADMP, necessary cost for investment per kW is calculated by Average Incremental Cost (hereinafter called "AIC") which is a model including LV feeder below BSP.

AIC model consists of two models, Urban Model and Rural Model. This concept is based on difference of installation span of distribution transformer and voltage between MV feeder in urban area and rural area. The models using AIC calculation are shown in Figure 3-8 and Figure 3-9. In addition, AIC is shown in Table 3-8. The table shows that the cost of investment per kW in rural area is more expensive than those in urban area.

Assumptions:

Feeder load (MVA)	60
132/15 kV BSP	1
No of 15 kV feeders per BSP	10
Average 15 kV feeder length including spurs (km)	15
Average main line length (km)	10
Average spur length (km)	5
Distance between distribution transformers (km)	0.5
No of LV feeders per distribution transformer	4
Average LV feeder length (km)	0.6
15 kV demand	10%

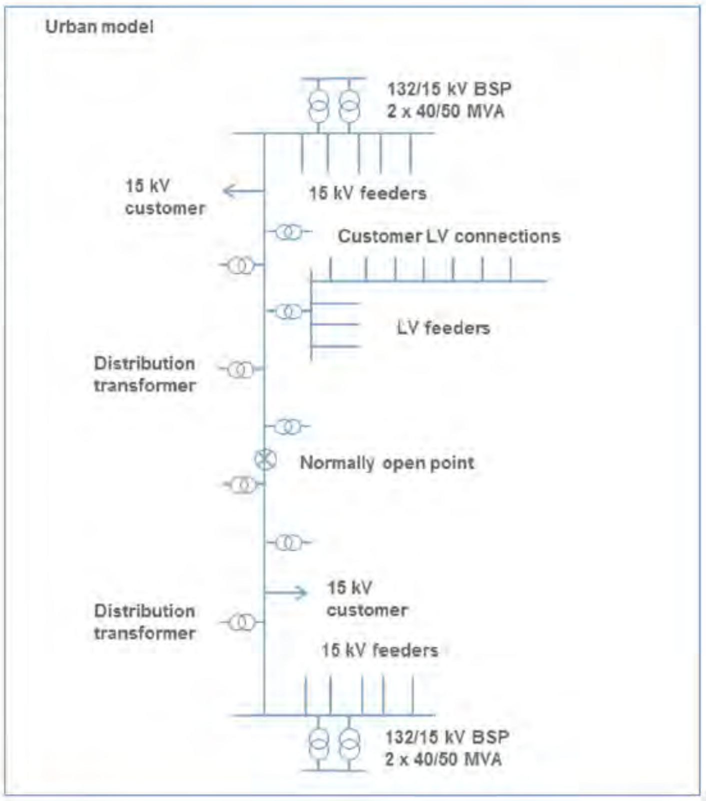

Figure 3-8 AIC Urban Model

Source: AADMP Volume 2 Part 2

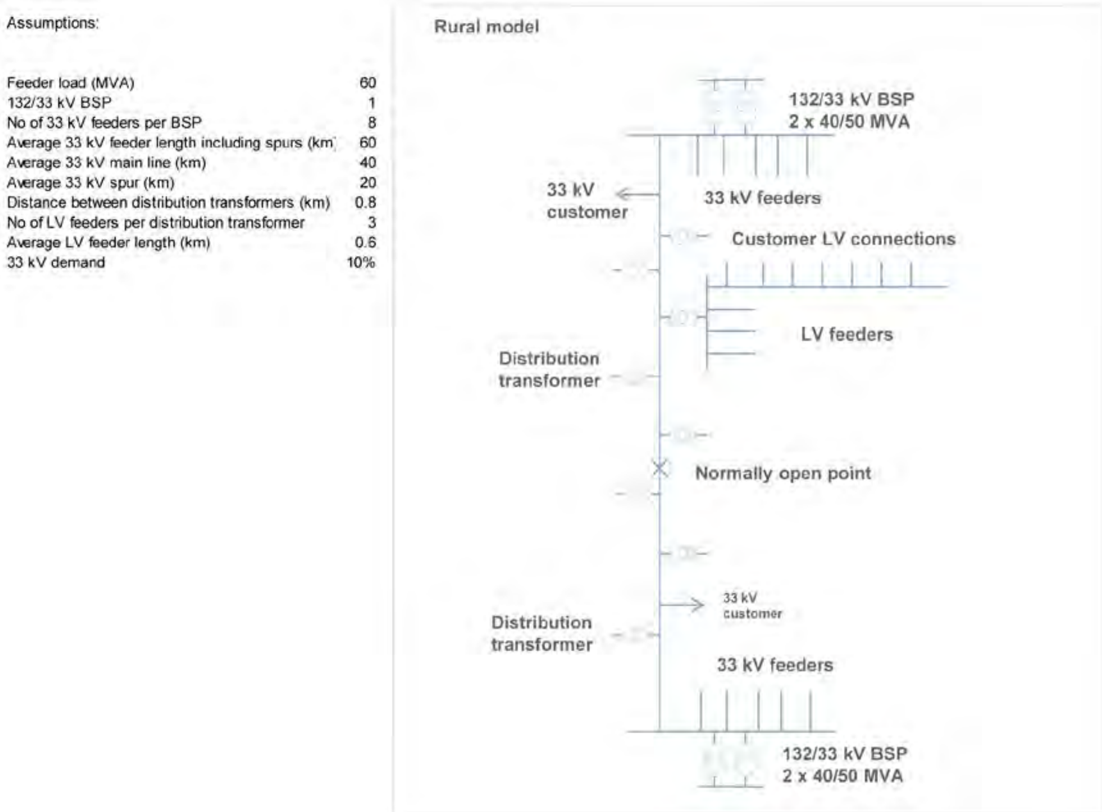

Figure 3-9 AIC Rural Model

Source: AADMP Volume 2 Part 2

Table 3-8 Average Incremental Cost (USD/kW)

Load Category	AIC
Urban LV	675
Urban MV	158
Rural LV	731
Rural MV	305

Source: AADMP Volume 2 Part 2

The AIC is multiplied by respective demand growth in each sub-city/woreda to obtain the annual investment costs. Urban Model is applied to sub-city in Addis Ababa, and Rural Model is applied to woreda in Oromia.

As the result of calculation, the average annual investment cost for 12 years from 2023 to 2034 is estimated to be USD 62 million, and USD 745 million in total[14]. This shows that continuous rehabilitation and expansion are planned from now on.

e) SCADA and Telecommunications

As offline management system of distribution facility in Addis Ababa Capital Region, Distribution Management System (hereinafter called "DMS") is introduced. In AADMP, new MV network SCADA system which can unify existing DMS is studied for specification and

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tasks. According to AADMP, SCADA and telecommunication system of MV is recommended to isolate from HV SCADA system from the viewpoints of future extensibility, operability, capacity constrain of HV SCADA system and business separation of EEP /EEU.

Meanwhile, the project under construction in AADRUP is introducing new distribution SCADA system by China firm, however, it is planned to add MV SCADA system to the existing HV SCADA system. Therefore, AADMP has suggested to change this plan.

3.3 Implementation Method of Proposed Projects

AADMP prepares the respective construction plans described in the previous section, and formulated contents of constructions and its budget. However, AADMP did not specify the package of construction works and procurement method. Therefore, AADMP Ic/R which is issued three months later after AADMP was issued, provides construction work as mentioned before. The package of construction work is shown in Figure 3-10.

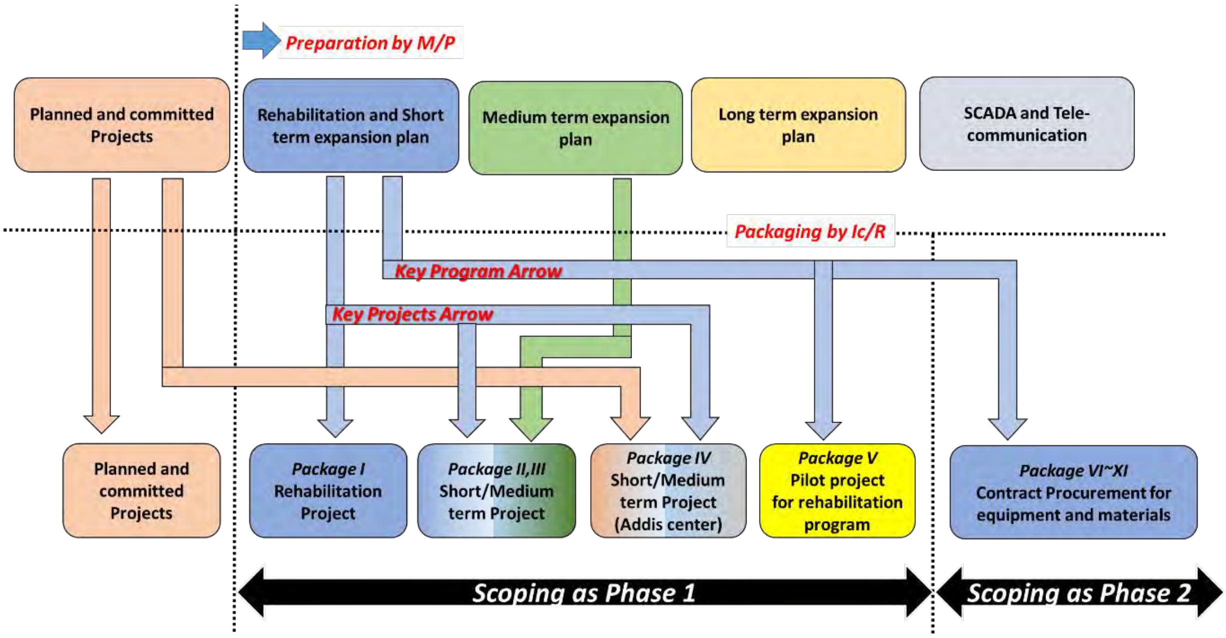

Figure 3-10 Image of Construction Package in AADMP Ic/R

Source: Prepared by JICA Study Team

There are two important points, the one is that Package 4. ADC Substation upgrade was changed dramatically because of low progress of a part of Planned and Committed Projects. Another one is that a part of full rehabilitation of distribution facility suggested as Key Program was included in Package 5 Pilot Project for Rehabilitation Work. Objective of Package 5 is to examine construction method of deteriorated distribution equipment and adequacy of construction budget. EEU will conduct widespread replacement of deteriorated facility as Rehabilitation Key Programs using experience which is obtained through Package 5.

In Planned and Committed Projects, to spread high demand in ADC substation located in the most important loading area in Addis Ababa, new substation named Black Lion substation (hereinafter called "BLL substation") is planned to be constructed one kilometer away from and north-west of ADC substation. BLL substation will be supplied from ADC substation by 132kV underground cable, therefore, by construction of BLL substation will be satisfied with N-1 criteria[15].

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However, in AADMP Ic/R, the plan was changed because of undefined delay of construction of BLL substation. In particular, ADC substation will be connected to Kaliti I substation which is 14 km away from ADC substation, as Short and Medium Term Projects. By this construction, ADC substation will be satisfied with N-1 criteria. In addition, EEP will install new transformer and replace to bigger capacity transformer to cope with overload in ADC substation.

Construction contents and procurement method of respective packages are shown in Table 3-9. In addition, as to Packages I to III, finance of AfDB is scheduled[16].

Table 3-9 Outline of Package of Construction and Procurement Method

No.	Project	Procurement Package	Contents	Cost (M US$)
I	Rehabilitation Project	Package I (EPC)	【Objective substations: 22 places】 - Construct new distribution line, upgrade, and modification of network - Construct new substations, upgrade and rehabilitation (except short term expansion and EEU's works from main rehabilitation projects of AADMP)	10.8
II	Short and Medium Term Project	Package II (EPC)	【Objective substations: 9 places (Under 66kV)】 - Construct new distribution line, upgrade and modification of operation voltage - additional installation of distribution transformer - Construct new substations and upgrade	21.1
III	Short and Medium Term Project	Package III (EPC)	【Objected substations: 12 places（Over 66kV）】 - Construct new substation and upgrade - Construct new 132kV transmission line132kV	46.9
IV	Short and Medium Term Project (ADC S/S Only)	Package IV (EPC)	【Objective substations: ADC S/S】 Upgrade plan of ADC substation - construction new 132kV underground cable - replacement of GIS from AIS	41.3
V	Rehabilitation Program (Pilot Project)	Package V (EPC)	Pilot project related to rehabilitation program suggested in AADMP (widespread rehabilitation) - Rehabilitation of MV/LV conductor - Rehabilitation of distribution transformer	23.7
VI	SCADA	N/A	- Installation of SCADA and Telecommunication system	--
VII	Consulting Service	N/A	- Detail design and supervise of this projects	--
VIII	Imported Goods	Package VI	- Distribution Transformer	19.7
IX	Imported Goods	Package VII	- MV/LV switchgear - MV conductor and cable - MV insulator and others（Import goods）	38.4
X	Imported Goods	Package VIII	- LV conductor and cable - LV cutout - LV insulator and others（Import goods）	52.8
XI	Domestic Goods	Package IX	- Wood pole, steel pole, concreate pole, steel pipe pole, arm hardware, branch line, etc. (Domestic goods)	37.6
XII	MV Feeders and MV/LV Substation Rehabilitation Works	Package X	- Rehabilitation works of MV/LV conductor and distribution transformer (Goods are provided by EEU)	30.0
XIII	LV Feeders Rehabilitation Works	Package XI	- Rehabilitation of MV conductor (Goods are provided by EEU)	34.6

Source: Prepared by JICA Study Team

16 Letter "Modification of Formulation of "Addis Ababa Transmission and Distribution System Rehabilitation and Upgrading Project ", dated March 24, 2017, JICA

3.4 Tasks Extracted from AADMP

3.4.1 Tasks in General related to AADMP

a) Task 1 Uncertainty due to related projects

AADMP study identifies parts of the network which do not meet the planning criteria in terms of voltage or loading limits based on the medium-term demand increase, as well as the areas of the network which were found to be in poor physical condition. Then, based on the result, a number of rehabilitation and expansion project were proposed. Meanwhile, these plans were being considered on the basis of many other planned and committed projects such as AADRUP, and it is necessary to revise the timing and contents of the AADMP plan according to the progress of the related projects.

b) Task 2 Lack of information to evaluate the feasibility and validity of AADMP

Since it is not specified in the AADMP related document about the preconditions and various kinds of data used in AADMP, detailed confirmation of these is necessary before commencement of the implementation stage. The specific contents are described below.

- Key projects were studied by state evaluation and network analysis on substation units, however, the model used for network analysis cannot be confirmed by AADMP.
- The rationale for the unit price used for cost estimation is unknown. In particular, the breakdown of the unit price (Refurbish / Repair, Replacement) used for calculating the rehabilitation cost of the Key Program is unknown.
- Asset evaluation by HI indicator was done, but the criterion of judgment of each equipment is not clear. In particular, in the Key Program, the ratio of the repair method (maintenance, refurbish / repair or replacement) is calculated from the survey results, however, the criterion for classification is not indicated.
- In the sample survey for identifying the state of the distribution equipment, there is no information that can judge the validity and effectiveness of the survey, as the number of samples, sample extraction method, etc. are not described.

Regarding the above Tasks 1 and 2, it is necessary to confirm the feasibility and validity of AADMP by updating information and confirming the contents of unknown points in the field survey.

3.4.2 Task Relevant to Individual Package

a) Task 3 Task relevant to ADC substation (Package IV)

ADC substation is planned to replace AIS with GIS, however, GIS will be installed on the same foot print of the existing AIS because of small spread of the ADC substation.

In the case of replacement of the same foot print, to prevent long period power outage, constructor need adequate construction method such as bypass method to minimize power outage. However, relevant documents including AADMP did not specify construction method, therefore there is a task as possibility of construction.

For this Task 3, study is done for realistic solution in site survey.

3.4.3 Task from the perspective of "Quality Infrastructure"

In the AADMP, it was focusing to solve insufficient capacity among the three problems (Lack of capacity, Poor reliability and High losses) in the transmission and distribution network of the study area mentioned in Section 1. As a result of solving capacity shortage, the remaining two problems (Poor reliability and High losses) will only be partially resolved.
An ideal distribution network is a quality distribution network that can be sustainable for a long time, which satisfies with the elements as shown in Figure 3-11.

In particular, since Addis Ababa is one of Africa's leading world cities and located many international organizations such as Headquarters of African Union, it is expected to become a city with great influence that will demonstrate initiatives to other African countries. From this point of view, the construction of an ideal distribution network with quality is a necessary proposition. The task that AADMP lacks from the viewpoint of that should aim for establishment of ideal distribution network.

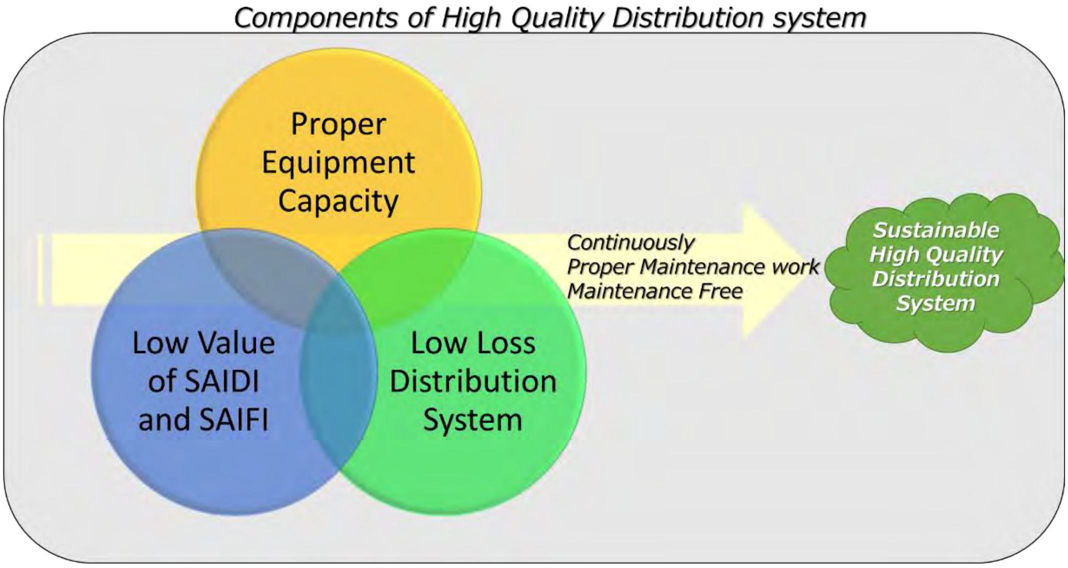

Figure 3-11 Quality distribution system component

Source: Prepared by JICA Study Team

a) Task 4 Approach concerning distribution loss reduction

In AADMP, it is proposed to reduce the loss by boosting the distribution line voltage (15 kV to 33 kV), installing the primary substation and the like. However, it is limited to proposals based on current specifications, and lacks recommendations on equipment specifications from a viewpoint of lower loss.

In other words, the network-wide rehabilitation of the distribution equipment implemented after Package 5 is an opportunity to upgrade into quality distribution network, however, the study on loss reduction does not extend to low loss equipment.

b) Task 5 Approach on improving supply reliability

To supply high quality electricity, it is necessary to improve both the frequency of power outages (SAIFI) and the duration of power failure (SAIDI). Although it is expected that the frequency of blackouts will decrease as a result of the network-wide rehabilitation, it is not considered to improve the specification of the equipment. In order to achieve higher supply reliability, efforts to reduce power outage time are necessary. However, this is only a recommendation on the specification of SCADA for MV network. It is necessary to consider the introduction of distribution equipment that leads to improvement of supply reliability.

c) Task 6 Approach on equipment maintenance

In AADMP, there were many descriptions about the lack of equipment maintenance. Although the importance of maintenance was explained, it did not mention the concrete method. Also, in order to maintain large quantities of distribution equipment periodically and maintain high reliability, it is necessary to introduce an asset management system and to train engineers and field engineers.

The AADMP stated the necessity of such tackling[17], however, long-term tackling are necessary for the development and introduction of systems and human resource. Therefore, in parallel with such development, it is necessary to tackle the introduction of power distribution equipment with long-term reliability and easy maintenance.

The above-mentioned Tasks 4 to 6 are task from the viewpoint of improvement of "Quality Infrastructure" that the distribution network in the Addis Ababa Capital Region should aim, and by solving these task it will be able to upgrade into a quality distribution network. A conceptual diagram to solve problem is shown in Figure 3-12.

