Yangon City Electricity Supply Board
Ministry of Electric Power
Republic of the Union of Myanmar
Japan International Cooperation Agency

# Republic of the Union of Myanmar

# Preparatory Survey for Power Improvement Project in the Greater Yangon

# Final Report

February 2014

Japan International Cooperation Agency (JICA)

Chubu Electric Power Co., Inc.

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# Figures and Tables

# Abbreviations and Acronyms

| | |
|---|---|
| ACSR | Aluminum Conductor Steel Reinforced |
| ADB | Asian Development Bank |
| AIMS | the ASEAN Interconnection Master Plan Study |
| AIS | Air Insulated Switchgear, Air Insulated Substation |
| ASEAN | Association of Southeast Asian Nations |
| CB | Circuit Breaker |
| CDC | City Development Committee |
| CH | Cable Head |
| CPLAD | City Planning and Land Administration Department |
| CT | Current Transformer |
| DS | Disconnecting Switch (Isolator) |
| EIA | Environmental Impact Assessment |
| ECC | Environmental Compliance Certificate |
| ECD | Environmental Conservation Department (of MOECAF) |
| ECL | Environmental Conservation Law |
| ECR | Environmental Conservation Rules |
| EDL | Electricite Du Laos |
| EGAT | Electricity Generating Authority of Thailand |
| ES | Earthing Switch |
| ESC | Environmental and Social Considerations |
| ESE | Electric Supply Enterprise |
| EVN | Electricity of Vietnam |
| FY | Fiscal Year |
| GAD | General Administration Department (under MOHA) |
| GCB | Gas Circuit Breaker |
| GIS | Gas Insulated Switchgear |
| GOC Ry | Grounding Over Current Relay (Earthing Fault Relay) |
| JICA | Japan International Cooperation Agency |
| LA | Lightning Arrester |
| LDC | Load Dispatching Center |
| LTC | Load Tap Changer |
| MEPE | Myanmar Electric Power Enterprise |
| METI | Ministry of Economy, Trade and Industry (of Japan) |
| MOAI | Ministry of Agriculture and Irrigation |
| MOC | Ministry of Culture |
| MOECAF | Ministry of Environmental Conservation and Forestry |
| MOEP | Ministry of Electric Power |
| MOF | Ministry of Forestry (predecessor of MOECAF) |
| MOHA | Ministry of Home Affaires |
| MOPD | Ministry of National Planning and Economic Development |
| NCEA | National Commission for Environmental Affairs |

| | |
|---|---|
| NEDA | The Neighboring Countries Economic Development Cooperation Agency |
| NEP | National Environmental Policy |
| NPV | Net Present Value |
| NSDS | National Sustainable Development Strategy |
| NVTC | No-Voltage Tap Changer |
| OC Ry | Over Current Relay |
| OCB | Oil Circuit Breaker (LOCB: Low level Oil Circuit Breaker) |
| ODA | Official Development Assistance |
| OLTC | On-Load Tap Charger |
| PCB | Polychlorinated Biphenyl |
| PF | Power Factor |
| P/S | Power Station |
| PT | Potential Transformer |
| RAP | Resettlement Action Plan |
| SCADA | Supervisory Control and Data Acquisition |
| SIA | Social Impact Assessment |
| SLORC | State Law and Order Restoration Council |
| SLRD | Settlement and Land Record Department |
| SPDC | State Peace and Development Council |
| S/S | Substation |
| VCB | Vacuum Circuit Breaker |
| XLPE | Cross-Linked Polyethylene |
| YCDC | Yangon City Development Committee |
| YESB | Yangon City Electricity Supply Board |

# Appendix

# Chapter 1 Background

## 1.1 Background

The Yangon City is the economic center of Myanmar where 5.1 million people, or nearly 10% of the country's total population, are concentrated. As the population grows, the Yangon metropolitan area has been formed with the expansion of its surrounding areas. In 2012, the peak power supply in the whole Myanmar totaled about 1,800MW, of which about 44% (about 790MW) was supplied to the Yangon City. However, while the total generating capacity in Myanmar reached about 3,900MW as of Dec 2012, the effective output remains its 33-47% due to aging existing power facilities, shortage of fuel for thermal power generation, and output constraint of hydropower generation in dry seasons. Therefore, in the Yangon City where the largest amount of power is demanded in Myanmar, electric power supply hardly meets demand, and load shedding is necessary in dry seasons because potential power demand largely exceeds supply. Moreover, the power transmission and distribution losses in the whole Myanmar reach about 25%, with the transmission loss 7% and the power distribution loss 18% as of 2012. Under the tight supply-demand conditions, there are high needs for improving the efficiency and enhancing electric power supply reliability by reducing the loss rate. Furthermore, since aging facilities have been used under overload conditions for a long time, there are high risks of trouble occurrence while there are concerns over the occurrence of large-scale power outage.

In the Yangon City, the demand for electric power is expected to continue to increase due to economic development, and, therefore, the securing of stable electric power supply and the enhancement of electric supply reliability have become urgent tasks. In particular, there is high need for repairing and reinforcing the existing distribution facilities in the Yangon City in order to reduce power distribution loss and also as measures against aging facilities. Therefore, Yangon City Electricity Supply Board (hereinafter referred to as "YESB"), which is in charge of power distribution in the Yangon City, formulated the medium- to long-term investment plan as well as the 5-year distribution network development plan (FY2011 to FY2015). And under the 5-year plan, YESB plans to upgrade the voltage of distribution networks in the Yangon City to 66kV and repair existing 33kV substations.

Under such circumstances, based on the Minutes of Meeting (M/M) concluded on April 9, 2013, JICA will review the distribution networks development plan in the Yangon City and conduct preparatory surveys with the aim to formulate Japanese ODA loan projects as priority projects.

### (1) Objectives of this survey

| |
|---|
| Objective 1: To review the distribution networks development plan in the Yangon City and select priority projects |
| Objective 2: To select and evaluate the candidate projects for Japanese ODA loan |

(1)Survey areas

33 townships in the Yangon City, Myanmar

(2) Counterpart

Yangon City Electricity Supply Board (YESB)

## 1.2 Study schedule

The survey conducted for 9 months from June 2013 to February 2014. This Survey has four stages. In the first Stage, survey team collected basic information in YESB and, surveyed the priority investment plan and selected candidate projects for Japanese ODA loan. In the second stage, survey team examined the priority investment plan and survey candidate projects for Japanese ODA loan in detail. In the third stage, survey team proposed the priority investment plan and candidate projects for Japanese ODA loan. The 4th and 5th stage, survey team explained proposals related to the Yangon power distribution projects and proposals on continuous technical cooperation.

Kick-off meeting was held for explanation and discussion of the survey policies and Inception Report on July 5, 2013. During the survey period, technical transfer workshop held at YESB. The entire schedule for the survey and the overall flow of the survey are as shown in Figure 1-1 and Figure 1-2.