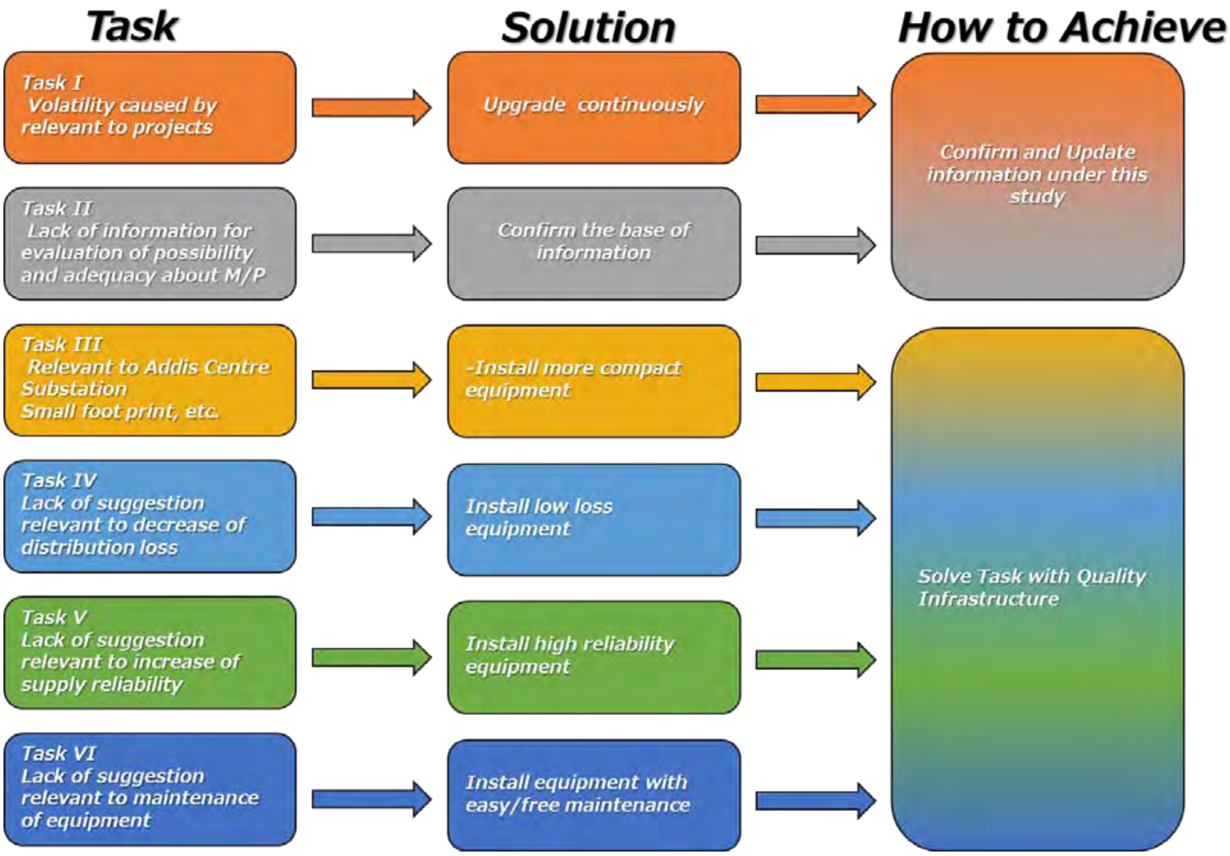

Figure 3-12 AADMP Task and Solutions

Source: Prepared by JICA Study Team

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3.5 Applicable Quality Infrastructure for Network in Addis Ababa

This Section describes preliminary examination about applicable Quality Infrastructure as solution for Tasks 4 to 6 which are extracted as a viewpoint from “High Quality Infrastructure” and Task 3 which is extracted as individual package.

In particular, for Task 3, we examine the Quality Infrastructure which is advantageous against small foot print. For Task 4 to 6, we examine the Quality Infrastructure which is advantageous against increase of supply reliability and decrease of distribution loss. The equipment which satisfies the advantage mentioned above are shown in Table 3-10.

Table 3-10 Applicable Quality Infrastructure for Addis Ababa Capital Region

Applicable Target		Examination Equipment	Advantage of Quality Infrastructure	Correspondence
D/L Equipment	Distribution Transformer	Amorphous Transformer (AMT)	AMT has high characteristic efficiency compared to traditional transformer (CRGOT). AMT is expected reduction of distribution loss.	Task 4
	Insulator for MV	Pin Post Insulator	Pin post insulator is different from pin insulator using distribution line generally. There is no pin part inside of porcelain, therefore Pin post insulator is expected reduction of fault of crack dramatically. Contamination resistance is superior.	Task 5,6
	Automatic Operation of Switchgear (Distribution Automation System)	Time Sequential Sectionalizing System	Time Sequential Sectionalizing System can reduce recovery time and minimize power outage section by combining with substation reclosing relay[18].	Task 5
S/S Equipment	132 ~ 66kV Substation Outdoor Switchgear	GIS (Gas Insulated Switchgear)	GIS has advantage to minimize foot print and gas leak quantity. GIS made in Japan has intent to install it outdoor. There are so many installation record overseas. Overseas maker start manufacturing outdoor type GIS, however installation record of outdoor type GIS is big difference.	Task 3,6
	132 ~ 66kV Transformer Connection equipment	Direct Connection GIS with Transformer	The equipment which connects transformer (oil insulated) to GIS (gas insulated) directly is Quality Infrastructure. It is costly equipment, however there is few possibility to fault occur because all live parts are covered. Moreover it can install very small foot print.	Task 3,6
	132 ~ 66kV Power Capacitor	Tank Type Power Capacitor	It is costly equipment compared to conventional can type capacitor, however it has advantage of maintenance free and earthquake resistance. It is Quality Infrastructure.	Task 5,6

Source: Prepared by JICA Study Team

a) Amorphous Transformer (AMT)

Amorphous transformer (hereinafter called “AMT”) is equipped with amorphous alloy core inside transformer. No-load loss can be greatly reduced by its excellent electrical characteristics. Depending on the operational condition of the transformer, it can be reduced by about 40% compared to conventional transformer (hereinafter called “CRGOT”).

Although AMT would increase initial cost compared to CRGOT, AMT can reduce operational cost due to decrease of distribution loss. Therefore, JICA Study Team considers availability from the viewpoint of lifecycle cost. As shown in Figure 3-13, effect of decreasing distribution loss by AMT against CRGOT is depending on utilization and load factor. For consideration of availability, we need to know operational condition of transformer which is used by EEU’s MV distribution network during site survey.

18 Distribution line in study area, Automatic Operation of Switchgear is applied only hospital and important facilities such a government institution. –Source: AADMP Volume 3 Part 2

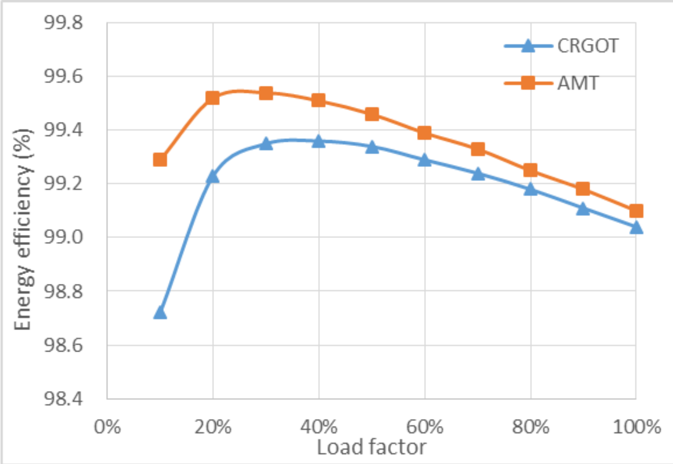


Figure 3-13 Comparison of Efficient Characteristic between AMT and CRGOT

Source: Prepared by JICA Study Team using document from Toshiba Corporation

b) Pin Post Insulator

Pin post insulator is solid-core type insulator, as shown in Figure 3-14, and has ever installed in Ethiopia by Japanese Grant Project in the past[19]. There is no fear of crack by expansion of concrete because of no metal pin parts covered with concrete inside of porcelain. Moreover, lightning and anti-contamination performance are superior because of long creepage distance. (Figure 3-15) Due to air pollution caused by the economic growth in Ethiopia, there is a possibility that trouble in distribution lines will increase in the future. Therefore, JICA Study Team examines the applicability of pin post insulator.

Figure 3-14 Pin Post Insulator

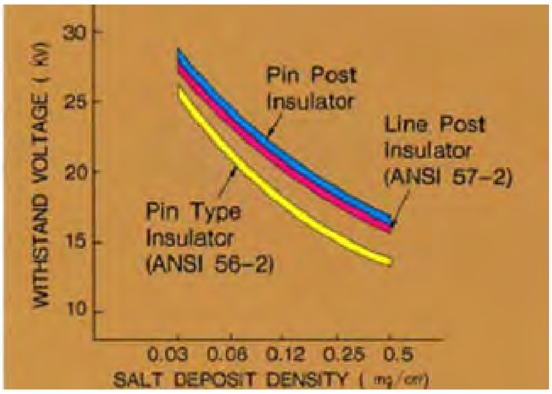


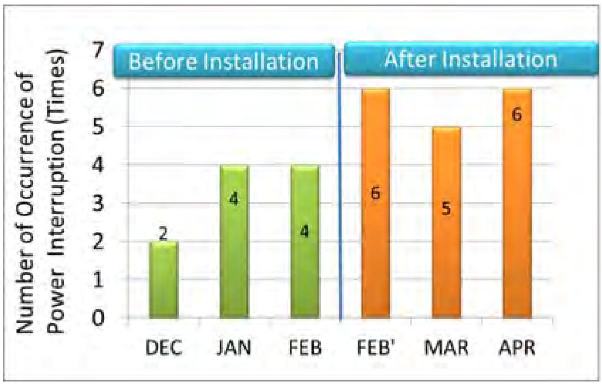
Figure 3-15 Comparison of Pollution Resistance

Source: Acquisition documents by JICA Study Team from NGK Insulators, Ltd.

c) Time Sequential Sectionalizing System (TSS)

Time Sequential Sectionalizing (hereinafter called “TSS”) System is very effective to reduce outage time as shown in Figure 3-16. AADMP does not specify the specification and rehabilitation plan of switchgear for MV feeder clearly, therefore, TSS system is required to examine applicability with spec in Ethiopia. However, TSS system can operate independently from the existing distribution management system, therefore, there are strong possibility to be able to apply TSS system to the existing distribution system.

19 Addis Ababa Administration area distribution network upgrading plan, GOJ, ODA (1997-98)



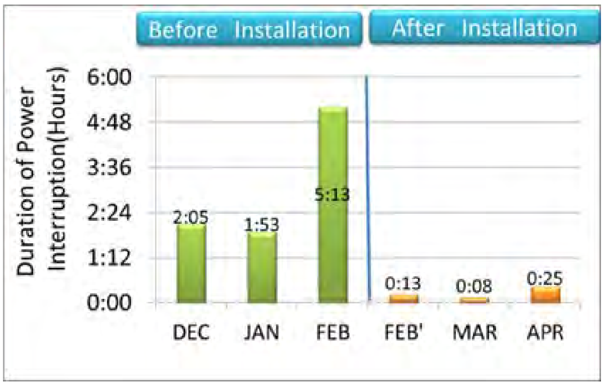


Figure 3-16 Comparison of Outage Before/After the Installation of TSS System

Source: Acquisition documents by JICA Study Team from Nissin Electric

d) Tank Type Capacitor

Tank type capacitor can be installed with smaller foot print compared to conventional "can-type" capacitor and has an advantage of earthquake resistance because of being installed on foundation directly. Tank type capacitor and can-type capacitor are shown in Figure 3-17 and Figure 3-18. Moreover, characteristic of the respective capacitors is shown in Table 3-11. Equipment cost of tank type capacitor would be four times or five times higher in cost of can-type. However, tank type capacitor has a characteristic of long lifespan, maintenance free, etc.

Figure 3-17 Tank Type Capacitor

Figure 3-18 Can Type Capacitor

Source: Acquisition documents by JICA Study Team from Nissin Electric

Table 3-11 Comparison of Characteristics of Capacitor

	Tank Type	Can Type
Lifespan	Long	Short
Maintenance	Free	Need (Include auxiliary equipment)
Safety	High (Outer case is grounded)	Low (Outer case is live parts)
Foot print	Small	Large

Source: Prepared by JICA Study Team based on document from Nissin

e) GIS (Outdoor Installation Type)

GIS is the switchgear whose live parts is covered by earthed metal enclosure and filled up SF6 gas which is 3 times of dielectric strength of air.

GIS can reduce foot print dramatically compared to Air Insulated Switchgear (hereinafter called "AIS"), therefore, GIS is mainly installed in urban area which have narrow foot print. In addition, GIS does not need fear of declining dielectric strength even low air density and high altitude area such as Ethiopia, because GIS's live parts is covered by SF6 gas with high pressure. Even Western manufacturers produce a lot of GIS, however, GIS made in Western manufacturers is assumed to be installed inside the building. Meanwhile, GIS made in Japan is both installed inside and outside, and there are so many installation track record in overseas. By installing GIS outside, construction cost of building can be reduced. An example installing GIS is shown in Figure 3-19.

Figure 3-19 An Example of Outdoor and Indoor Type GIS

Source: Acquisition documents by JICA Study Team from Nissin Electric

Chapter 4 ANALYSIS OF TRANSMISSION AND DISTRIBUTION NETWORK IMPROVEMENT IN THE CAPITAL REGION AND RECOMMENDATIONS

4.1 Analysis of Transmission and Distribution Network Improvement in the Capital Region

4.1.1 Result of Field Survey for Substation Equipment

JICA Study Team conducted field survey of five substations and Load Dispatching center. List of survey facility relevant to substations are show below.

- Addis Centre Substation (Existing)
- Addis Centre Substation (New site)
- Addis East Substation
- Nifas Silk Substation
- Kaliti-I Substation
- Black Lion Substation (Under Construction)
- Load Dispatching Center

Summery of respective substations are show below.

a) Addis Centre Substation (Existing)

ADC substation is located in southeast of Mexico Square which is center of Addis Ababa Capital Region. ADC substation has supplied significant customer such as African Union, Palace, etc. Therefore, ADC substation is required for one of the highest reliability in Ethiopia. EEP is planning to install new head quarter at southeast of Mexico Square including exiting ADC substation site. According to AADMP Ic/R, ADC substation will conduct whole replacement using existing ADC substation foot print. However, according to interview of relevant persons such as EEP, AfDB, city administration, etc. ADC substation will be moved 700 meter away from and south of existing site. Existing ADC substation consists of three transformer called T1, T2, T3 which are good and fair condition. Cubicle which is connected T3 is very poor condition and located in non-manned control room. Moreover, alarm such as trip information is not sent to manned control room. Therefore, operator which is in ADC substation has to monitor T3 cubicle periodically. Existing ADC substation is shown in Figure 4-1, Figure 4-2.

Figure 4-1 Power Transformer

Figure 4-2 Incoming Transmission Line

b) Addis Centre Substation (New Site)

As mentioned before, ADC Substation will be moved to new location. The new site is 8000 meter square and administrated by city government. Some illegal residents are in site. However, according to interview, city government will resettle the residents by government's responsibility and budget including compensation for residents. EEP needs to submit substation layout to be supplied with new site by city government. Moreover, EEP tries to minimize substation layout to get understanding city government because new ADC substation site is located center of Addis Ababa Capital Region. New ADC substation site is shown in Figure 4-3 and Figure 4-4.

Figure 4-3 Road in front of New ADC S/S

Figure 4-4 Location Map ADC S/S

c) Upgrading of ADC Substation

Upgrading of ADC substation is critical project to build reliable power system for Addis Ababa Capital Region. However, plan of upgrading of ADC substation changed several times due to progress of BLL substation, land acquisition, load shifted, etc. Change of plans are shown in Figure 4-5. According to AADMP, new substation called BLL Substation will be installed about one kilometer away from existing ADC substation to support ADC substation's demand supply. However, according to AADMP Ic/R, construction of BLL substation was undefined delay. Therefore, construction of new ADC substation which has five transformers was planned. Moreover, to supply power demand and satisfy N-1 criteria, replacing existing single circuit transmission tower with new double circuit underground transmission line was planned. At the time of Kick off meeting held by EEP with JICA Study Team in July, 2017, EEP has announced to change a composition of transmission line from all underground transmission line to mixed transmission line both underground cable and overhead transmission line to save construction cost. Moreover, to boost reliability of ADC substation and BLL substation, JICA Study Team suggested to install new underground transmission line from BLL substation to ADC substation. Due to this power system configuration, ADC substation and BLL substation could cope with N-2 criteria such as simultaneous double busbar fault, two circuit transmission fault, etc.

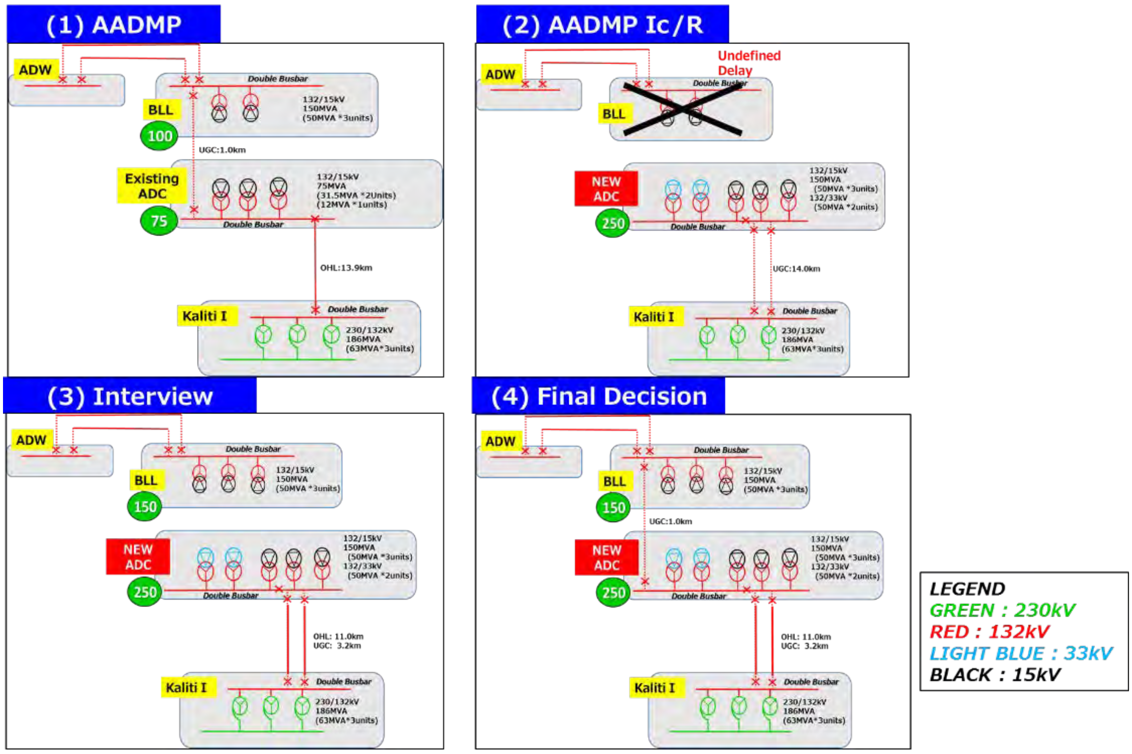


Figure 4-5 Change of Plan About ADC S/S

d) Addis East and Nifas Silk Substation

JICA Study Team surveyed Addis East Substation (hereinafter called “ADE substation”) and Nifas Silk Substation (hereinafter called “NIF substation”) to understand standard of new substation. ADE and NIF substation are upgraded from 45kV to 132kV recently. Both substations are installed indoor type GIS and 132/15kV stepdown transformer. ADE substation is supplied by double overhead transmission line from Cotibie substation. NIF substation is supplied by double underground cable from Kaliti-II substation. Moreover, both substation are installed Substation Automation System (hereinafter called “SAS”) using bay control units. Communication protocol in substation is applied to IEC61850. Both substation design are met with world standard. Therefore, there is no serious problem about new substation. ADE and NIF substation are shown in Figure 4-6 to Figure 4-9.