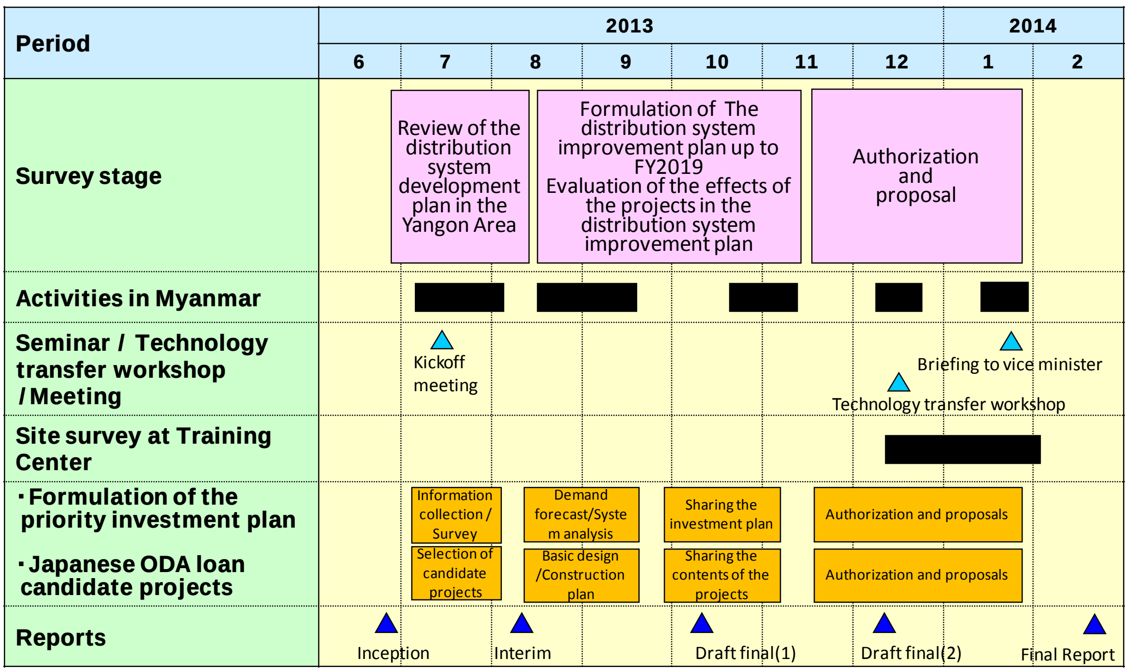
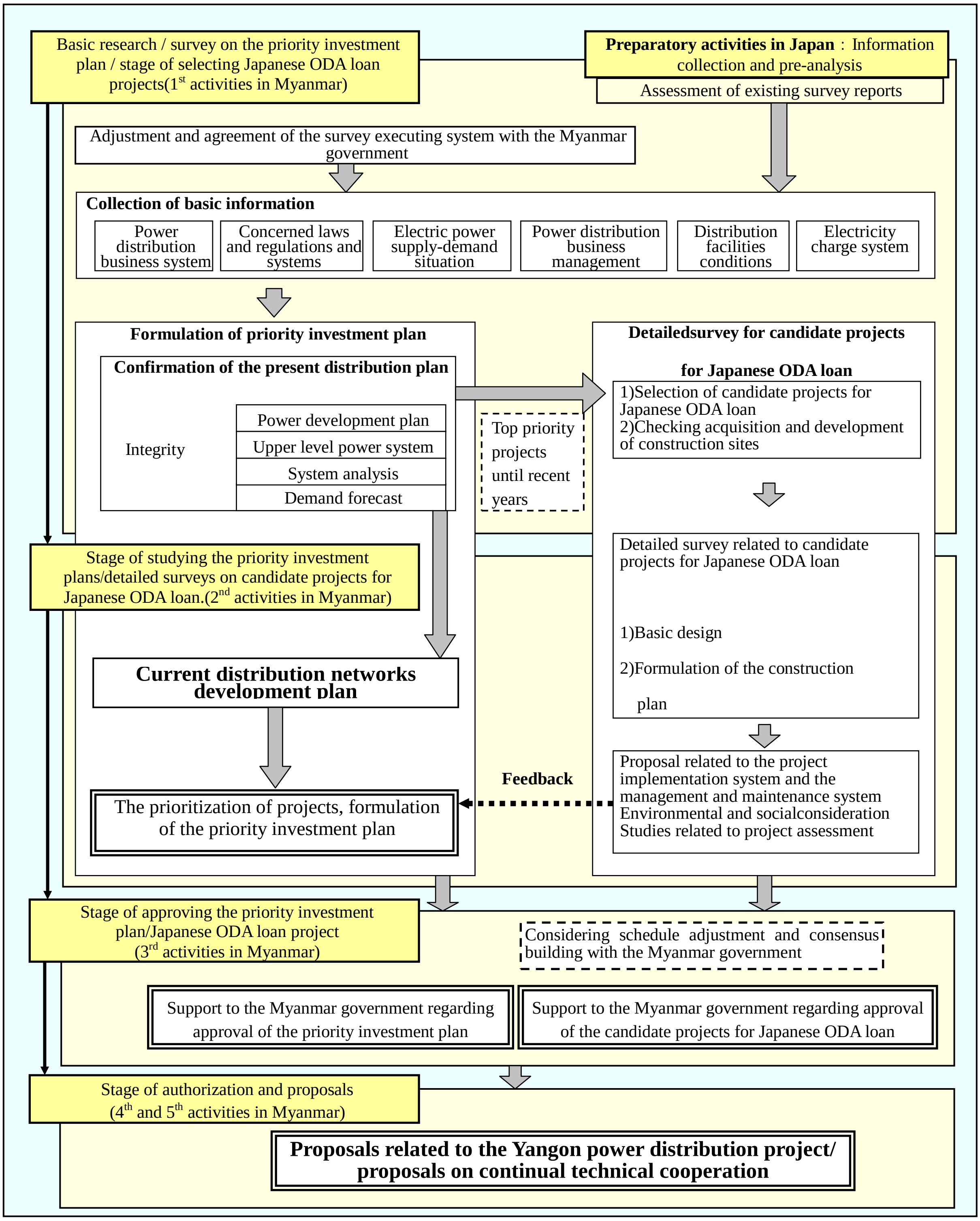



Figure 1-1: Study schedule




Source: JICA study team

Figure 1-2: Overall flow of the survey

## 1.3 JICA survey team and counterpart

For the smooth and efficient implementation of the survey, counterpart teams are formed by expert field, and members of the teams, as shown below, are working on the survey.

Table 1-1: Counterpart Team Members

| Survey group | Member | | |
|---|---|---|---|
| | JICA survey team | YESB counterpart | [Division] |
| Project Coordination | Mr.Yoshitaka SAITO<br>Mr.Hideki WADA<br>(Until July, 2013)<br>Ms.Mina KOBAYASHI<br>(After August, 2013)<br>Ms.Yumiko MUTO<br>(After October, 2013) | Ms.Yee Mon Mon | [Chairman Office] |
| Distribution System Planning | Dr. Koji SHIKIMACHI<br>Mr. Osamu TANIHATA<br>Mr. Tatsuya WATANABE<br>Mr. Masami OBA<br>Mr. Megumi ICHIKAWA<br>(After August, 2013) | Ms.KhinThapye Nu<br>Dr.AyeSandarMyo<br>Mr.MyoKyawSwe | [Chairman Office]<br>[Distribution Dept. ]<br>[Distribution Dept. ] |
| Power Supply Planning | Mr. Kazunori OHARA<br>Mr. Masanori YANAGIDA | Mr.AungTun Lin<br>Dr.ThweThweSoe | [Testing & General service Dept. ]<br>[Planning Dept.] |
| Power demand forecast | Mr.Hiroo YAMAGATA | Dr.AyeSandarMyo<br>Dr.ZarZarTun | [Distribution Dept. ]<br>[Planning Dept.] |
| Economic and financial analysis / Distribution business management | Mr. Masafumi IINO | Ms.SoeSoeNew | [Financial Dept.] |
| Environmental and social considerations | Mr. Tsuyoshi SASAKA | Mr.Yaw Mas | [Administration Dept.] |