Figure 4-6 ADE S/S Power Transformer and GIS

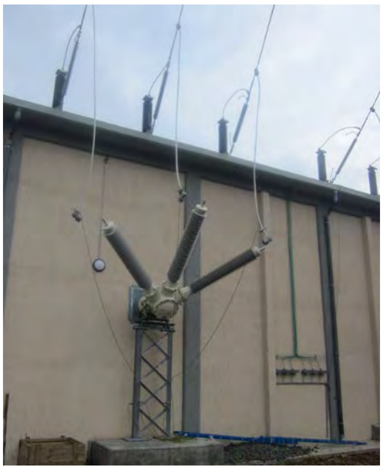


Figure 4-7 ADE S/S Incoming T/L

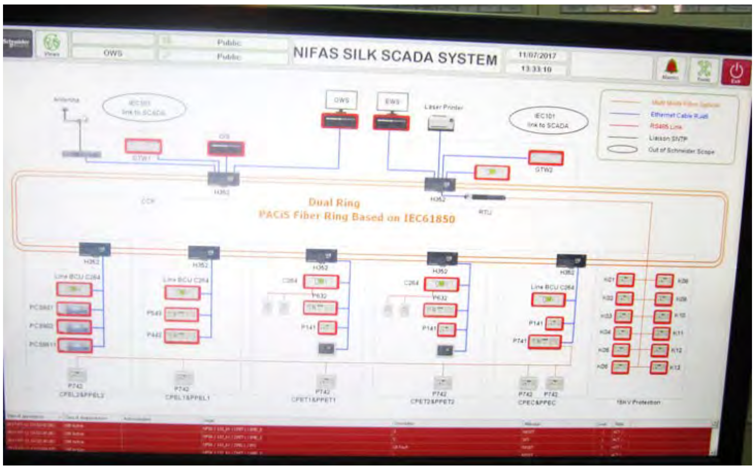


Figure 4-8 NIF S/S Configuration of SAS

Figure 4-9 NIF S/S Incoming T/L

e) Kaliti-I Substation

Kaliti-I substation is power source for existing ADC substation. Kaliti-I substation is supplied by 230kV, then stepdown from 230kV to 132kV by autotransformer. Circuit configuration of 230kV and 132kV are composed of double busbar system of AIS. Therefore, Kaliti-I substation has high reliability. However, since transmission line to ADC substation is single overhead transmission line, in case of single bus fault, ADC substation would be power outage. Control and protection configuration of Kaliti-I substation is used of Remote Terminal Unit (hereinafter called “RTU”) based SCADA and mimic board panel as backup. Kaliti-I substation is shown in Figure 4-10 to Figure 4-13.

Figure 4-10 Power Transformer 230/132kV

Figure 4-11 Outgoing T/L

Figure 4-12 230kV Switchgear Yard

Figure 4-13 Existing RTU (Micom C264)

f) Black Lion Substation (Under Construction)

BLL substation is located in 500 meter away from and north of existing ADC substation. As mentioned before, main purpose of BLL substation is to support of ADC substation demand supply. As of July, 2017, BLL substation is under construction. Main equipment such as power transformers have already installed in BLL substation. However, transmission line from Addis West substation as power source for BLL substation to BLL substation has not started construction yet. A part of transmission line needs to be underground due to land constrain Therefore, completion of BLL substation is expected within this year. Present condition and location of BLL substation are shown in Figure 4-14, Figure 4-15.

Figure 4-14 BLL Substation

Figure 4-15 Location Map

g) Load Dispatching Center (LDC)

LDC is located in nearby Weregenu substation which is eastside of Addis Ababa Capital Region. LDC is responsible for monitoring and operation of HV facility through HV SCADA system. LDC operates and monitors whole Ethiopia substations equipment above secondary side circuit breaker of transformer. The number of substations is 192 in Ethiopia. LDC operates and monitor power stations such as Hydro power plant. As to substation, LDC can monitor circuit breaker condition, close or open including trip information. However, LDC cannot monitor alarm such as low gas pressure, MCB trip, etc. GE's e-terra platform is adopted as SCADA system

4.1.2 Result of Field Survey for Distribution Equipment

a) Configuration of Distribution Network

1) Configuration of Distribution Equipment

The distribution network in Addis Ababa is implemented with 15kV or 33kV on the primary side (medium voltage) and 400V/230V on the secondary side (low voltage), and most of the facilities are formed by overhead distribution equipment. The medium voltage feeder and the low voltage feeder are supported by separate poles (Figure 4-16: left), the route of both feeder also has a different layout, with few overlapping parts.

Pin type insulator and line post insulator are used for insulation of MV feeder. Pin type insulators are used for old equipment, line post insulator are used in newly installed equipment.

Various capacity transformers are applied to the distribution transformer, but mainly those of the 200-315 kVA class are installed. Small capacity Transformers (up to 400 kVA) are installed at the poles of the MV feeder using a concrete pedestal (Figure 4-16: center), or installed at the H arranged poles (Figure 4-16: Right). In the case of a large capacity transformers of 500 kVA or more, they are installed on the ground.

A cutout and a lightning arrestor are installed on the primary side of the transformer to protect from overcurrent and lightning overvoltage.

Low-voltage feeders are 400V / 230V three-phase four-wire distribution line.

It is supplied to small-scale customers by the overhead service line connected to above-mentioned low-voltage feeder. Large customers are directly supplied at 15 kV, or directly supplied at 33 kV in areas where 33 kV distribution facilities are in place.

Figure 4-16 Installation Status of Distribution Equipment

2) Configuration of Distribution Network

The network configuration of the distribution system in Addis Ababa is configured by a large capacity backbone line called an Express way draw out from each substation, and it is connected at the end point to the another Express way draw out from the adjacent substation. At this interconnection point, a switching station (hereinafter called “Sw/St”: ring main unit) is installed, and the interconnection switch is normally open.

When a failure occurs in one Express way, the CB of the substation operates and outage occurs. However, by operating switch of Sw/St, it is possible to transfer the load to adjacent Express way and supply power without using the damaged Express way. Theses system ensure supply reliability of the distribution network. Details of the Express way will be described later.

The existing old distribution network is networked by overhead line apart from Express way, and this network is used to supply to the area via Express way. This supply network is separated to a number of fixed area, end of which is connected to the branch circuit of Sw/St installed at Express way and supplied via it.

3) Express Way system

The distribution network configuration in Addis Ababa is based on a backbone feeder called Express way. The basic structure of the Express way is shown in Figure 4-17.

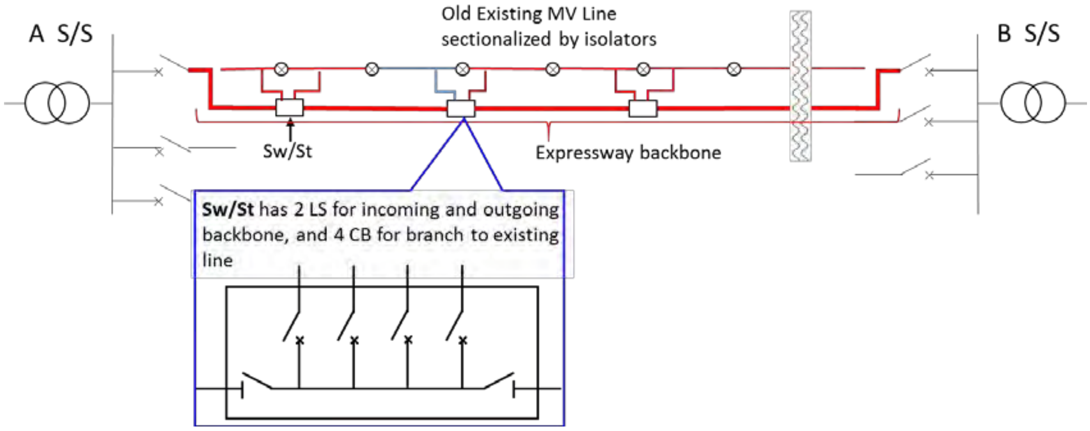


Figure 4-17 Basic Structure of the Express Way

Express way consists of high capacity feeder draw out from substation and 3 or 4 Sw/St (Figure 4-18) installed in the way of feeder. End point of Express way is connected via Sw/St to another Express way draw out from adjacent substation. In the event of a fault in one Express way, it is possible to supply to each other's without fault section. Sw / St is a multi-circuit switchgear, and it can branch to four circuit. Each circuit is connected to the existing overhead distribution line and supplies to the surrounding area.

Appearance

Inside

Figure 4-18 Switching Station

Each circuit of Sw/St is equipped with a circuit breaker with protection relay. If a fault occurs in the distribution line connected to this circuit breaker, it is operated and the fault section is disconnected before the circuit breaker of the substation operates.

The Express way is equipped with an optical fiber line, and the status information of Sw/St (voltage, current, accident type, circuit breaker state) will be transferred to substations and Distribution Control Center (hereinafter called "DCC") via the SCADA system which will be introduced in the future. In the Express way with SCADA system, it is possible to automate distribution system operation including remote control of distribution system. This function is equivalent to the time sequential sectionalizing system[20] which is option of JICA Study Team.

However, both distribution lines and communication lines are damaged in many places due to the construction work of the LRT. In addition, the automation system (Software) for distribution system operation is under construction yet. Therefore, the current Express way cannot automate the operation of distribution system, and as a result, the following problem arises in the distribution system in Addis Ababa.

b) State of Distribution Equipment

1) Addis Centre Substation

The ADC substation is supplied to the center of Addis Ababa through a 15 kV distribution line. This substation is planned to be reinforced with the relocation in the future, the current situation is as follows. The ADC substation is supplied by single overhead transmission line of 132 kV from Kaliti I and steps down to the distribution voltage of 15 kV. Two 31.5 MVA transformers (T1 and T2) and a 12 MVA transformer (T3) are installed in ADC substation and the total capacity is 75 MVA. There are twelve feeders supplied from T1 and T2 (Figure 4-19) and two feeders supplied from T3.

An example of the daily load curve of the feeder of T1 and T2 is shown in Figure 4-20. The sum of feeder load is 54 MW, and the load factor of T1 · T2 is as high as 85%.

Figure 4-19 15kV Switchgear Panels

20 3.5 C) Time Sequential Sectionalizing System (TSS)

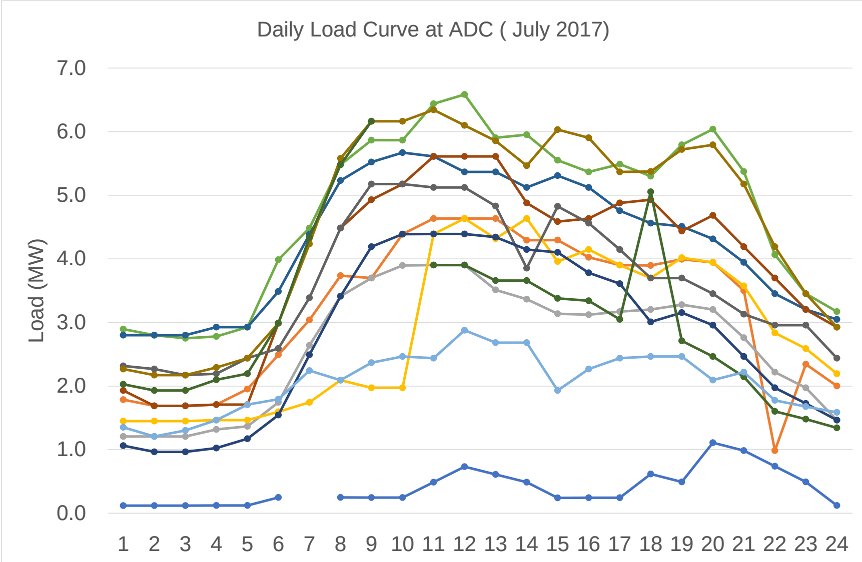


Figure 4-20 An Example of Daily Load Curve of ADC

Previously, eleven Express way was drawn out from ADC substation, but eight of them are not in service currently due to the damage by the construction work of LRT (Figure 4-21). Therefore, supply from ADC is mainly conducted with conventional outgoing equipment (Figure 4-22).

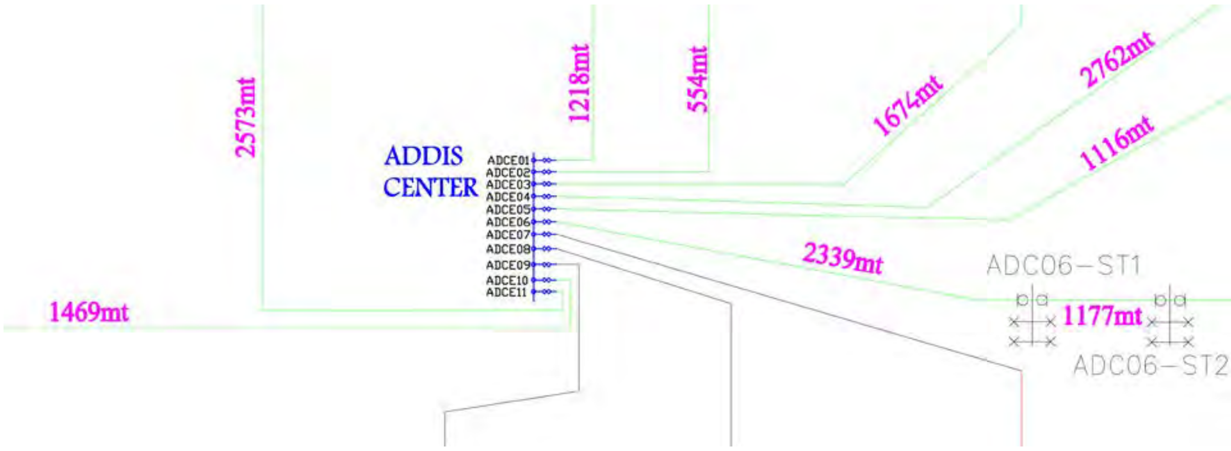


Figure 4-21 Status of Expressway draw from ADC

Figure 4-22 Conventional Outgoing Feeder Equipment

In the area surrounding the ADC substation, other projects about distribution facilities is undergoing, so there is mixture of old and new rehabilitated facilities (Figure 4-24).

In old feeders, thin conductors are mainly used for both medium-voltage and low-voltage, which might be a factor of increasing distribution loss, so it is necessary to reconsider the conductor size at rehabilitation.

Thin wooden poles are often used, so it is necessary to be replaced to concrete pole which can support to larger size conductor or transformer when it is rehabilitated.

Figure 4-23 Mixed Situation of New and Old Facilities

2) Addis East Substation

ADE substation is supplied by single 45kV overhead transmission line from Cotobie and steps down to distribution voltage of 15 kV. ADE substation has two 6MVA transformer (T1 and T 2) (Figure 4-24), and total capacity is 12 MVA.

Currently, the ADE substation is upgrading in the neighboring land. After completion of upgrading, ADE substation will be supplied by double 132kV overhead transmission line from Cotobie and total capacity will be increased to 150kVA with three 50MVA transformer. Also construction of twelve overhead Express way from newly ADE substation is proceeding (Figure 4-25), supply capacity for the surrounding area of ADE substation will be greatly increased after completion.

Figure 4-24 Transformer of ADE (6MVA)

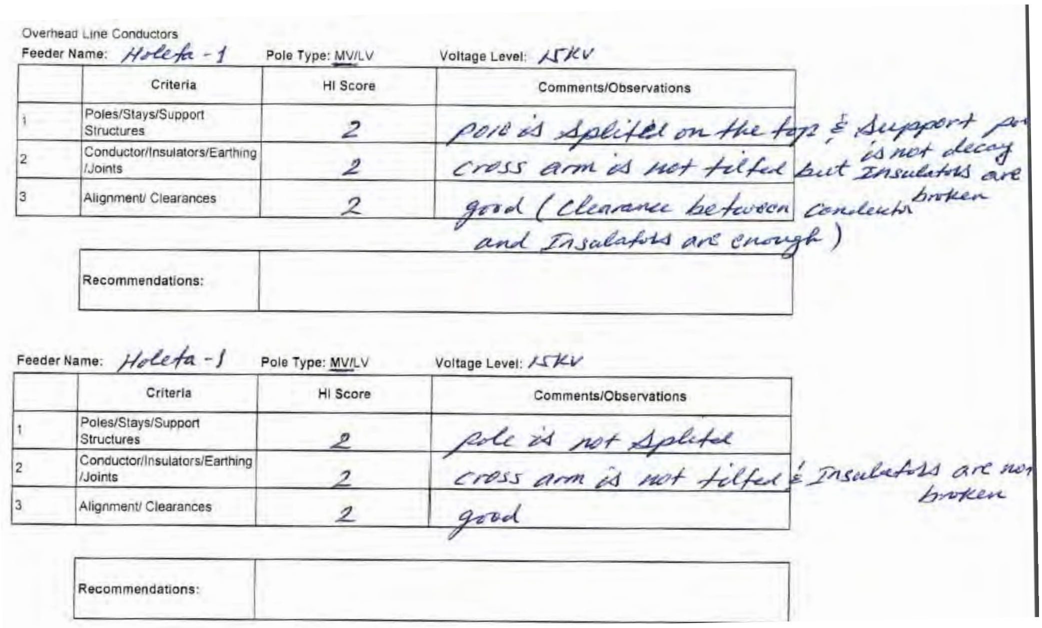
Figure 4-25 Expressway Outgoing Equipment under Construction

3) Progress of distribution network construction by various projects

In Addis Ababa, distribution network expansion and refurbishment projects by many donor are undergoing in parallel. Therefore, when implementing similar new constructions in the future, it is necessary to clarify the scope of their implementation so as not to cause duplicate construction.

4) Confirmation of condition assessment for rehabilitation

In order to evaluate the validity of the condition assessment of the distribution equipment conducted in AADMP, JICA Study Team confirmed the distribution equipment jointly with the EEP project team. Based on the survey sheet conducted by AADMP (Fig. 4 26), JICA Study Team conducted verification of EEP researcher's judgment criteria and on-site equipment, and confirmed that AADMP survey results is validity.



Overhead Line Conductors

Feeder Name: Holeta - 1 Pole Type: MV/LV Voltage Level: 15KV

	Criteria	HI Score	Comments/Observations
1	Poles/Stays/Support Structures	2	pole is Splited on the top & Support is not decay
2	Conductor/Insulators/Earthing /Joints	2	cross arm is not tilted but Insulators are broken
3	Alignment/ Clearances	2	good (Clearance between conductors and Insulators are enough)

Recommendations:	

Feeder Name: Holeta - 1 Pole Type: MV/LV Voltage Level: 15KV

	Criteria	HI Score	Comments/Observations
1	Poles/Stays/Support Structures	2	pole is not Splited
2	Conductor/Insulators/Earthing /Joints	2	cross arm is not tilted & Insulators are not broken
3	Alignment/ Clearances	2	good

Recommendations:	

Figure 4-26 An Example of Survey Sheet

Low Voltage Feeder

Status of protection fuse for transformer secondary side

Figure 4-27 Confirmation of Validity of Distribution Equipment Assessment

c) Status of Distribution Network operation

1) Monitoring network condition at substation

Currently, operation of the distribution system (the equipment on the load side from the secondary side of the substation transformer) is being implemented by the EEU.

The monitoring and control personnel (Figure 4-29) reside at the substation 24 hours in three shifts to periodically measure and record the voltage and current of the transformer and distribution feeder. When these measured values are abnormal or an alarm of the protection relay is displayed, the monitoring and control personnel contacts the DCC and conduct an appropriate circuit breaker operation, thereby coping with the abnormality. Since such data of the substation is not displayed in the DCC, there is no means for grasping the state of the substation as a whole.

Figure 4-28 Monitoring and Control Personnel

Since SCADA system is not maintained between DCC and each substation, communication measure is only by manual communication such as telephone. Figure 4-29 shows the current communication system related to distribution network operation. From such circumstances, it is urgent to install SCADA in order to improve reliability and efficiency of network operation.

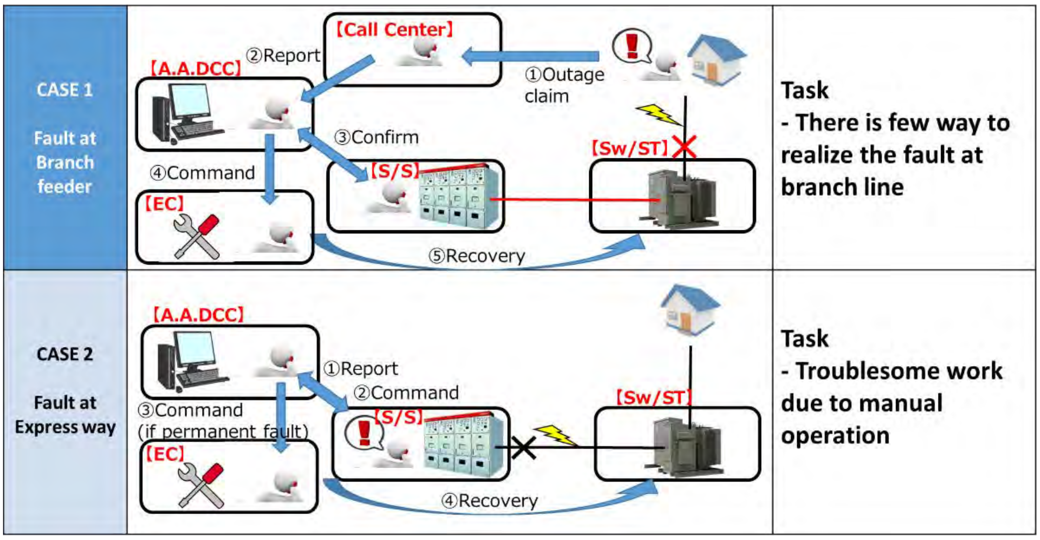


Figure 4-29 Communication System related to Distribution Network Operation

2) Distribution Control Center

DCC plays a role of collectively monitoring and controlling substations and distribution systems in Addis Ababa. However, as described above, the all the data and information processing is carried out by manual processing by the DCC operator (Figure 4-30).