# Chapter 2 Present Status

## 2.1 Present status of the power distribution sector

The Electricity Law established in the Republic of the Union of Myanmar in 1984 is concerning with the exploration, production, transmission, distribution and usage of electricity and involves inspection matter for the safety use of electricity. The law is now updated with ADB assistance to reflect present international standards and to create the right conditions for establishing an electricity regulator, expanding rural electrification, and promoting off grid solutions.

In Myanmar, the upper systems of 66kV or higher are managed by the Myanma Electric Power Enterprise (MEPE) while the electric power systems of 66kV or lower (including the primary 66kV substations) are managed by YESB in the Yangon city or by the Electricity Supply Enterprise (ESE) in cities outside of Yangon. Figure 2-1 shows the organization chart of the YESB, the counterpart managing the areas to be surveyed of this project. The YESB consists of the headquarters (199 executive officers and 1,410 employees) and four district offices (175 executive officers and 3,055 employees; including the township offices under jurisdiction). It is divided into the administration (subtotal of 466 members), finance (subtotal of 1,466 members), material planning (subtotal of 57 members) and engineer (subtotal of 1,647 members) departments. The engineer department is further divided into the distribution (21 executive officers and 376 employees), planning (22 executive officers and 311 employees) and testing & general service (16 executive officers and 157 employees) divisions.

Figure 2-2, Figure 2-3 and Figure 2-4 show the lower organization charts and the fixed and current appointed numbers of the members in each lower section of the engineer departments, distribution division and testing & general service division in the headquarters. Approximately halves of the fixed numbers are currently not occupied.

The distribution division consists of the system network & control, substation, mobile, and 24 hours maintenance sections for system control, construction, maintenance or modification of substations, 24-hour operations and maintenance, and provision of emergency power supply systems. The planning division consists of the underground, overhead, setting new substation, and training sections for construction or maintenance of underground cables and overhead lines, the substation construction plan and education. The testing & general service division consists of the testing, permitting meters, inspection meters, and loss reduction sections for the investigations on the causes for cable fault, and acceptance and approval of new consumers. The district offices with the township offices under jurisdiction are responsible for the acceptance of the applications for electricity use, operation, maintenance and repair of overhead power distribution lines of 11kV or less, and the initial response in case a fault occurs. The duties of each lower section in these divisions are summarized in Appendix 2-1.

# Yangon City Electricity Supply Board Organization Chart (as of Aug 2013)

| Department Name | Constitution | Appoint | Vacancy | Percentage |
|---|---|---|---|---|
| Administration | 877 | 466 | 411 | 53% |
| Finance | 1515 | 1466 | 49 | 97% |
| Engineer | 2346 | 1647 | 699 | 70% |
| Material Planning | 105 | 57 | 48 | 54% |
| Total | 4843 | 3636 | 1207 | 75% |

| Subject | Constitution | Appoint | | | Vacancy |
|---|---|---|---|---|---|
| | | Number | | Percentage | |
| | | Officer | Daily Wages | | |
| Officer | 378 | 308 | | 81.48 | 70 |
| Personnel | 4465 | 3328 | 822 | 74.53 | 1137 |
| Total | 4843 | 3636 | 822 | 75.07 | 1207 |

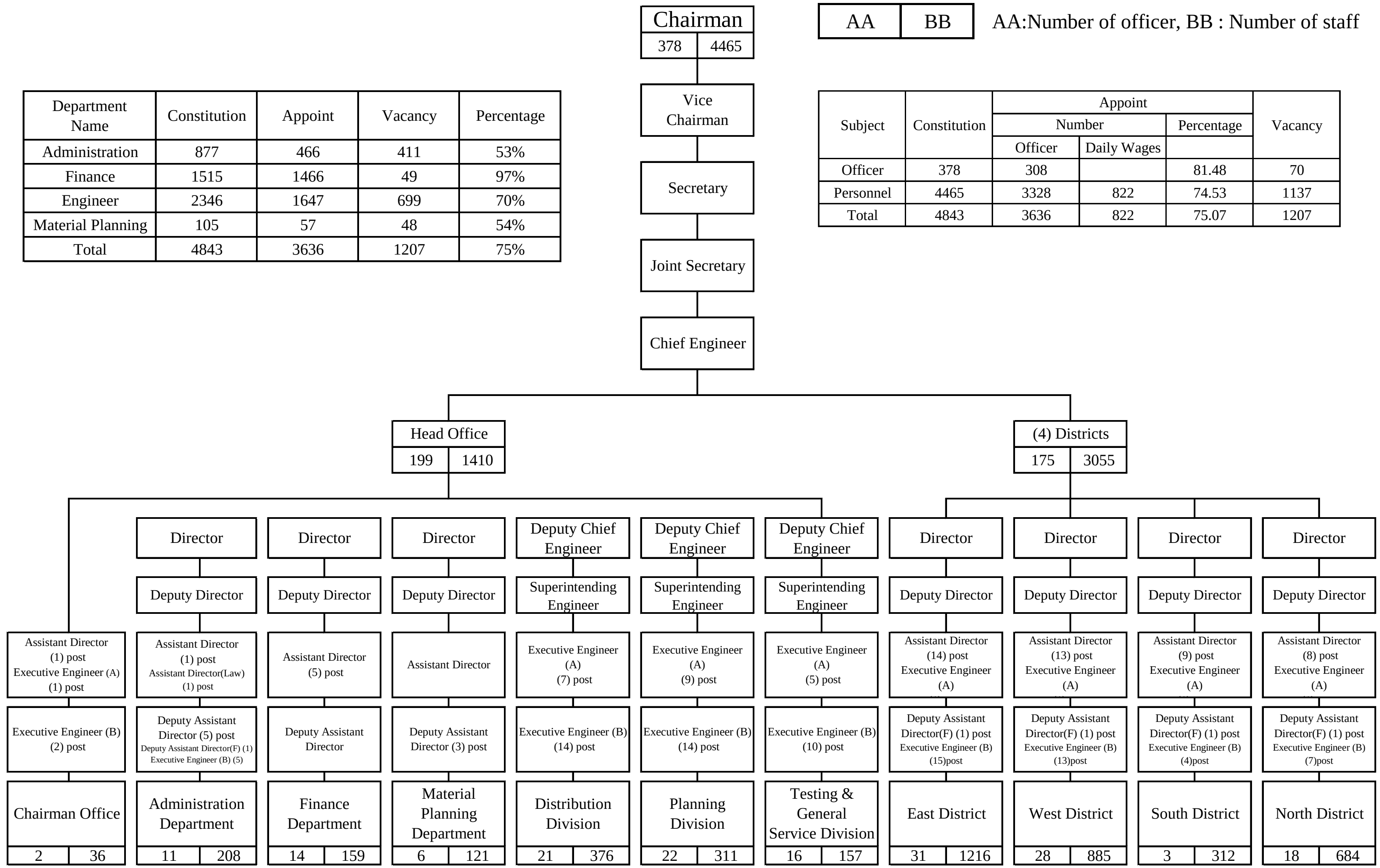



Figure 2-1: Organization Chart of Yangon Electricity Supply Board

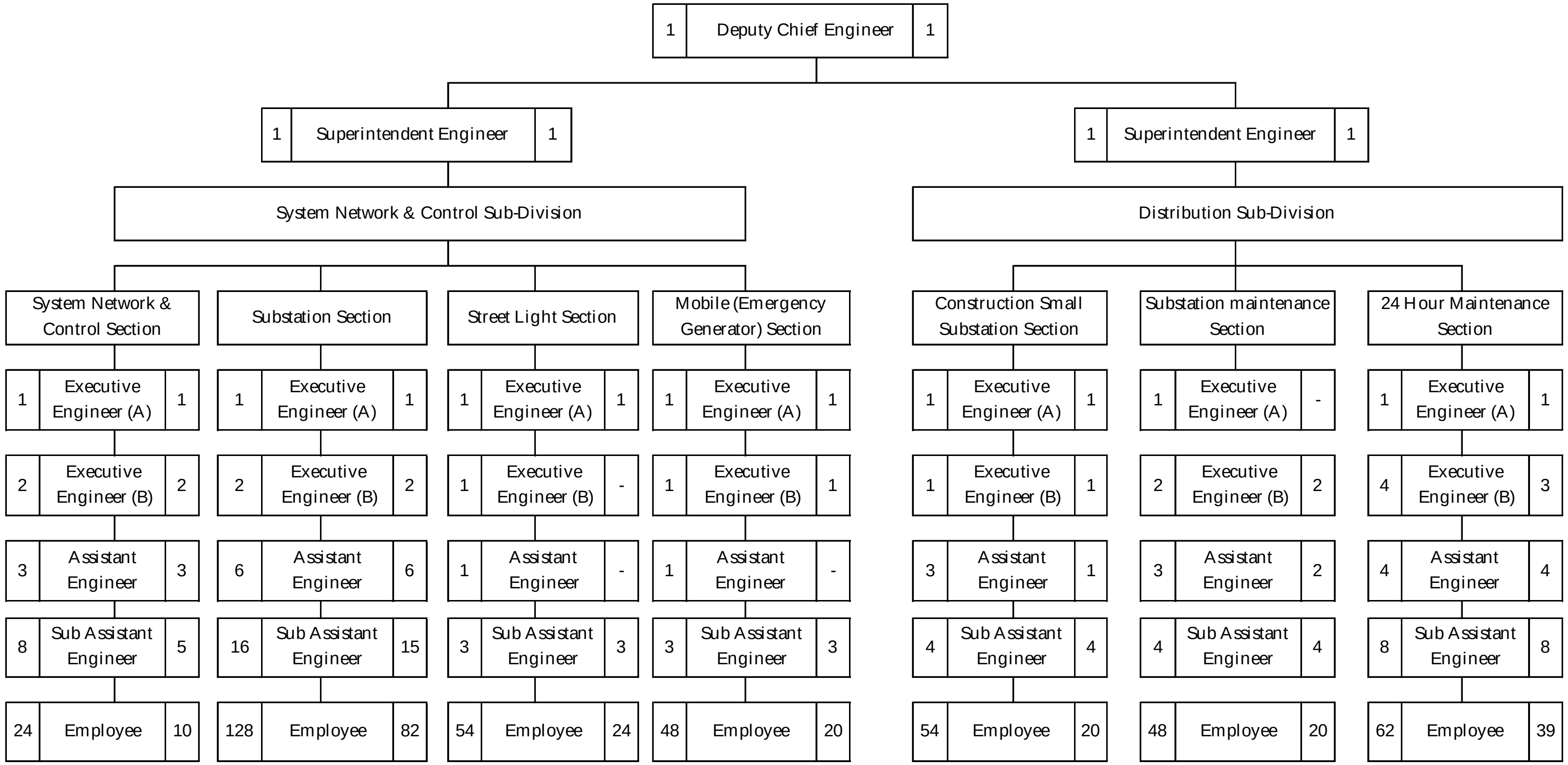
Source:YESB information

JUL/2013

# Yangon City Electricity Supply Board

## Distribution Division

| Subject | Constitution | Appointed | | Vacancy |
|---|---|---|---|---|
| | | No | % | |
| Offical | 45 | 38 | 82 | 7 |
| Employee | 376 | 215 | 58 | 161 |
| **Total** | **421** | **253** | **60** | **168** |




Number in left: Fixed seat, Number in right: Appointed seat

Figure 2-2: Organization Chart of Yangon Electricity Supply Board, Distribution division