On the other hand, as a first step toward automation of power distribution network operation in the future, a database called as DMS600 has been installed that can display all distribution lines in Addis Ababa (Figure 4-31). However, DMS600 is installed with offline, and it is not utilized for the work of the above DCC operator.

DMS600 is planned to be expanded to automation function of the monitoring and control of the substation and distribution system by combine with the automatic control function of Express way.

Figure 4-30 DCC Operator

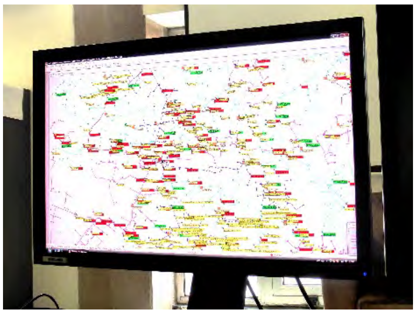


Figure 4-31 DMS600

3) Correspondence to fault of distribution network

Current communication system of each department related to the network operation at fault of distribution network is similarly as shown in Figure 4-29.

When a fault occurs on the Express way backbone, a relay at the substation detects a fault, and the restoration is carried out shown in Case 2 in Figure 4-29.

On the other hand, when a fault occurs in the distribution system connected to the branch circuit of the Express way, a fault is detected by the Sw/St relay. But there is a problem in detection of fault due to the incompletion of automation for Express way. In other words, if a fault occurs in the branch circuit of the Express way, the substation relays does not detect the fault because the Sw/St circuit breaker operates quickly. So substation operator cannot know the fault occurrence and fault circuit. In this case EEU currently can know fault information only by contact from customers.

In view of such circumstances, it is urgent to install an automatic control function of Express way in order to streamline the operation of distribution network including reduction of fault restoration time.

d) Workshop for repairmen of distribution transformer

EEU repairs aging transformers and fault transformers at their own workshop. Since the structure of AMT which is considering introduction in the future project is different from the conventional transformer (CRGOT) currently installed by EEU, JICA Study Team investigated that it can respond to repair AMT with existing facilities of Workshop whether or not.

Repair in the workshop is carried out by the following procedure. (Figure 4-32)

Acceptance of transformer
⇒ Judgment test of deterioration (resistance and insulation resistance measurement)
⇒ Replace deteriorated / failed parts
⇒ Replace insulated oil
⇒ Characteristic test by actual load
⇒ Shipping

In the case of coil fault, the work of disassembling the iron core and replacing with a new coil is carried out. Coils for replacement are manufactured themselves using winding machines equipped at the Workshop (Figure 4-33). Only the cylindrical coil (Figure 4-34) can be manufactured with this winding machine.

On the other hand, AMT considering to introduce is used a rectangular coil structure (Figure 4-35), so in order to cope with the similar repair as CRGOT, it is necessary to deploy dedicated winding machines and introduction training.

In addition, there are many stock of partially deteriorated transformer, and repair parts can be procured by taking out sound parts from them (Figure 4-36).

Figure 4-32 Transformer Repair Line

Figure 4-33 Coil Winding Machine

Figure 4-34 Cylindrical Coil

Figure 4-35 Rectangular Coil

Figure 4-36 Transformer Stock

4.1.3 Results of consideration for Introduction of Quality Infrastructure (Substation)

JICA Study Team conducted evaluation of Quality Infrastructures from the technical viewpoints. This chapter describes Quality Infrastructures relevant to substation.

Applicable Quality Infrastructures for substation are shown below.

- Outdoor Type Gas Insulated Switchgear
- Direct Connection GIS with Transformer
- Tank Type Capacitor

a) Outdoor Type Gas Insulated Switchgear

Addis Ababa Capital Region is expected to build numerous huge building. Especially, the area which is supplied from ADC substation would be a center of not only Addis Ababa Capital Region but also in Africa. According to interview relevant persons such as EEP, city administration, etc. spread of the site for installation of new ADC substation is expected to strict constraint. Therefore, it is necessary to minimize the spread of the site for new ADC substation. From such a situation, outdoor type GIS is high possibility that new ADC substation is installed. According to our substation design, spread of the site for new ADC substation which GIS installs could be 2500 meter square. The draft substation layout for new ADC substation is shown in Figure 4-37.

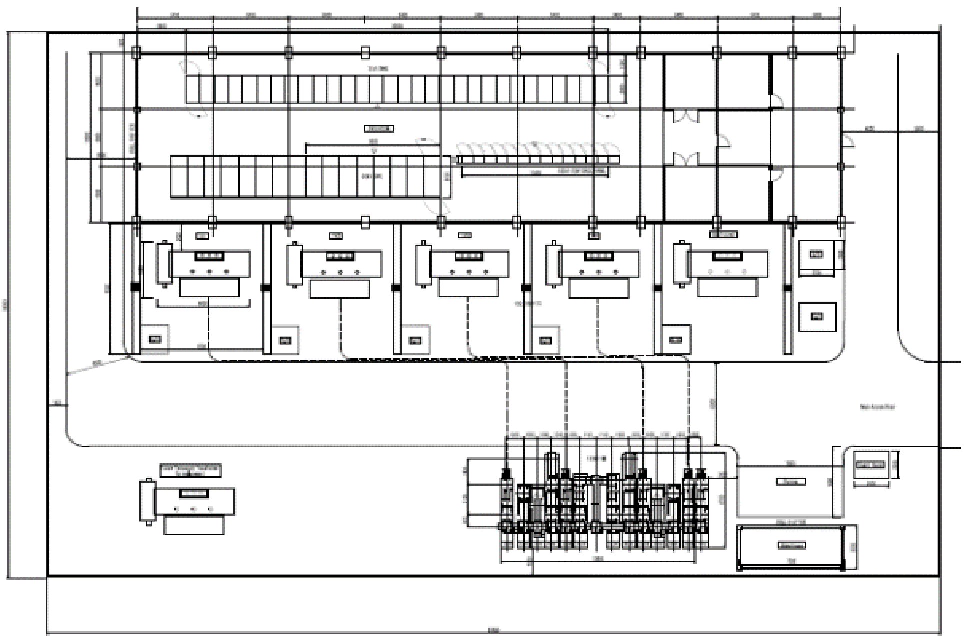


Figure 4-37 Substation Layout for New ADC Substation

b) Direct Connection GIS with Transformer

Direct connection GIS with transformer could reduce substation foot print. However number of transformers new ADC substation would be a five units, therefore, enclosure of GIS would be long. Moreover, foundation of transformer and GIS needs to unify. From those reasons, construction cost is expected to be high. JICA Study Team suggests that direct connection GIS with transformer is better to install substation which consists of under three units of transformer and is located in narrow foot print.

c) Tank Type Capacitor

According to interview EEP and JICA Study Team Survey, there is no big problem about operation voltage in 132kV. Some substation have installed capacitor in 15kV as shown in Figure 4-38.

Figure 4-38 15kV Capacitor in Addis East Substation

Tank type capacitor has strong earthquake resistance. However, there is few earthquake in Ethiopia. Moreover, according to the data from National Geophysical Data Center, in Ethiopia, especially in Addis Ababa Capital Region, there is no earthquake over the five degree of Magnitude. From such a situation, currently tank type capacitor is not matched in Addis Ababa power system.

4.1.4 Results of consideration for Introduction of Quality Infrastructure (Distribution)

JICA Study Team conducted evaluation of Quality Infrastructures from the technical viewpoints. This chapter describes Quality Infrastructures relevant to distribution.

Applicable Quality Infrastructures for distribution are shown below.

- Amorphous Alloy Core Transformer (AMT)
- Pin Post Insulator (PPI)
- Time Sequential Sectionalizing System (TSS)
- Low Loss Conductor (LLC) (Addition after field survey)

a) Amorphous Alloy Core Transformer (AMT)

In order to examine the acceptability of AMT, JICA Study Team conducted a field survey to grasp the type and amount of transformers used in the Addis Ababa metropolitan area and the usage situation. The results are shown in Table 4-1. As mentioned in Section 4.1.2, transformers with a relatively small capacity up to 400 kVA are installed on a pole-mounted, and those with a large capacity of 500 kVA or more are used on the ground-mounted.

Table 4-1 Number of Transformer in Addis Ababa

Rating	15kV/400V	33kV/400V	Total	Remark
25kVA	79	4	83	Pole-mounted
50kVA	432	3	435	Pole-mounted
100kVA	1,028	20	1,048	Pole-mounted
200kVA	1,506	-	1,506	Pole-mounted
300kVA	88	-	88	Pole-mounted
315kVA	1,862	3	1,865	Pole-mounted
400kVA	8	-	8	Pole-mounted
500kVA	3	-	3	Ground-mounted
630kVA	411	-	411	Ground-mounted
800kVA	96	-	96	Ground-mounted
1,000kVA	16	-	16	Ground-mounted
1,250kVA	96	-	96	Ground-mounted
1,500kVA	7	-	7	Ground-mounted
1,600kVA	6	-	6	Ground-mounted
1,750kVA	2	-	2	Ground-mounted
1,800kVA	3	1	4	Ground-mounted
2,500kVA	29	5	34	Ground-mounted
16,000kVA	1	-	1	Ground-mounted
Total	**5,673**	**36**	**5,709**	

Whether or not AMT can be installed is considered by calculating the profit of the difference in initial cost for conventional CRGOT and loss cost reduction by loss reduction with AMT. In this calculation, since there is no difference between AMT and CRGOT in installation work cost, operation cost, etc., it was compared only with the difference of transformer procurement cost and loss cost. Regarding the procurement cost of CRGOT, JICA Study Team adopted the cheaper one of the standard unit purchase price in Ethiopia that was confirmed in the field survey and the estimation unit price obtained from the transformer manufacturing company with the introduction record to Ethiopia.

In addition, the parameters used for profit calculation are shown in Table 4-2. An example of examination results at 315 kVA with the largest number of facilities is shown in Figure 4-39.

In the case of 315 kVA, the initial cost is about 10% higher than CRGOT, but it is possible to regain the difference of the initial cost in less than 7 years due to loss reduction.

Table 4-2 Parameter of Profit Calculation concerning Loss Evaluation

Factor	Value
Cost of Losses	0.09USD/kWh
Load Factor(LF)	0.65
Loss Load Factor（LLF）	0.49
Discount Rate	10%

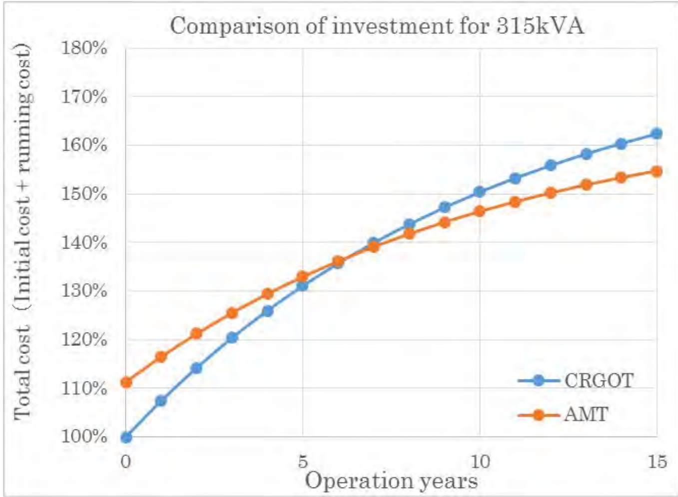


Figure 4-39 An Example of Profit Calculation Result

Evaluation results for other capacities are shown in Table 4-3. It can be confirmed that the initial cost difference can be regained in about 10 years in the case of relatively small capacity transformer for pole-mounted.

On the other hand, in the case of large-capacity transformers (500kVA or more) for ground-mounted, it takes more than 20 years to regain the difference of initial cost, because of larger initial cost difference and smaller effect of loss reduction compared to small capacity one.

From the above, JICA Study Team propose introduction of AMT only to pole-mounted transformer.

Table 4-3 Results of Profit Calculation about AMT Introduction

Type	Unit cost (USD)			Total Loss (W) (at 65% load)			Break-even period(years)
	CRGOT	AMT	ratio	CRGOT	AMT	ratio	
25kVA	3,800	4,000	105%	230	152	66%	5
50kVA	4,700	4,900	104%	359	245	68%	3
100kVA	5,900	6,300	107%	569	421	74%	5
200kVA	9,900	10,400	105%	910	694	76%	4
315kVA	11,500	12,800	111%	1,349	963	71%	7
400kVA	11,800	13,700	116%	1,624	1,250	77%	11
500kVA	12,600	15,600	124%	1,888	1,470	78%	***25***
1,000kVA	20,000	24,700	124%	3,053	2,459	81%	***30+***

b) Pin Post Insulator (PPI)

JICA Study Team confirmed record of the power outage caused by the distribution equipment fault, which is provided from EEP. It can be confirmed that power outage due to fault of insulator and interruption due to replacement work for damaged insulator are occurred multiple times a year. It is also confirmed that Many of these damaged insulators are pin type insulator.

In the meanwhile, the PPI provided by the Japanese grant aid in 1999 is still used in Addis Ababa (Figure 4-40), and it was confirmed that EEP/EEU is well aware of the reliability of PPI.

Figure 4-40 Usage Status of Pin Post Insulator (lower row)

Since the Addis Ababa is located at a high altitude of 2,300m, the insulation level necessary for the insulator must be corrected according to IEC 60071-2. The JICA Study Team confirmed in the field survey that the insulation level applied by EEP/EEU was based on the report issued in 2008, and 24kV class as maximum system voltage for 15kV distribution network and 41.5kV class for 33kV are applied.

On the other hand, it is difficult to apply to a 33 kV distribution network because PPI are manufactured only up to 36 kV class with maximum system voltage. Therefore, JICA Study Team propose applying PPI limited to 15 kV distribution network.

c) Time Sequential Sectionalizing System (TSS)

As mentioned in Section 4.1.2, the Expressway system has been installed in the center of Addis Ababa. After both of restoration of Express way and installation of SCADA system by the ongoing project AADRUP are completion, reliability equal to or higher than that of the TSS can be secured.

However, the Express way system requires constructing newly interconnection backbone between substations in parallel with the existing feeder, so the applicable area is limited. Therefore, installation of Express way is only in the center of the city, it has not been installed in areas where it is difficult to construct interconnection backbone between substations.

Since it was confirmed that the EEP/EEU are aware of task to improve reliability in the area where the Express way has not been installed, JICA Study Team propose introducing TSS to the suburbs.

d) Low Loss Conductor (LLC)

JICA Study Team confirmed strong consciousness of EEP / EEU concerning loss reduction at field survey, so made additional proposal on low loss conductor. LLC can secure the larger cross sectional area with the same diameter as the AAAC standardly used for EEP / EEU by using a trapezoidal element wire, so that less power loss can be achieved (Figure 4-41).

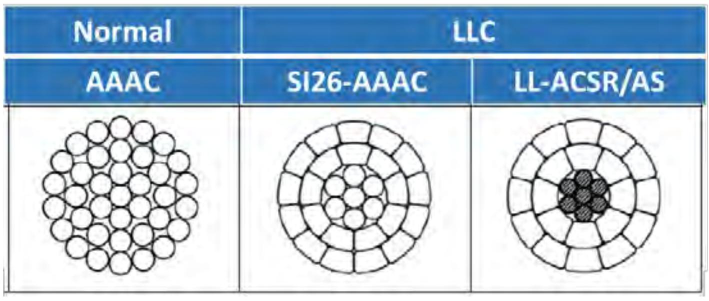


Figure 4-41 Cross Sectional View of LLC

For rehabilitation work of the distribution network implemented by Package V, it is expected that a several size of conductor will coexist, so it is difficult to calculate the introduction effect of LLC before determining the target area and construction volume. Therefore, JICA Study Team propose that details of the introduction of LLC should be carried out in a subsequent survey (corresponding to feasibility study) where the target area will be determined.

4.2 Recommendation

4.2.1 Verifying the Project Component for Expected Package as Japanese Yen Loan

As the result of the kick off meeting on 3 July 2017 between JICA Study Team and EEP/EEU, following understanding were confirmed that Package I to III are financed AfDB. Regarding to Package IV to VI, the technical study is required before the appraisal by JICA.
Based on the above, technical study was conducted.
Contents of each package are below.

Package IV: Full replacement and upgrading of ADC substation, and 132kV transmission line from ADC substation to KALITI I substation (2c.c.t.)
Package V: Pilot project for rehabilitation of distribution network
Package VI: SCADA and telecommunications

Result of technical study as Japanese Yen Loan are shown in Table 4-4.

Table 4-4 Results of Technical Study as Japanese Yen Loan

Item		Result of technical study as Japanese Yen Loan
Package IV (Substation and transmission line)	Upgrade Addis Centre Substation	Following were changed by comparison with the original bidding documents. Location of substation: 500m to south from original location. Addis Ababa city (administration) is planning to provide the land for new substation. However, official proposal by EEP are required to final determination. JICA Study Team are waiting the final determination of land of substation. Type of GIS: Outdoor type. The layout of outdoor type is shown in Figure 4-37.
	Transmission line (ADC~Kaliti I)	The original plan was underground cable between all districts on the bidding documents, but some section in the city is the underground cable from the viewpoint of the cost reduction, and the remaining section makes it the same route as an existing overhead line. The voltage of the transmission line and the number of lines are 132kV / 2 circuit. The transmission route is shown in Figure 4-42 (Option 1). About 3.2 km length is underground cable and about 11.0 km length is overhead line.
Package V (Distribution)	Bill of quantity of the bidding documents	A unit price bidding methodology was indicated on the original bidding documents. After beginning stage of implementation, the Contractor shall conduct the field survey, and replace the equipment judged by the criteria after the Client approval. According to the explanation by EEP, AfDB does not approve above a unit price bidding methodology. And EEP requested that the Consultant should prepare the bill of quantity on the bidding documents. However, JICA Study Team considered it is not realistic for the following reasons, - Huge volume of distribution equipment including Low Voltage target area, - Unstable domestic security situation, - A drastic change of the condition of distribution equipment is assumed in the Addis area where development is remarkable.
	Contents of Package	In the original bidding document, the content is only replacement of equipment. However, the results of site survey and discussion with EEP, engineering work is required to conduct the rehabilitation of distribution network. For example, protective coordination between the fuse and the breakers, the estimate of the capacity of the distribution transformer, reconfiguration of LV feeder etc. The contents of Package V is shown in Table 4-5.
	Target Area	According to EEP, there is a possibility that the investment to the center area of Addis city will become a waste. Because life time of distribution equipment is more than 20 years in general, but many development and abolishment plans are currently being implemented at center of Addis city. Target area of Item A is shown in Figure 4-43.
		Medium Feeders that highest number of outages would address more than 88% of outages was requested additionally by EEP. List of MV feeders is shown in Table 4-6, Item B. Installation of Time sequential Sectionalizing on area that the express is not installed, were proposed by JICA Study Team. List of MV feeders is shown in Table 4-7, Item C.
Package VI(SCADA)	Operation of High Voltage (More than 132kV)	NLC links with most of substations and generations at Ethiopia. Operation of the most of breakers and limitation of generating output was controlled by NLC smoothly. AFD (French) are planning to support the NDC. (Refer to APPENDIX 10)
	Operation of MV	An off-line Distribution Management System (DMS) was installed. However, the DMS does not receive any real-time data about measuring values or actual switching positions of circuit breakers etc. (Refer to APPENDIX 10).
	Project by Power China	In the AAMDP, Hydro China was planning to install SCADA system. Now, Power China is installing SCADA system. About the installation schedule, the document prepared by Power China including the drawings for approval by EEU was submitted. But those documents is described as mainly hardware specification. Then contents of Project is installation of SCADA system at DCC, 36 newly Sw/S and repair 56 existing Sw/S. (Refer to APPENDIX 10)

Recommendation for Package VI (SCADA) as Japanese Yen Loan

Following technical issue for SCADA was point out.

- ♦ Specification of SCADA(online DMS) software is no clear.

  Specification of SCADA (online DMS) including mapping of signals is not describe on their drawings and other documents clearly(mainly described hard ware). So, it is very difficult to study on the scope of work of the package VI.

- ♦ Assessment of SCADA system is difficult

  Before appraisal by donner, the existing condition of SCADA system should be assessed by the Consultant, to study the scope of work, and the budget so on. However the impact of incomplete work by Power China is very big. So, we cannot asses the SCADA without full information of software, actual mapping of signals and so on.

- ♦ Responsibility for future integration and remodeling is not clear

  When commissioning of the package VI (SCADA), remodeling of existing software installed by Power China will be required, But responsible of software integration and remodeling is not clear.

Recommendation by JICA Study Team

The study on extension of the MV distribution network automation should commence after completion of Power China's automation system.

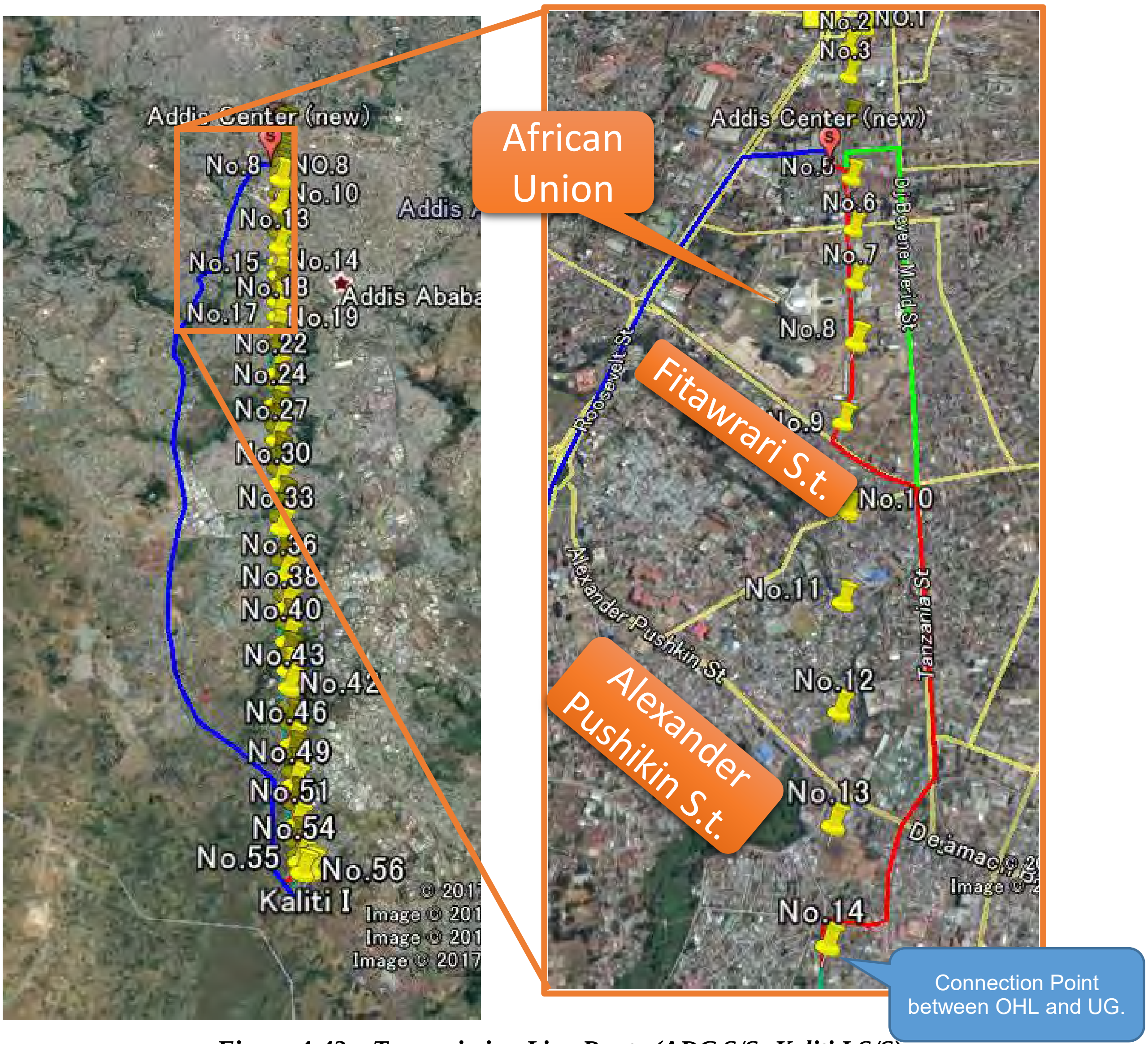


Figure 4-42 Transmission Line Route (ADC S/S~Kaliti I S/S)

Legend

: Original Plan (all U/G)
: Option 1 (UG/OHL)
: Existing OHL (Tower)
: Option 2 (UG/OHL)

Table 4-5 Contents of Package 5 (Rehabilitation of Distribution network) Draft

Item	Target	Medium Voltage	Distribution Transformer	Low Voltage
A	Original Bidding Documents	*Not include*	Include (1,290 cases)	Include (Total 600km)
	Quality Infrastructure	PPI	Amo T	-
B	Highest number of outages would address ～88% of outages (Request from EEP)	Include (Total 275km)	Include (757 cases)	*Not include*
	Quality Infrastructure	PPI	Amo T	-
C	Out side of City area within Study Area of AADMP [No express way] (Proposal from JICA Study Team)	Include	Include	*Not include*
	Quality Infrastructure	TSS, PPI	Amo T	-

Legend; Amo T: Amorphous Metal Core Distribution Transformers, PPI: Pin Post Insulators, TSS: Time sequential Sectionalizing

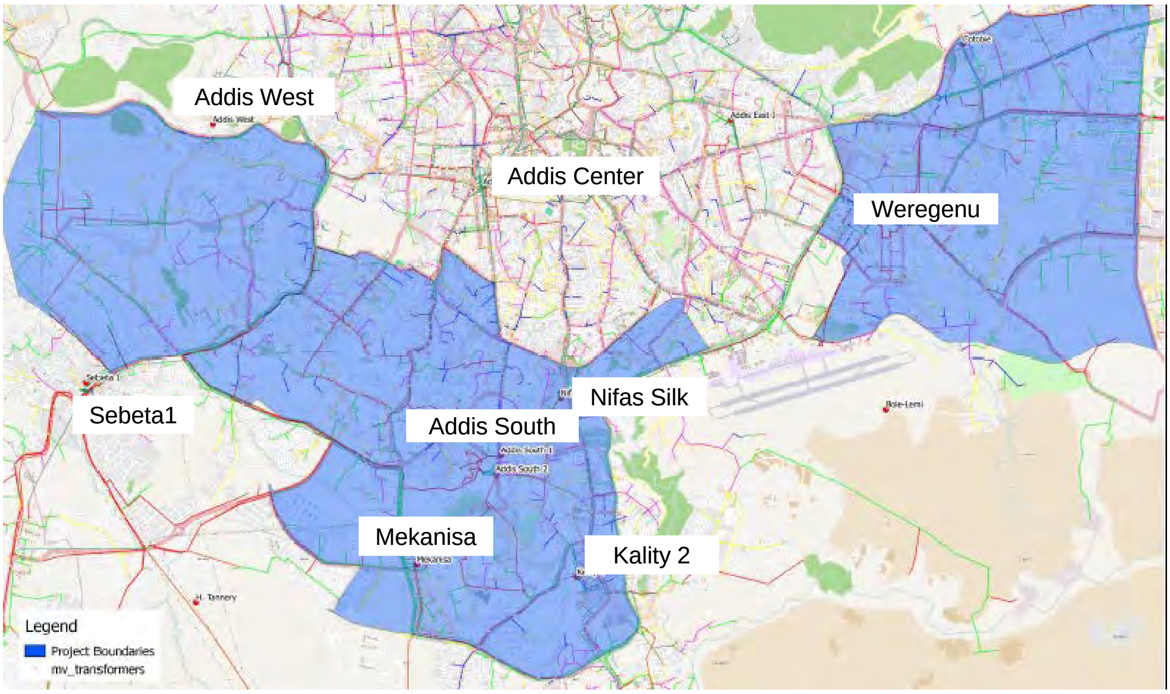


Figure 4-43 Candidate Target Area (Package 5 / Item A)

Number of Pole Mounted Distribution Transformer Default works: 1,290 case
Total length of Low Voltage Default Works: 600 km

Table 4-6 Candidate Target Area (Package 5 / Item B)

No.	Requested Feeder from EEP				Required Information						Remarks
	Feeder Name	Substation	# of outages	% of total outages	Length of MV (km)	Number of Distribution Transformer (Unit)	Number of Transformer (Unit)				
							Pole mounted		Pad mounted	Package	
							< 300 kVA	> 315 kVA	> 500 kVA	> 500 kVA	
1	Cotobie-33	Cotobie	462	3.1%	80.3	53	37	14	2		
2	Sebeta II-03	Sebeta II	369	2.5%	102.0	137	112	25			Section affected by Package I - 4.646 km
3	Legetafo-07	Legetafo	367	2.5%	23.4						
4	Gefersa-04	Gefersa	323	2.2%	11.2	93	59	22	12		Section affected by Package I - 4.09km
5	Legetafo-08	Legetafo	268	1.8%	20.6	47	28	17	2		Section affected by Package I - 6.55km
6	Sebeta-07	Sebeta	245	1.7%	19.5	10	3	7			Section affected by Package I - 5.53km
7	Weregenu-06	Weregenu	245	1.7%	14.1	25	16	6	2	1	Section affected by Package I - 0.53km
8	Kaliti North-K2	Kaliti North	194	1.3%	7.5	50	16	15	11	8	
9	Sululta -02	Sululta	186	1.3%	13.5	6	4	2			
10	Weregenu-12	Weregenu	174	1.2%	15.4	15	9	5		1	
11	Sebeta-13	Sebeta	171	1.2%							
12	Sebeta-10	Sebeta	170	1.2%							
13	Sebeta-11	Sebeta	168	1.1%							
14	Gelan -04	Gelan	167	1.1%	37.2	66	29	25	12		Section affected by Package I - 20.34km
15	Sebeta-12	Sebeta	165	1.1%							
16	Weregenu-08	Weregenu	156	1.1%	8.5	84	55	23	1	5	
17	Weregenu-07	Weregenu	144	1.0%	9.4	18	5	11	2		
18	Kaliti North-K4	Kaliti North	140	1.0%	6.3	9	3	2	2	2	
19	Sebeta-09	Sebeta	140	1.0%	4.0						
20	Sululta-05	Sululta A & B	135	0.9%							
21	Sululta-07(Sul33-01)	Sululta A & B	130	0.9%	51.4	31	27	2	2		
22	Sululta-01	Sululta A & B	115	0.8%	24.5	43	24	19			
23	Sululta-08(Sul33-02)	Sululta A & B	114	0.8%	32.4	44	37	1	6		
24	Goffa-06	Goffa	105	0.7%	22.4	67	31	36			
25	Sululta-06	Sululta A & B	103	0.7%	69.1	10	-	8	2		
26	Gefersa-07	Gefersa	100	0.7%	11.5	19	8	2	9		
27	Kaliti North-K7	Kaliti North	99	0.7%	21.8						
28	Addis North -05	Addis North	97	0.7%	16.2	42	20	22			Section affected by Package I - 0.91km
29	Addis Center-14	Addis Center	93	0.6%	29.9	34	13	12	9		Not in Package I or II
30	Weregenu-09	Weregenu	79	0.5%	6.3	11	5		2	4	Section affected by Package I - 0.12 km
31	Addis North -06	Addis North	77	0.5%	6.9	57	27	27	2	1	
32	Goffa-05	Goffa	76	0.5%	13.0	51	24	24	3		
33	Sebeta-06	Sebeta	69	0.5%	3.5	5	1	3	1		
34	Mekanissa-06	Mekanissa	67	0.5%	2.7	1				1	
35	Addis Center-15	Addis Center	61	0.4%	4.9	34	20	6	7	1	
36	Gelan -03	Gelan	60	0.4%	18.3	17	5	3	9		Section affected by Package I -9.213km
37	Mekanissa-05	Mekanissa	57	0.4%	19.0	67	37	27	2	1	Section affected by Package I - 0.17km

Number of MV feeder: 37 Total length of MV: 275 (km) Number of Distribution Transformer: 757 (case)
Some feeders will be selected based in the following survey.

Table 4-7 Candidate Target Area (Package 5 / Item C)

No.	Proposed Feeder by NEWJEC		Required Information						Remarks
	Feeder Name	Substation	Length of MV (km)	Number of Distribution Transformer (Unit)	Number of Transformer (Unit)				
					Pole mounted		Pad mounted	Package	
					< 300 kVA	> 300 kVA	> 500 kVA	> 500 kVA	
1	ABS 15-01	Aba Samuel	5.3	4	2	2			
2	ALM-15-01	Addis Alem	191.6	99	89	6	4		
3	ALM-15-02	Addis Alem	107.5	79	53	22	4		
4	ALM-15-03	Addis Alem	15.37	13	11	2			
5	ALM-15-04	Addis Alem	38.98	14	12	2			
6	ALM-15-05	Addis Alem	16.12	2			2		
7	DUK-15-01	Dukem	10.6	40	33	1	6		Section affected by Package I - 3.31km
8	DUK-15-02	Dukem	7.32	16	12	3	1		Section affected by Package I - 2.02 km
9	DUK-15-03	Dukem	3.52	11	7	2	2		
10	LEG-15-03	Legetafo	114.63	91	68	16	7		Section affected by Package I - 2.77km
11	LEG-15-04	Legetafo	15	54	42	12			Section affected by Package I - 4.81km
12	LEG-15-08	Legetafo	20.58	47	28	17	2		
13	LEG-15-09	Legetafo	Dedicated Line						
14	SUL-15-01	Sululta	24.47	43	24	19			
15	SUL-15-02	Sululta	13.5	6	4	2			
16	SUL-15-03	Sululta	27.4	23	17	6			
17	SUL-15-04	Sululta	34.04	40	24	4	12		
19	SUL-15-06	Sululta	69.08	10	-	8	2		
18	GEJ-15-01	Gedja	38.04	36	30	6			
20	GEJ-15-02	Gedja	19.16	18	10	-	8		
21	BEL-15-04	Bella	12.18	45	22	22	1		Section affected by Package I - 2.17km
22	GLN-15-01	Gelan	27.92	64	35	20	9		
23	GLN-15-03	Gelan	18.27	17	5	3	9		Section affected by Package I - 9.213km

Number of MV feeder: 21, Total length of MV : 778 (km),Number of Distribution Transformer: 691 (case)
Some feeders will be selected based in the following survey.

4.2.2 Study on Applicable Quality Infrastructure

Result of Study on Applicable Quality Infrastructure is shown in Table 4-8.

Table 4-8 Results of Study on Applicable Quality Infrastructure

	Item	Result of technical study
Substation	GIS (Outdoor type)	The location of new ADC substation is the center of inner city, therefore, the minimization of land space for substation is required. From the technical viewpoint, outdoor type GIS should be apply to new ADC substation. The draft substation layout for new ADC substation is shown in Figure 4-37.
	Tank Type Capacitor	According to interview EEP and JICA Study Team Survey, there is no big problem about operation voltage in 132kV. From such a situation, currently tank type capacitor is not matched in Addis Ababa power system.
Distribution	Amorphous Alloy Core Transformer (AMT)	In the case of 315 kVA with the largest number of facilities in EEU, the initial cost is about 10% higher than CRGOT, but it is possible to regain the difference of the initial cost in less than 7 years due to loss reduction. Therefore AMT was judged to apply as Quality Infrastructure in Addis Ababa.
	Pin Post Insulators (PPT)	It was confirmed that EEP/EEU is well aware of the reliability of PPI. And PPI should be applied to 15 kV distribution network. (Refer to Section 4.1.4 b))
	Time Sequential Sectionalizing System (TSS)	Expressway system has been installed in the center of Addis Ababa. Reliability of expressway system equal to or higher than that of the TSS can be secured. However, the Express way system requires constructing newly interconnection backbone between substations in parallel with the existing feeder, so the applicable area is limited. Therefore, installation of Express way is only in the center of the city. TSS should be applied to the suburbs. (Refer to Section 4.1.4 c))

4.2.3 Project finding for Transmission, Substation and Distribution System in Addis Ababa

As the result of site survey and discussion with EEP/EEU, Candidate projects of transmission, substation in Addis are proposed.
Result are shown in Table 4-9. Also, AfDB and EEP requested JICA to consider to finance additionally the projects shown in Table 4-10 which were planned to be covered by AfDB's finance.

Table 4-9 Proposed New Projects of Transmission and Substation in Addis

No.	Contents
1	132kV underground transmission line between BLL S/S to ADC S/S including modification of BLL S/S (GIS equipment etc.) Tentative transmission line route and major specification are shown in Figure 4-44, Table 4-11.
2	Transfer of existing transformers in ADC S/S
3	Technical Cooperation Projects which are the management of distribution equipment and the rehabilitation distribution network, etc. to EEU

Table 4-10 Proposed New Projects of Transmission and Substation in Addis (Additional)

No.	Contents
1	Replace existing transformers with 2 x 132/15 kV 40 MVA transformers in Addis North S/S
2	New 132kV D/C line to t-off point replacing existing S/C line inclusive of loop reconfiguration on meeting point
3	Upgrade DBZII to 33 kV and shift steel mill to DBZIII (Debre Zeit II Substation Upgrade)
4	33 kV substation installation incl. two new 132/33 kV transformers at Legetafo Substation

Table 4-11 Major Specification of Transmission Line from BLL S/S ~ ADC S/S (Draft)

Item	Specification
Voltage	132kV
Number of circuit	1 circuit
Total Length of route	2.4 km
Installation method	Underground Cable with pipe

Figure 4-44 Transmission Line Route from BLL S/S ~ ADC S/S (Draft)

APPENDICES

APPENDIX-1

MEMBER LIST OF JICA STUDY TEAM

Appendix-1：Member List of JICA Study Team

Name	Work Assignment	Positon
Mr.Nobuyuki KOBE	Cooperation Planning	Japan International Corporation Agency (JICA) Africa Division 2, Africa Department
Ms.Hiroko HOAKI	Cooperation Planning	Japan International Corporation Agency (JICA) Africa Division 2, Africa Department
Mr.Yoshiyuki KUDO	Technical Adviser (Electricity Sector)	Japan International Corporation Agency (JICA) Industrial Development and Public Policy Department
Mr. Kenichiro YAGI	Chief Consultant/ Substation Planning	NEWJEC Inc.
Mr.Akira KAWABE	Substation/ Construction Plan	NEWJEC Inc.
Mr.Takamu GENGI	Distribution Planning	NEWJEC Inc.
Mr.Shinichi KAWABE	Distribution/ Procurement	NEWJEC Inc.