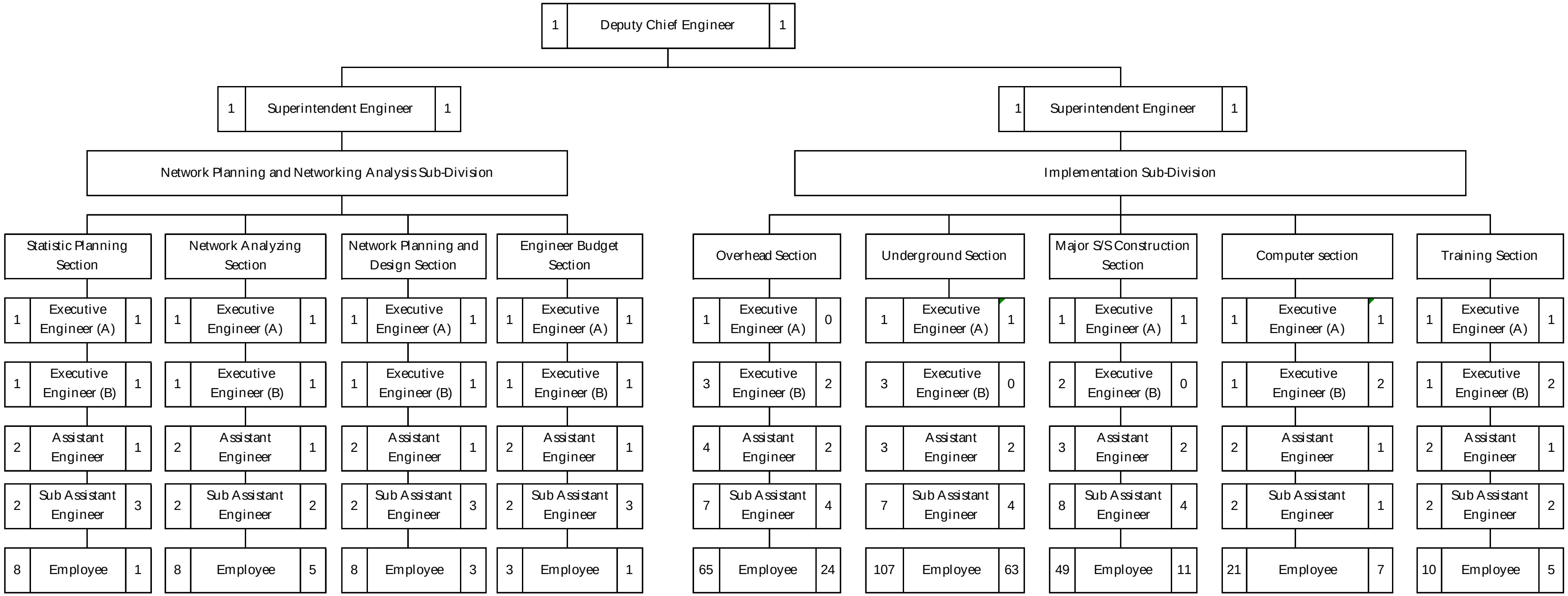
Source:YESB information

OCT/2013

# Yangon City Electricity Supply Board

## Planning Division

| Subject | Constitution | Appointed | | Vacancy |
|---|---|---|---|---|
| | | No | % | |
| Offical | 48 | 34 | 71 | 14 |
| Employee | 311 | 160 | 51 | 151 |
| **Total** | **359** | **194** | **54** | **165** |




Number in left: Fixed seat, Number in right: Appointed seat

Figure 2-3:Organaization Chart of Yangon Electricity Supply Board, Testing & General Services Division

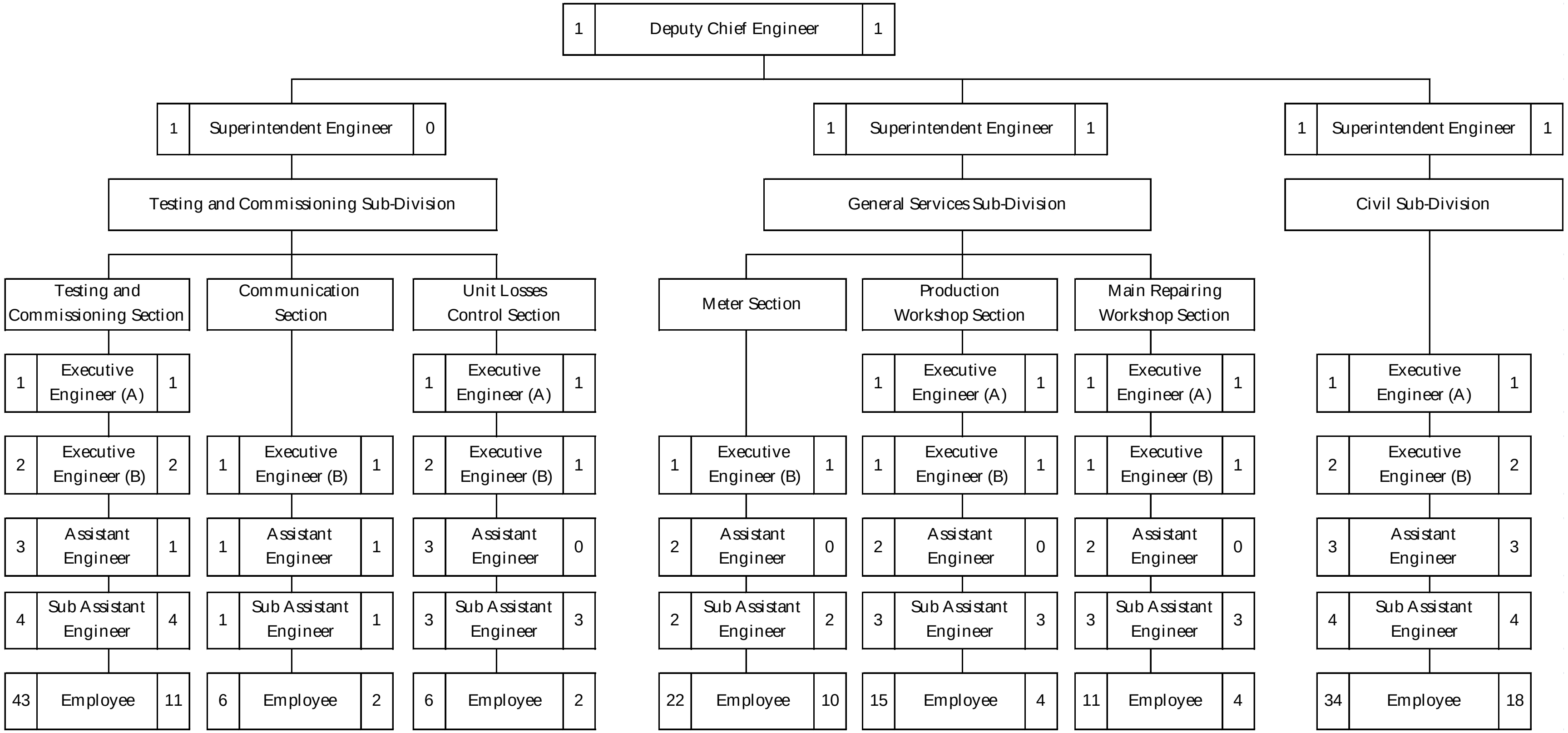
Source: YESB information

AUG/2013

# Yangon City Electricity Supply Board

## Testing & General Services Division

| Subject | Constitution | Appointed | | Vacancy |
|---|---|---|---|---|
| | | No | % | |
| Officer | 35 | 22 | 63 | 13 |
| Personnel | 157 | 71 | 45 | 86 |
| **Total** | **192** | **93** | **48** | **99** |