APPENDIX-2

SCHEDULE OF SITE SURVEY

Appendix-2：Schedule of Site Survey

	Date	Day	JICA			NEWJEC Inc.			
			Nobuyuki KOBE	Hiroko HOAKI	Yoshiyuki KUDO	Kenichiro YAGI	Takamu GENJI	Shinichi KAWABE	Akira KAWABE
			Cooperation Planning , Africa Division 2, Africa Department	Cooperation Planning , Africa Division 2, Africa Department	Technical Advisor, Energy and Mining Group, Industrial Development and Public Policy Department	Chief Consultant／Substation Engineer	Distribution Engineer	Distribution Engineer	Substation Engineer
1	2017/7/1	Sat				Lv. Narita by ET1400 / ET609			
2	2017/7/2	Sun				Ar. Addis Ababa			
3	2017/7/3	Mon				9:00 Meeting with JICA Ethiopia 14:00 Meeting with EEP, EEU and Fad			
4	2017/7/4	Tue				AM Internal Meeting PM Discussion with EEP			
5	2017/7/5	Wed				AM Site Visit (Kaliti I Substation) PM Site Visit (Addis East Substation,☐ Primary substation, Switching Substation)			
6	2017/7/6	Thu				AM Interview with City Government (Urban Planning institute), Site Visit (Addis Center [original & new]) PM Data Collection			
7	2017/7/7	Fri				AM National Load Center(NLC), Distribution Control Center (DCC) PM Workshop, which repair distribution transformer			
8	2017/7/8	Sat							
9	2017/7/9	Sun							
10	2017/7/10	Mon				AM Internal Discussion PM Discussion with EEU Engineering (Mr.Getachew)			Internal Discussion, Study
11	2017/7/11	Tue				Same as Mr.Kawabe	Data Collection	AM Site Visit (Kaliti I Substation) PM Site Visit (Nifas Substation)	
12	2017/7/12	Wed				Same as Mr.Kawabe	Data Collection	AM Site Visit (Transmission Line Route) PM Internal Discussion	
13	2017/7/13	Thu				AM Discussion with EEP PM Discussion with EEP			
14	2017/7/14	Fri				AM Discussion with EEP (Transmission Engineering Office), Discussion with EEP(Strategy and Business Analysis) 16:30 JICA Ethiopia	Data Collection	AM Data Collection 16:30 JICA Ethiopia	Same as Mr.Yagi
15	2017/7/15	Sat							
16	2017/7/16	Sun							
17	2017/7/17	Mon				Internal discussion Discussion with EEP (Package 5)			
18	2017/7/18	Tue				Discussion with EEU Engineering (Package 5 and SCADA) Discussion with EEP (Package 4)			
19	2017/7/19	Wed				Discussion with EEU Engineering (SCADA) Internal discussion, Meeting with Local Contractor			
20	2017/7/20	Thu				Internal discussion Discussion with EEP (SCADA)			
21	2017/7/21	Fri				9:00 Interim repot to Mr.Mekuria (EEP, Strategy and Investment) 12:00 TV Meeting with JICA Tokyo, 15:00 Meeting with Local Consultant			
22	2017/7/22	Sat							
23	2017/7/23	Sun							
24	2017/7/24	Mon	Lv. Narita by EK319 / EK 723			AM Site Visit (Distribution, LV area) PM Site Visit (Black Lion S/S, transmission line route from B/L to ADC) 17:00 Meeting with JICA Ethiopia			
25	2017/7/25	Tue	Ar. Addis Ababa, 17:30 Internal Meeting (JICA H.Q., JICA Ethiopia, Consultant)			AM Site Visit (Addis Alum) , 14:00 Discussion with EEU, 16:00 Discussion with Green & Beautification Authority, 17:30 Internal Meeting (JICA H.Q., JICA Ethiopia, Consultant)			
26	2017/7/26	Wed	9:00 Meeting with EEP 14:30 Meeting with EEU			9:00 Meeting with EEP 14:30 Meeting with EEU			
27	2017/7/27	Thu	10:00 Meeting with AfDB 15:00 Report to Embassy of Japan			9:30 Meeting with Local Consultant 15:00 Report to Embassy of Japan			
28	2017/7/28	Fri	9:30 Work Shop 16:30 Report to JICA Ethiopia						
29	2017/7/29	Sat	Lv.Addis Ababa by EK724 / EK318			Lv.Addis Ababa by ET672			
30	2017/7/30	Sat	Ar. Narita			Ar. Narita			

APPENDIX-3

LIST OF PARTIES

Appendix-3：List of Parties

Name	Organization	Department	Position
Mr.Mekuria Lemma	EEP (Ethiopian Electric Power)		Strategy and Investment Head
Mr.Abinet Ahmed		Addis Ababa Power System Master Plan	Project Manager
Mr.Elias Mekonnen			Distribution Construction Super Incident III
Mr.Kassahum Tsehay			Distribution Construction Super Incident III
Mr.Chumala Samuel			Planning and Design Engineer III
Mr. Aman Belete			Planning and Design Engineer III
Mr.Melaku Yigzaw			Strategy and Business Analyst III, Electrical Engineer
Mr.Aklilu Torckeper		Transmission Engineering Office	Acting Manager
Mr.SEIFU MOGES		Transmission Engineering Office/ Substation Design Section	
Mr.Megistu Tesso		Kaliti I Substation	Manager
Mr.Gosaye Mengistie Abayneh	EEU (Ethiopian Electric Utility)		Chief Executive Officer
Mr.Adefris Merid Asfaw			Senior Technical Advisor
Mr.Aklilu Kebede Yiman			Distribution Projects Management Office Head
Mr.Getachew Adane		Engineering	Transmission Planning of Engineering
Mr.Melkamu Abebe		Planning	Head: Strategic Environmental and Social
Mr.Girma Mekuria	AfDB	Ethiopia Country Office	Senior Energy Expert
Mr.Abebaw Sentie	Addis Ababa City Government	Urban Planning Institute	Urban Planning Institute Director
Mr. Tesfy KINANA	A.A city government sanitation, beautification and parks development agency		Vice Deputy Manager
Mr.Ken YAMADA	JICA Ethiopia		Chief Representative
Mr.Hiroyuki TANAKA			Senior Representative
Mr.Takeshi MATSUYAMA			Senior Representative
Mr. Akitoshi IIO			Advisor
Mr.Gaku SAITO			Representative

APPENDIX-4

MINUTES OF MEETING

Minutes of Meeting for:
The Kickoff Meeting for the Data Collection Survey in Addis Ababa Distribution and Transmission Network

3 July 2017
Prepared by JICA Study Team (NEWJEC Inc.)

1. List of Participants

(1) Ethiopia Electric Power (EEP)

- Abinet Ahmed — A.A. Power System MP Project Manager Strategy and Investment group, EEP
- Girma Mekuria — Senior Energy Expert Energy Dept. AfDB
- Daniel Musle — EEP
- Gitachew Adene — Transmission Planning Engineer, EEU
- Melkemm Abebe — Investment Planning EEU

(2) Japan International Corporate Agency (JICA here on) study team

- Akitoshi IIO — Advisor JICA Ethiopia
- Raher Ladesse — Program Officer JICA Ethiopia
- Kenichiro YAGI and 3 participants from NEWJEC

2. Location

EEP Head office, 2nd floor,

3. Contents

- Package 5 is just taken 10% of network wide program. EEP does not know actually scope of work. It is vast scale project which will be completed coming five or ten years, so EEP want to know what happened through the project.
- This JICA study team is to examine each packages whether these packages are feasible, reliable or not. Preparation of BoQ would be next stage like a feasible study.
- According to AfDB, Package 4 and 5 is to be financed by JICA after Data Collection Study conduct by JICA Study Team to confirm reliability, cost, design, etc.

- Package 5 includes not only MV but also LV, around 420km rehabilitation. Actual quantity of work is decided by field inspection conducting by contractor.
- EIA and compensation for resettlement for new Addis Center Substation (ADC S/S here on) will be conducted by city government.
- MV SCADA system is design stage by EEU. MV SCADA system has two options, One is independent communication medium from existing communication medium using HV SCADA system (M/P consultant recommended) the another is to use existing communication medium
  EEU request the solution which is the best way, to use existing medium or install new medium.
- Tank type capacitor is not suitable for Ethiopia, because there is no earthquake in Ethiopia.
- Maximum capacity of Amorphous Transformer is 1500MVA. Therefore, Amorphous Transformer can cope with future capacity growth.
- EEU is concerned about installation new type distribution transformer because EEU will need additional spare parts and training for repair. JICA study team will investigate difference CRGO and AMT.
- EEP requested JICA study team that ADC S/S should upgrade 132kV to 230kV. Because ADC S/S is very important substation which supply sensitive customer such as African Union and Palace.
- JICA study team will conduct which is the best way, supply by 230kV or132kV to new ADC S/S.
- EEU will provide us which distribution line is critical and serious.
- EEP requested EEU whether load shift from old ADC S/S to surrounding substations can conduct or not. If load shift cannot conduct, EEP will consider to install mobile substation at new ADC S/S.
- Chinese company (Power China) tried to install SCADA system, main contents is to install fiber optic cable in the city.

End of Document

Data Collection Survey on Addis Ababa Transmission and Distribution System (JICA)

Kick- Off Meeting - 3 July 2017

Attendance Register

Name	Organization	Department	Position	Emal Address	Telephone Number
Rahel Tadesse	JICA ET office	Infrastructure	Program Officer	tadesserahel.et@jica.go.jp	+251 911970324
Daniel Mulatu	EEP	Station Opr.	Mgr General	danielmulatu @yahoo.ca	+251862857
Getachew Adane	EEU	Engineering	Transmission Planning Engineer	gechadane 45@gmail.com	0911075312
Melkamu Abebe	EEU	Planning	Head: Investment, Environment & Social	melkamu.abe@gmail.com	0911248469.
Abinet Ahmed	EEP	Strategy & Investment	A.A. Distribution M.P project Manager	abinet2@gmail.com	0910075517
Girma Mokenia	AfDB	Energy Dept.	~~Senior~~ Senior Energy Expert	g.abiyehoy@afdb.org	0911466775
Akihoshi Iio	JICA	Ethiopia	Advisor	iio.akioshi@jica.go.jp	0911233889
Kenichiro YAGI	NEWJEC	NEWJEC	Cheif Consultant.	yagikn@newjec.co.jp	
Takamu Genji	Ditto		Distribution Planning	genjitk@newjec.com	
Shinichi KAWABE	NEWJEC		Distribution Engineer	kawabesn@newjec.com	
Akira KAWABE	NEWJEC		Substation Engineer		

Data Collection Survey on Addis Ababa Transmission and Distribution System

July 2017

Japan International Cooperation Agency

NEWJEC Inc.

Background

2015 September : Final Report of AADMP was prepared for EEP.

2015 December : Inception Report (Revision 1) was prepared.

2016 January : Highlights and Summary of AADMP was prepared.

2016 August : JICA dispatched the contact mission.

2016 October : JICA and AfDB dispatched the joint FF mission.

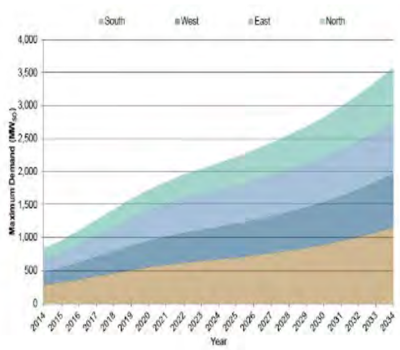
2017 June : Data Collection Survey by the Japanese Consultant was started.

Study Area

Addis Ababa Transmission Network

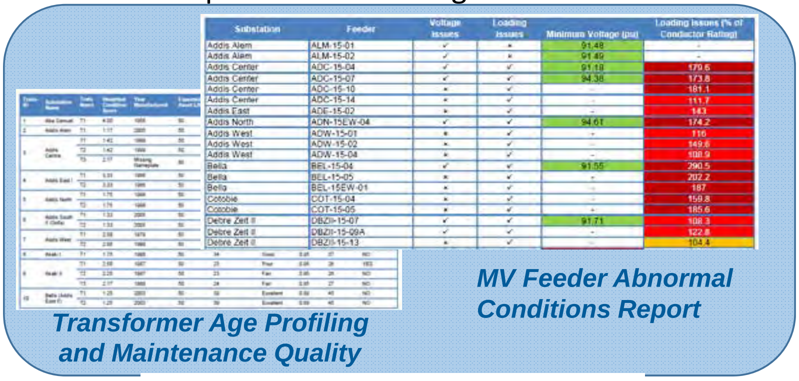
AADMP: Addis Ababa Distribution Master Plan , EEP: Ethiopian Electric Power

Study on Addis Ababa Distribution Master Plan



Demand Forecast

Health index for Transformer, Main Switchgear, Substation Compound and Building Maintenance



Assessment of Existing Network

a) Planned and committed projects
b) Rehabilitation and short term expansion plan
c) Medium term expansion plan
d) long term expansion plan
e) SCADA and Telecommunications

Substation	Planning Period	Intervention	Description
Aba Samuel	Medium Term	Substation Upgrade	Replace the 45/15 kV substation w
Addis Alem	Medium Term	Feeder Upgrade	15 km 33kV feeder to Primary SS
Addis Alem	Medium Term	Substation Upgrade	Replace the 45/15 kV substation w
Addis Center	Medium Term	New Feeder	132kV U/G cable from Black Lion
Addis North	Medium Term	Substation Upgrade	Replace existing transformers with
Akaki I	Medium Term	Substation Upgrade	Convert substation to 33/15 kV wit
Akaki I	Medium Term	New Feeder	Built 3.5km OHL 33kV 150 sqmm
Akaki I	Medium Term	Feeder Rehabilitation	Refurbish 45 kV feeder Kaliti I to A
Akaki II	Medium Term	Feeder Rehabilitation	Refurbish 45 kV feeder Kaliti I to A
Akaki II	Medium Term	Substation Upgrade	Convert substation to 33/15 kV wit
Akaki II	Medium Term	New Feeder	Built 4km OHL 33kV 150 sqmm fe
Elala Geda	Medium Term	Substation Upgrade	Replace whole substation by 132/3
Elala Geda	Medium Term	New Feeder	Rebuild feeders with sparse dist.T
Elala Geda	Medium Term	Substation Upgrade	Add second 33/15 kV 7.5 MVA pr
Gedja	Medium Term	Substation Upgrade	Replace the 45/15 kV substation w
Gedja	Medium Term	New Feeder	New 33 kV feeder interlink to Sebe
Gefresa	Medium Term	Substation Upgrade	Replace existing GEF T1 132/33/1

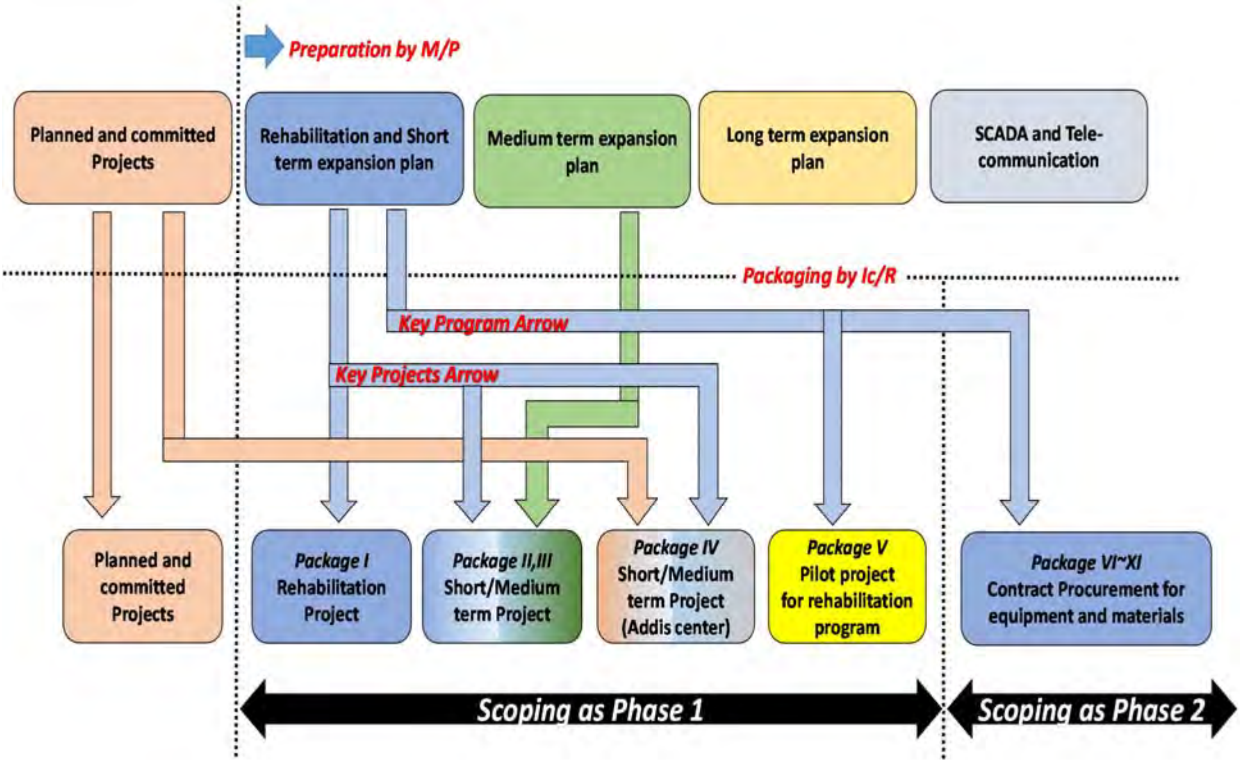
Projects and Programmes Summary

Economic and Financial Analysis

Strategic Environmental and Social Assessment

CONTRACT PACKAGE SYSTEM

In the inception report, formulated Scope of Work and procurement method based on each construction plans as shown below.



Contract Package System of JICA and AfDB

PK G#	Project	Contents	Budget (USD)	AfDB/ JICA
I	EPC: Rehabilitation	[22 S/S] *Feeder Reconfiguration *rehabilitation of S/S	10 mil	AfDB
II	EPC: Short &Middle (EEU)	[9 S/S] *New Feeder *New distribution transformer *rehabilitation of MV	21mil	AfDB
III	EPC: Short &Middle (EEP)	[11 S/S] Substation Upgrade 132kV New transmission line (1cct) and cable (2cct)	52mil	AfDB
IV	EPC: Short &Middle (Addis Centre S/S)	[Addis Centre S/S] Substation Upgrade	46mil	JICA
V	EPC: Pilot Project	Rehabilitation of MV Network for Phase 2	24mil	JICA
?	EPC:SCADA	Introduce SCADA and communication system	23mil	???

Task of AADMP

・Tasks in general related to AADMP

Task 1 Uncertainty due to related projects

AADMP is based on other relevant projects such as AADRUP
According to progress of other projects, AADMP plan would be necessary to revise the timing and contents

Task 2 Lack of information to evaluate the feasibility and validity of AADMP

No detailed information about the preconditions and various kinds of data used in AADMP,
Detailed confirmation of these is necessary before shifting to the implementation stage.

・Tasks related to individual package

Task 3 Task relevant to ADC substation (Package IV)

-According to Inception report (Original plan)
GIS will be installed on the same foot print of existing AIS
No detailed construction method to avoid long period power outage in ADC substation.

-According to interview to EEP (Alternative plan)
Green area regulation around African Union would affect substation layout

Task from perspective of “Quality Infrastructure”

AADMP focused on solving particularly insufficient capacity among the three problems (Lack of capacity, Poor reliability and High losses) in the study area.
There were no detailed solutions against two other problems. (Poor reliability and High losses)
We describe the tasks from the viewpoint of lack of solution for ideal distribution network.

Task 4 Approach relevant to distribution loss reduction

Lack of suggestion for loss reduction about specifications of equipment which will be installed as full renovation.

Task 5 Approach on improving supply reliability

To ensure the low value of the frequency of power outages (SAIFI) and the duration of power failure (SAIDI), are important for reliable distribution system.
However, Lack of suggestion for reliability increasing about specifications of equipment which will be installed as full renovation

Task 6 Approach on equipment maintenance

No concreate method about equipment maintenance.
Need Asset management system and training for employee.
Need equipment with long-term reliability and easy maintenance.

Purpose of this Survey

Item 1

Verifying the project component for expected formation as Japanese Yen Loan.

Item 2

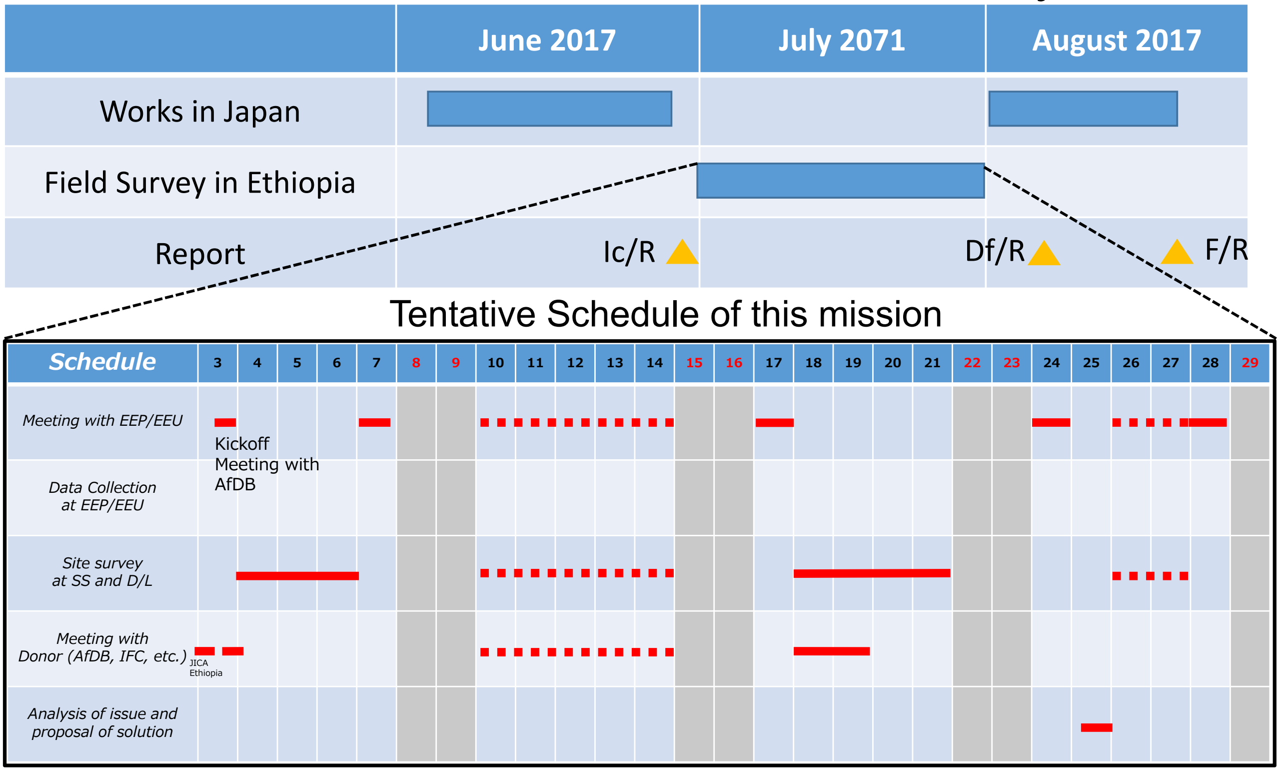
Study on Applicable Quality Infrastructure.

Item 3

Project finding for transmission, substation and distribution system in Addis Ababa.

Schedule of Data Collection Survey

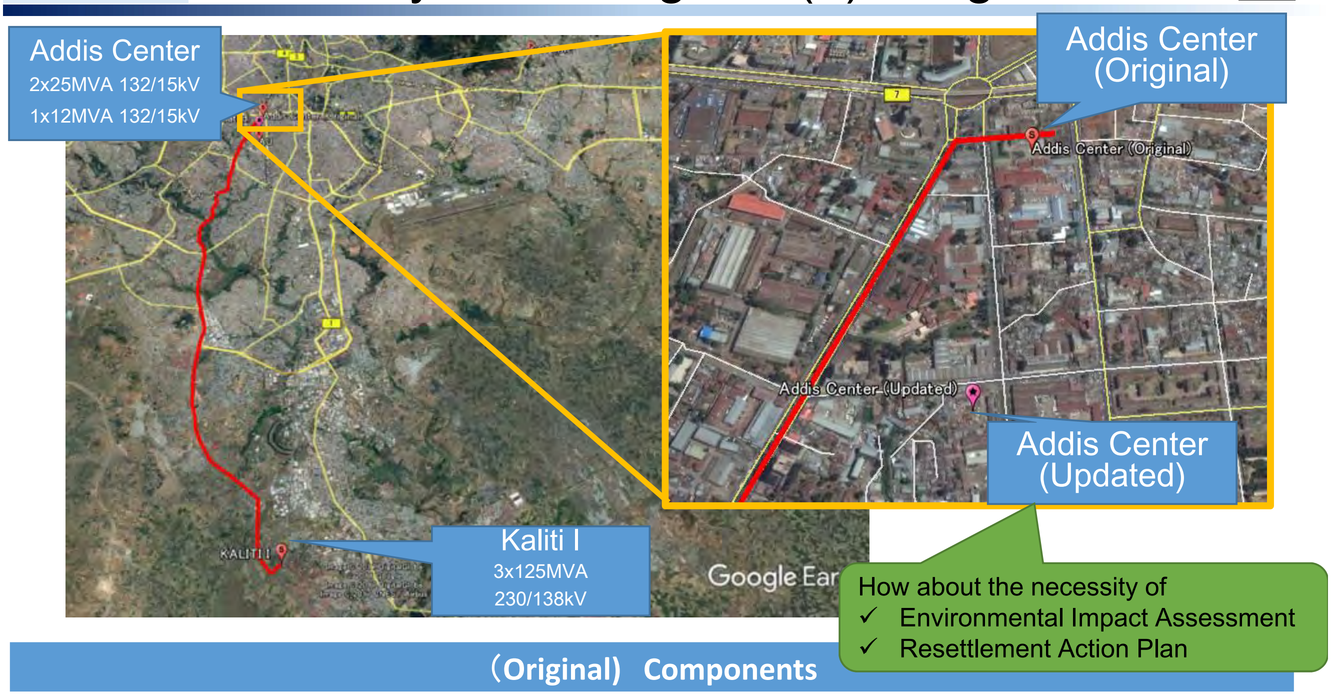
Schedule of Data Collection Survey



Ic/R: Inception Report, Df/R: Draft Final Report, F/R Final Report

Item1 Verification

Summary of Package IV (1) “Original “

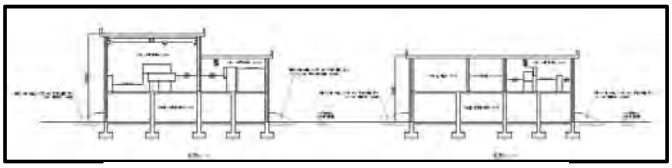


（Original） Components
132kV U/G cable from Kaliti I ,14km 2500sqmm CU/phase ;2 circuits
✓ **Build new 132/33/15 kV GIS substation on the foot print of the existing one;** ✓ **Install 3x50MVA transformers 132/15kV and associated switchgear;** ✓ **Install 1x50MVA transformer 132/33kV and associated switchgear**

Item1 Verification

Summary of Package IV (2) “Original”

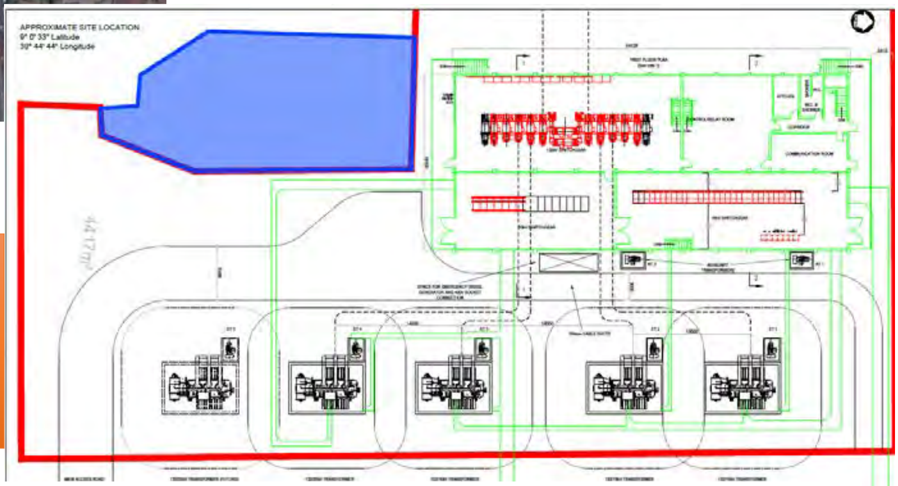
Site Layout 1 (Original)
(4,417m2)



Section Drawing

- ✓ Saving for installation space,
- ✓ Environment- friendly,
- ✓ Easy to maintain,

will be considered.



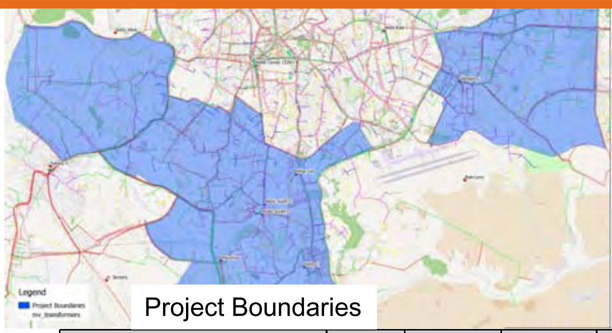
Addis Center GIS Substation Site Layout 2 (Original)

Update of the location of Addis Center S/S and the line path of 132kV Cable are required.

Item1 Verification

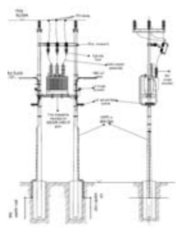
Summary of Package V

Pilot EPC Project for Rehabilitation



Project Boundaries

1 Rehabilitation Survey by the Contractor
2 After approval from the Employer, Rehabilitation works will be conducted.



Confirmation is required.

	Total quantity [km, Cases]	Pac.V Target quantity [km, Cases] ※1	Refurbish Target quantity [km, Cases]	Replace Target quantity [km, Cases]	Refurbish Unit Costs	Replace Unit Costs	Refurbish Cost	Replace Cost	Total Cost [USD]
MV Feeder	2,552	420	22.0%	31.0%					2,227,842
15kV Conductor	2,230	367	80.7	25.0	15,870	25,600	1,281,366	640,764	1,922,129
33kV Conductor	322	53	11.7	3.6	17,480	28,200	203,793	101,920	305,712
LV Feeder	6,553	480	16.0%	66.0%					2,527,970
LV Feeder with low pole	3,505	257	41.1	27.1	17,480	28,200	718,043	764,543	1,482,586
LV Feeder with multi pole	3,048	223	35.7	23.6	14,520	22,340	518,684	526,700	1,045,383
Distribution Transformer	5,716	1,290	18.6%	39.5%					17,615,504
15kV<300kVA Pole-mounted	2,840	641	119.2	253.2	12,020	24,989	1,432,957	6,326,475	7,759,432
15kV>315kVA Pole-mounted	1,910	431	80.2	170.3	13,539	28,925	1,085,501	4,924,944	6,010,446
15kV>500kVA KIOSK	504	114	21.2	44.9	16,246	37,518	343,706	1,685,640	2,029,346
15kV>500kVA Package	160	36	6.7	14.3	21,912	48,766	147,168	695,555	842,723
33kV<300kVA Pole-mounted	239	54	10.0	21.3	13,462	27,988	135,057	596,299	731,357
33kV>315kVA Pole-mounted	51	12	2.1	4.5	15,164	32,396	32,463	147,284	179,748
33kV>500kVA KIOSK	6	1	0.3	0.5	18,196	42,020	4,583	22,475	27,058
33kV>500kVA Package	6	1	0.3	0.5	24,541	54,618	6,181	29,213	35,394
Total Cost									22,371,315

※1 Assumption with the same ratio between the total quantity and Pac.V quantity.

Item1
Verification

Summary of Package ?? (SCADA&Comm.)

Our understanding for SCADA and Communications are below

In AADMP

- New MV network SCADA system which can unify existing DMS was examined for spec and tasks.
- And a new and independent system for MV network was recommended from the viewpoints of future extensibility, operability, capacity constrain of HV SCADA system and business separation of EEP /EEU.

On the other hand

- Installation of distribution automation capability was planning under AADRUP, the plan is relying on the existing HV transmission telecommunication network.

Update of progress of the AADRUP
Confirmation of SCADA requirement
are required for solution

Item2
Quality Inf.

Applicable Quality Infrastructure

Applicable Quality Infrastructure for Addis Ababa Capital Region are show below.

For Package IV

- Gas Insulated Switchgear
- Tank Type Capacitor

For Package V

- Amorphous Alloy Core Distribution Transformers
- Pin Post Insulators
- Automatic Sectionalizing System

Applicable Quality Infrastructure

Applicable Quality Infrastructure in Addis Ababa Capital Region

Applicable Target		Examination Equipment	Advantage of Quality Infrastructure	TASK
D/L Equi	Distribution Transformer	Amorphous Transformer (AMT)	AMT has high characteristic efficiency compared to traditional (Cold Rolled Grain Oriented Electrical Steel) transformer (CRGO). AMT is expected reduction of distribution loss	Task 4
	Insulator for MV	Pin Post Insulator	Pin post insulator is different from pin insulator using distribution line generally. There is no pin part inside of porcelain, therefore Pin post insulator is expected reduction of fault of crack dramatically. Contamination resistance is superior.	Task 5,6
	Automatic Operation of Switchgear	Time Sequential Sectionalizing System	Time Sequential Sectionalizing System can reduce recovery time and minimize power outage section by combining with substation reclosing relay.	Task 5
S/S Equi	132～66kV Substation Outdoor Switchgear Transformer Connection Equipment	GIS (Gas Insulated Switchgear)	GIS has advantage to minimize foot print. GIS can install not only indoors but also outdoors. By installing GIS outdoors, spread of the substation can be smaller.	Task 3,6
		Direct Connection GIS with Transformer	The equipment which connects transformer (oil or gas) to GIS (gas insulated) directly. It is costly equipment, however there is few possibility to fault occur because all live parts are covered. Moreover it can install very small foot print.	Task 3,6
	132～66kV Power Capacitor	Tank Type Capacitor	It is costly equipment compared to conventional can type capacitor, however it has advantage of maintenance free and earthquake resistance.	Task 5,6

Gas Insulated Switchgear (Outdoor Type)

Task 3: Small foot print
Task 6: Maintenance

- ✓ **Saving for installation space,**
- ✓ **Saving for building cost**
- ✓ **Further quality infrastructure available (e.g. V-GIS,)**

- Reduce foot print dramatically compared to Air Insulated Switchgear
- No declining dielectric strength even low air density and high altitude area such a Ethiopia
- GIS can install not only indoors but also outdoors.
- By installing GIS outside, construction cost of building and installation foot print can be reduced

Tank Type Capacitor

Tank Type Capacitor

Can Type Capacitor

- Save foot print compared to conventional can type capacitor
- Advantage of earthquake resistance
- Long Lifespan, Maintenance Free, equipment cost is 4～5 times higher price of can type

	Tank Type	Can Type
Estimated product life cycle	**Longer**	**Shorter**
Maintenance	**Maintenance free**	**Complicated** It requires the maintenance for capacitor units, racks, bushings and insulators
Safety	**Safer** Surface of the tank is not live part	**Less Safe** Capacitors and rack are live part
Installation space	**Smaller**	**Larger**

Task 5: Reliability of Supply
Task 6: Maintenance

- ✓ **Strong against Earthquake,**
- ✓ **Saving for maintenance cost**

Procedure of examination in ADC substation

Confirmation of relevant requirement

- Green Area Regulation around AU
- EEP/EEU's requirement (Maintenance easy, spread of the site, construction cost)
- *Provisional decision about substation layout(indoor or outdoor)*

Field survey

- New ADC substation site
- Kaliti I substation
- Other substation (GIS substation e.g. Addis East)

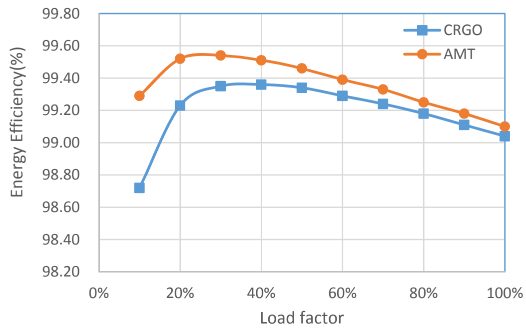
Proposal

- From the viewpoint of Cost, Reliability, maintenance easy, etc.

Where to install new equipment

Combination	Indoor TrB	Outdoor TrB
Indoor GIS	Scenery/security : good Foot print/Cost : bad	Original plan Scenery/security : basis Foot print/Cost : basis
Outdoor GIS	Scenery/security : fair Foot print/Cost : bad	Scenery/security : fair Foot print/Cost : good

Amorphous Alloy Core Distribution Transformers



Comparison of efficient characteristic between AMT and CRGO

Example of replacing CRGO by AMT

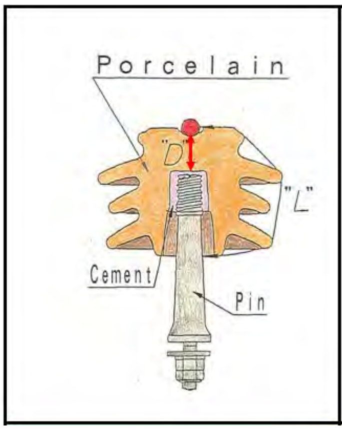
- AMT* can reduce power loss because of high energy efficiency.
- AMT is usually more expensive than traditional products(CRGO**), but running cost is lower than CRGO.
- By installing AMT, TOC*** can be reduced, with no special technique, just replace CRGO with AMT.

Task 4: Low Loss Equipment

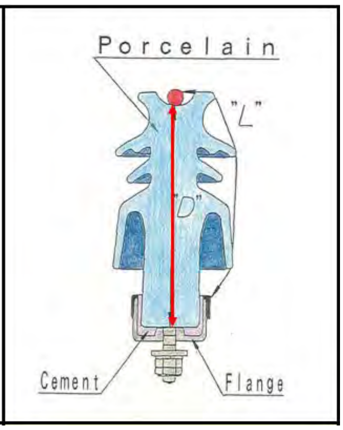
- ✓ **Saving for power loss**
- ✓ **Saving for TOC**
- ✓ **Further, CO_2 emission reduction**

*	Amorphous Alloy Trans former
**	Cold Rolled Grain Oriented Electrical Steel
***	Total Owning Cost

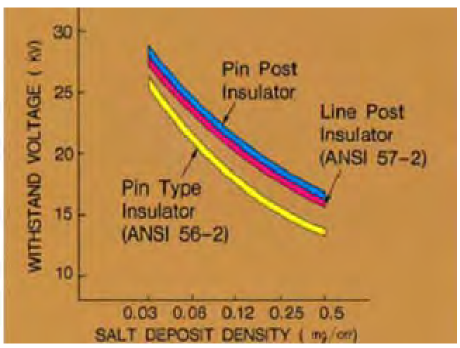
Pin Post Insulators



Pin Type Insulator



Pin Post Insulator



Higher anti-contamination Performance

- High reliability because of Long puncture path(D) and Flashover path(L).
- No clack because of no cement inside of porcelain body
- Higher anti-contamination Performance

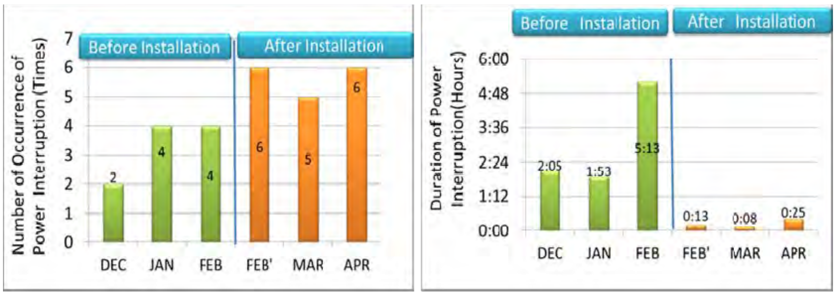
Task 5: Reliability of Supply
Task 6: Maintenance

- ✓ **Strong against lightning and contamination**
- ✓ **Saving for maintenance cost**

Item2
Quality Inf.

Automatic Sectionalizing System

- TSS* system can reduce to duration and area of power outage with minimum Initial investment.
- Applicable to various distribution system.
- Compatible with centralized control system for future upgrade



Comparison of Outage Before/After the Installation of TSS* System

Task 5: Reliability of Supply

- ✓ **Effective to reduce outage time**
- ✓ **Early identification of faulty section**

*TSS: Time sequential Sectionalizing

Item3
P.Finding

Project finding for T/L,S/S and D/L in Addis Ababa

Review of AADMP

Result of Site survey in Addis Ababa

Discussion with EEP/EEU

የኢትዮጵያ ኤሌክትሪክ ኃይል
ETHIOPIAN ELECTRIC POWER

Project finding for T/L,S/S and D/L in Addis Ababa is expected.

Site Survey Items

Candidate	Assumed condition and survey items	Applicable Quality Infrastructure	Remark
Addis Centre S/S	GIS install assumed in AADMP	GIS Direct Connection GIS with Transformer	Addis Center S/S has Possibility of relocation
Distribution network in urban area	Confirm operational condition of existing equipment Detail confirmation of sample	Amorphous Distribution Transformer	
Workshop, Installation points of Distribution poll in urban area	Pollution of insulator because of increase of traffic volume	Pin Post Insulator	Delivery of million scale by NGK in 1980s to 1990s
BSP in urban area, Distribution network in urban area	Hearing of method and others in case of fault on distribution line	Time Sequential Sectionalizing system	Having installation record in Southeast Asia
BSP in urban area	Existence of voltage drop and other problem	Tank Type Capacitor	

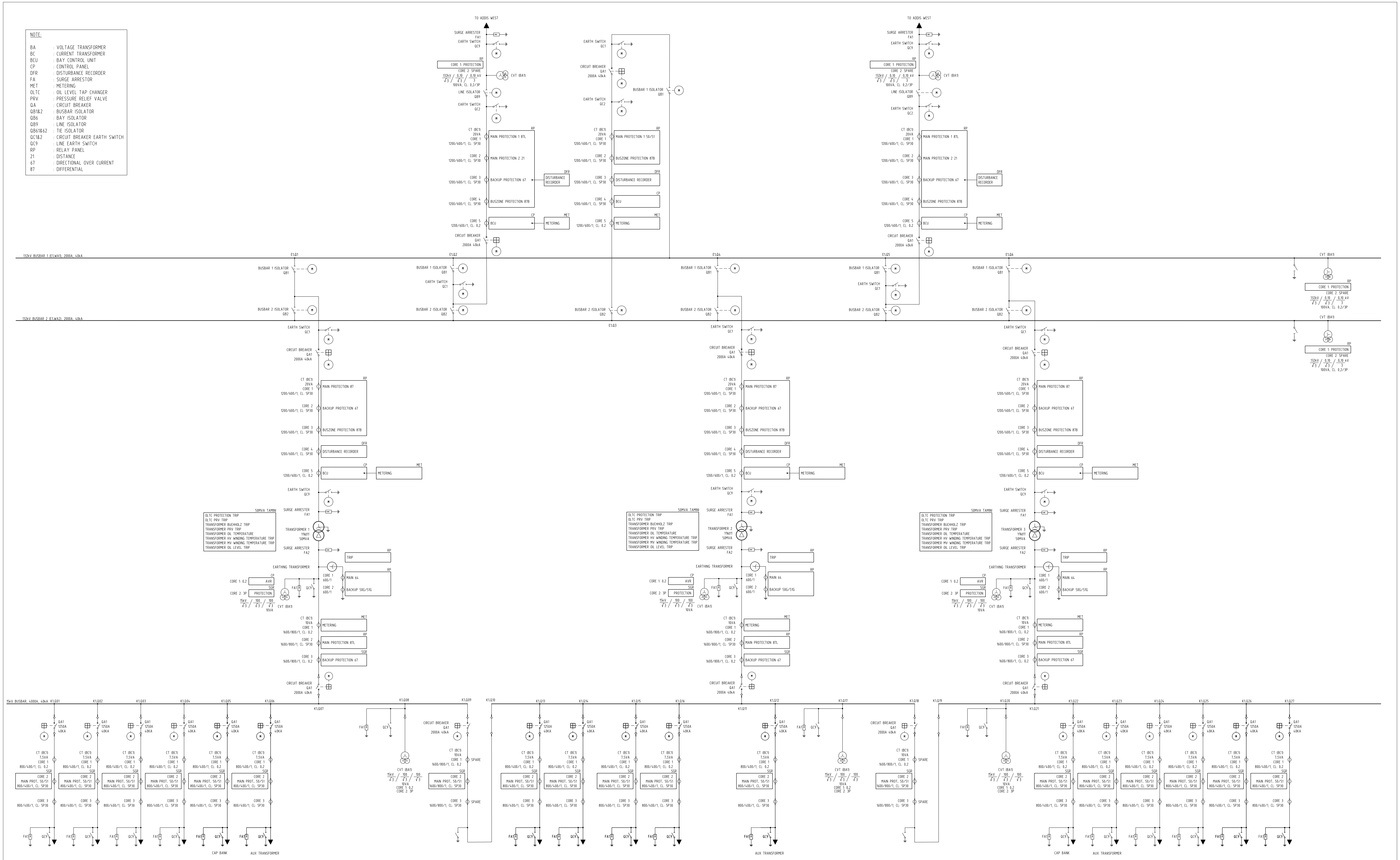
Thank you for your kind attention.

APPENDIX-5

BLACK LION SUBSTATION
SINGLE LINE DIAGRAM, LAYOUT

NOTE:

- BA : VOLTAGE TRANSFORMER
- BC : CURRENT TRANSFORMER
- BCU : BAY CONTROL UNIT
- CP : CONTROL PANEL
- DFR : DISTURBANCE RECORDER
- FA : SURGE ARRESTOR
- MET : METERING
- OLTC : OIL LEVEL TAP CHANGER
- PRV : PRESSURE RELIEF VALVE
- QA : CIRCUIT BREAKER
- QB1&2 : BUSBAR ISOLATOR
- QB6 : BAY ISOLATOR
- QB9 : LINE ISOLATOR
- QB61&62 : TIE ISOLATOR
- QC1&2 : CIRCUIT BREAKER EARTH SWITCH
- QC9 : LINE EARTH SWITCH
- RP : RELAY PANEL
- 21 : DISTANCE
- 67 : DIRECTIONAL OVER CURRENT
- 87 : DIFFERENTIAL



REVISIONS			
NO	BY	DATE	DESCRIPTION
A	K.M	2016/09/06	FOR APPROVAL

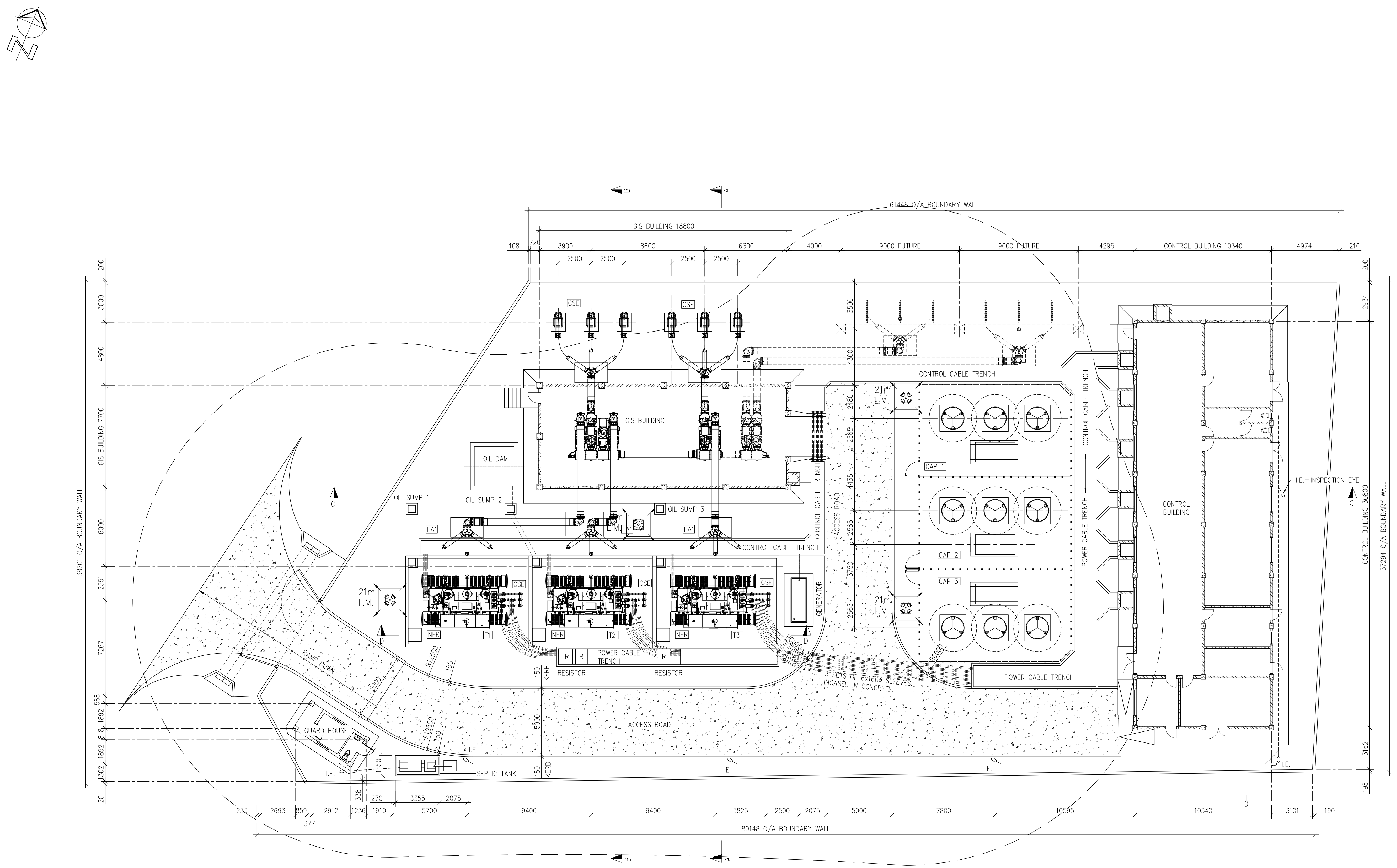
DATE	6-Oct-16
SCALE	N.T.S
DRAWN	T. MOEKETSI
DESIGNED	B. MACKAY
CHECKED	E. PHILLIPS

PROJECT: ETHIOPIA ETHIOPIA SUBSTATION
CUSTOMER: ETHIOPIAN ELECTRIC POWER
CONTRACT: ZA02766
TITLE: ADDIS TRANSMISSION NETWORK REHABILITATION PROJECT
DESCRIPTION: SINGLE LINE DIAGRAM - BLACK LION

BARLOW ROAD
HALFWAY HOUSE 1685
PRIVATE BAG X42
HALFWAY HOUSE 1685
Tel: (011) 805-1910
Telefax: (011) 805-1132
E-Mail : conco@conco.co.za

CONCO Energy Solutions

A0 DRAWING NO. ZA02766-05-D01 SHEET 01/01 REV A



LEGEND

T1	132/15kV POWER TRANSFORMER
T2	132/15kV POWER TRANSFORMER
T3	132/15kV POWER TRANSFORMER
NER	NEUTRAL EARTHING RESISTOR
CSE	CABLE SEALING END
FA1	SURGE ARRESTOR
CAP 1	CAPACITOR BANK 1
CAP 2	CAPACITOR BANK 2
CAP 3	CAPACITOR BANK 3

NOTE:

1. WHEN IN DOUBT, ASK.
2. ALL DIMENSIONS TO BE CONFIRMED ON SITE, ANY DISCREPANCIES OR UNCERTAINTIES TO BE DISCUSSED WITH PROJECT MANAGER AND/OR PRIMARY DESIGN OFFICE BEFORE CONTINUING WITH CONSTRUCTION.

INFORMATION ONLY

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ETHIOPIAN ELECTRIC POWER

REV	DATE	DESCRIPTION	BY	CHKD	REFERENCE DRAWING No.	REFERENCE DRAWING DESCRIPTION
E	21/06/17	CSE ADDED	JGJ	A.S.		
D	05/05/17	SEPTIC TANK ADDED	JGJ	G.B.		
C	19/01/17	RESISTORS ADDED	JGJ	R.B.		
B	19/10/16	TRANSFORMERS REVISED	JGJ	R.B.		
A	09/09/16	ISSUED FOR APPROVAL	JGJ	R.B.		

CONCO PROJECT APPROVAL

DRAWN	JGJ DE JONGH	09/09/2016
D.O. CHECK	G. BOTES	22/06/2017
PROJ. ENG.	A. SWANEPOEL	
B.U.M. / DIR.		

PROFESSIONAL ENGINEER / TECHNOLOGIST APPROVAL

NAME	CR Sillman PrTechEng CEng		
Reg. No.	200470105	SIGNATURE:	DATE:

CONSOLIDATED POWER PROJECTS GROUP AFRICA LIMITED
5th FLOOR, RAFFLES TOWER 19 CYBERCITY, EBENE MAURITIUS
TEL: ++230 403 55 55
PO BOX 34, REDUIT MAURITIUS
E-Mail: conco@concogrp.com
Web: www.concogrp.com

CONTRACT:
ADDIS ABABA HV TRANSMISSION NETWORK UPGRADING PROJECT CONTRACT No. 2
EEP PROJECT NUMBER CO/33.20/123/08

TITLE:
BLACK LION 132/15kV SUBSTATION
GENERAL ARRANGEMENT

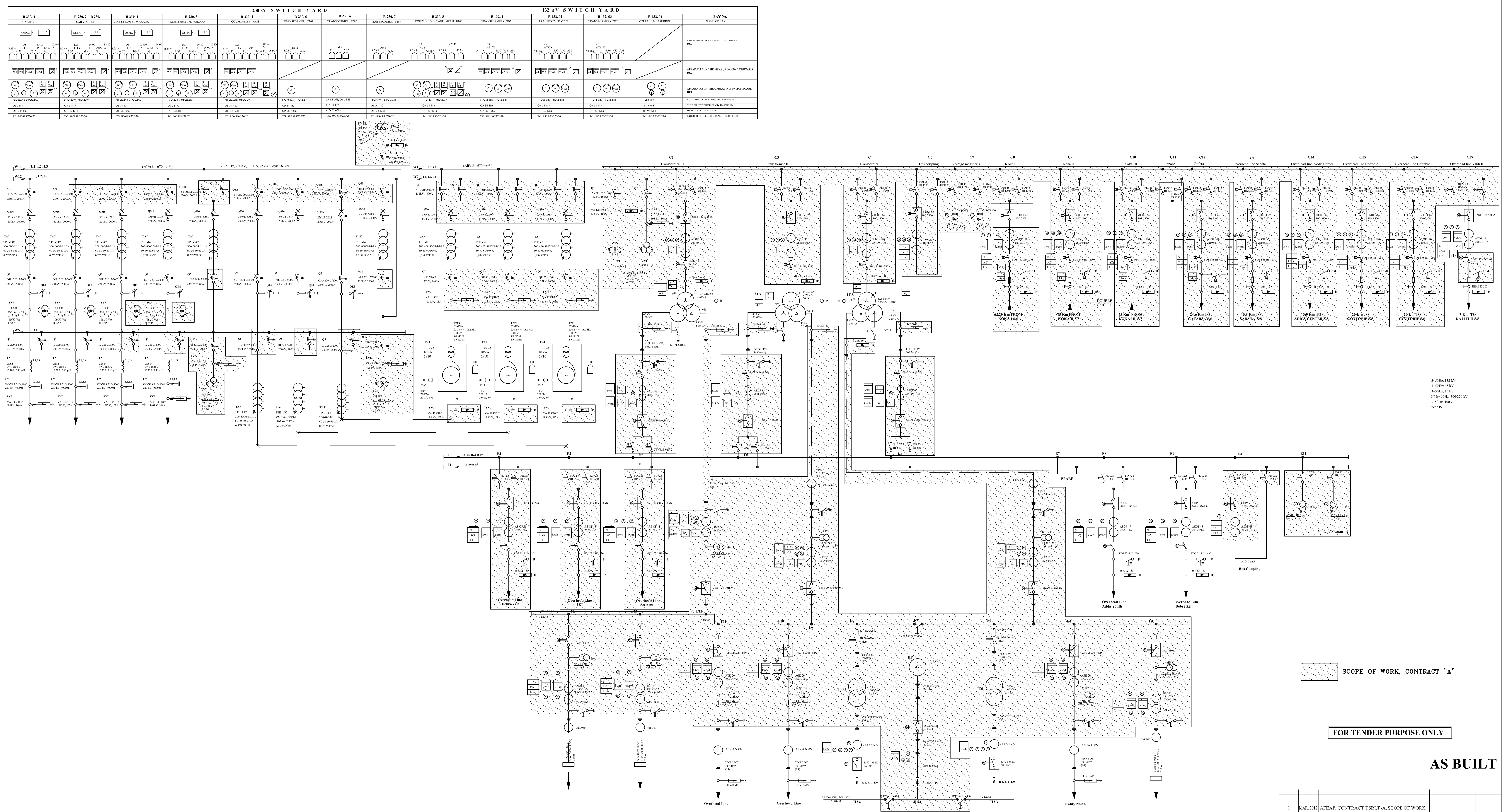
SCALE ON A1	SCALE ON A3	SHEET	DRG. No.	REV
1:150	1:300	1 OF 1	MU02337-602	E

21 June 2017 08:27:57 AM - Gihan De Jongh

C:\Vault Working Folder\PD\CPP-GA\Current Projects\Ethiopia - MU02337\600 Black Lion\MU02337-602.dwg

APPENDIX-6

KALITI I SUBSTATION
SINGLE LINE DIAGRAM, LAYOUT



FOR TENDER PURPOSE ONLY

AS BUILT

1	MAR. 2012	AFEAP, CONTRACT TSRUP-A, SCOPE OF WORK			
REV.	DATE	DESCRIPTION OF REVISION	BY	CHKD.	APPD.

ETHIOPIAN ELECTRIC POWER CORPORATION
ADDIS ABABA, ETHIOPIA

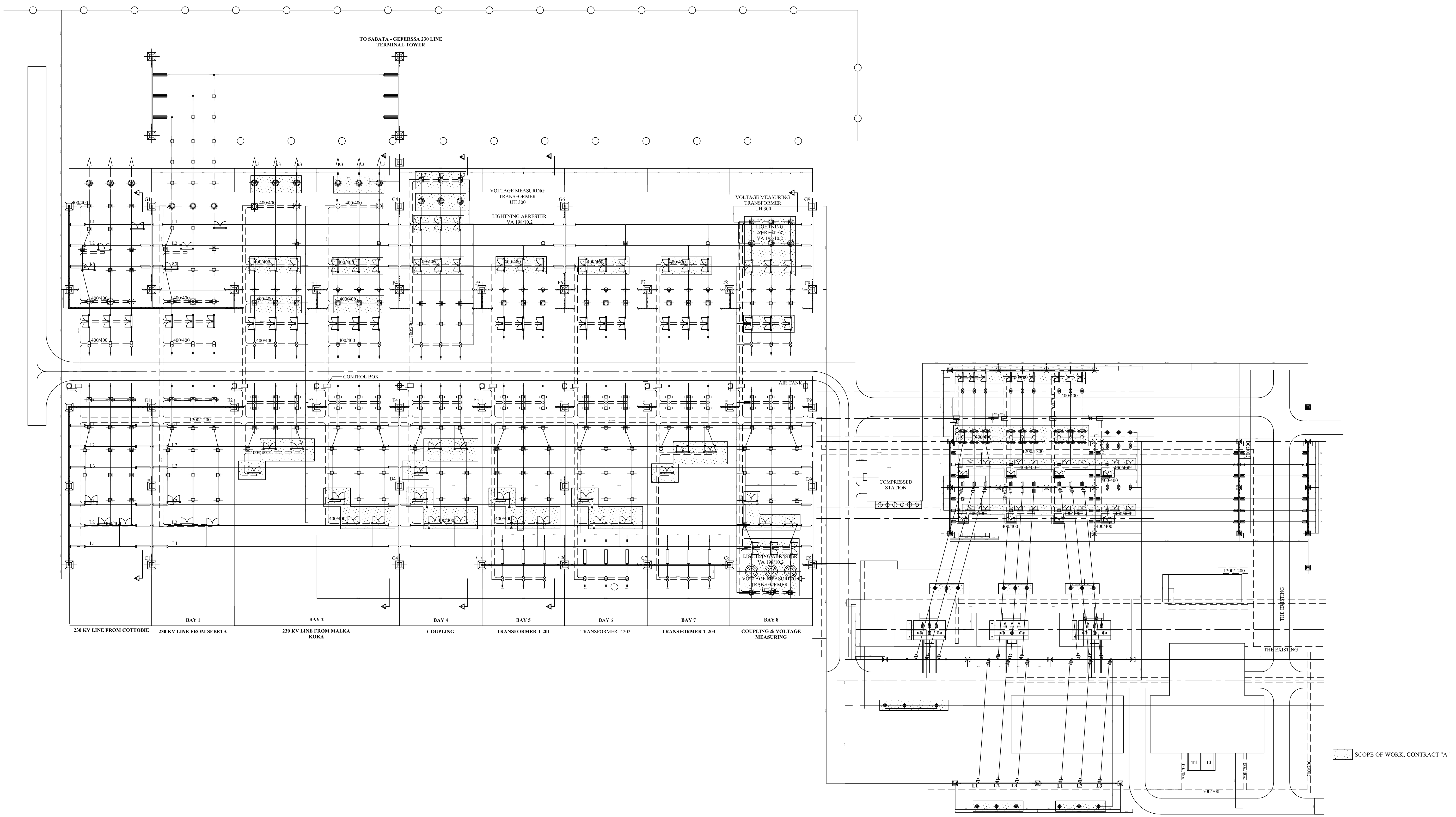
KALITI-I SUBSTATION

230/132/45/15 kV
SINGLE LINE DIAGRAM - EQUIPMENT DISMANTLING

DRAWN	Abeba G/Yohannes		Dec. 1/2009	SCALE N.T.S.
DESIGNED				DWG No KAL.I -03
CHECKED				
APPROVED				

PLOT DATE: Mars 21, 2012
FILENAME: K:\05\Z\200\0922228\07_Plans\Contract A_(REV.1) Drawings (20 MARS 2012)\KAL-I-03_R1.dwg

NOTE:
THIS DRAWING REPRESENTS THE EXISTING EQUIPMENT AT THE SUBSTATION, AND IT IS INCLUDED FOR INFORMATION AND REFERENCE



FOR TENDER PURPOSE ONLY

REV.	DATE	DESCRIPTION OF REVISION	BY	CHKD.	APPD.
1	MAR. 2012	AFEAP, CONTRACT TSRUP-A, SCOPE OF WORK			

ETHIOPIAN ELECTRIC POWER CORPORATION
ADDIS ABABA, ETHIOPIA

KALITI-I SUBSTATION

230 kV
SUBSTATION LAYOUT PLAN - EXISTING

DRAWN	Abeba G/Yohannes	SCALE 1:300
DESIGNED		
CHECKED		DWG No KALI.I-02
APPROVED	Alemayehu Wibeshet	