Number in left: Fixed seat, Number in right: Appointed seat

Figure 2-4:Organaization Chart of Yangon Electricity Supply Board, Testing & General Services Division

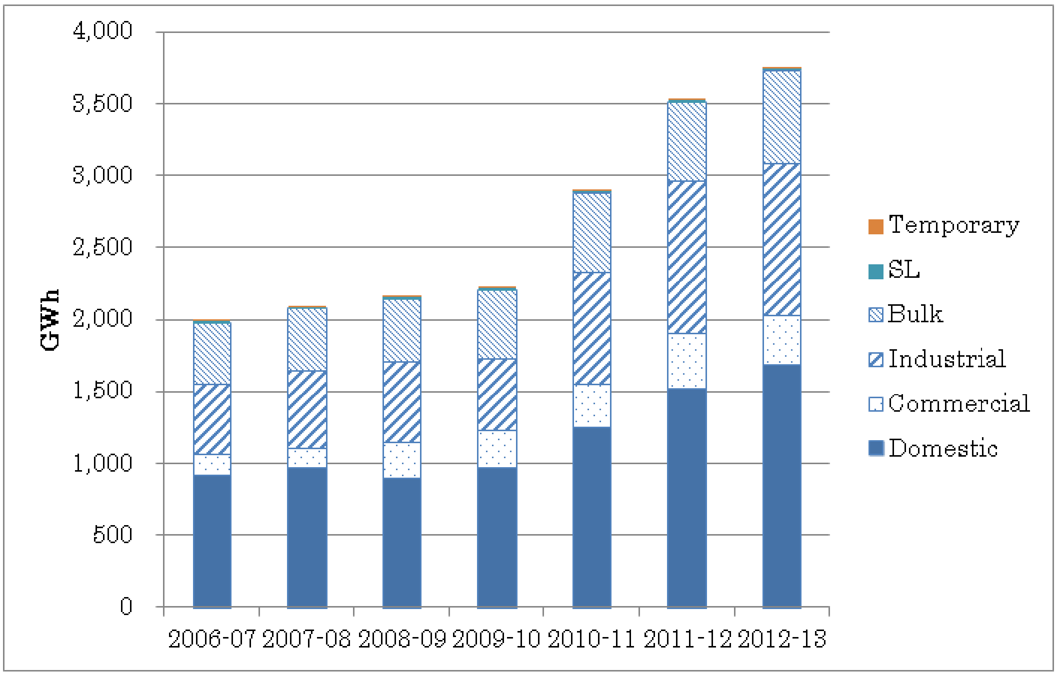
Source: YESB information

### 2.2 Yangon City Power Demand and its Trend

#### 2.2.1 Trend of the Yangon City Demand

The maximum demand of the Yangon distribution networks is around 900MW (about 60% of the national demand) as of June 2013, and the power generation capacity nationwide is around 1,500MW. In the dry season (between February and May) when power generated from hydroelectric power stations is low, load shedding is implemented for large-scale industries. With the recent increase in power demands, the power generation capacity in rainy seasons falls below the maximum demands in the nation, resulting in the frequent load shedding in addition to the abovementioned planned outage.

During most of the 2000s, the Yangon City showed about 4% annual growth in power demand (GWh). With the prospect of political reform since 2010-11, a huge wave of development and investment began. Power demand also surged. From 2009 to 2010, the growth rate was 30% strong, followed by 20% in 2011-12, and 6% in 2012–13.




Source: YESB

Figure 2-5: Yangon Power Demand (Sales, GWh)

Table 2-1:Yangon City Power Demand (Sales, GWh)

| Year | Domestic | Commercial | Industrial | Bulk | SL | Temporary | Total | Total Growth |
|---|---|---|---|---|---|---|---|---|
| 2006-07 | 915.9 | 143.00 | 489.3 | 419.2 | 21 | 4 | 1,992.40 | |
| 2007-08 | 959.5 | 135.10 | 541 | 434.4 | 14.4 | 3.2 | 2,087.60 | 4.8% |
| 2008-09 | 892.22 | 246.48 | 566.7 | 431 | 14.4 | 3 | 2,153.80 | 3.2% |
| 2009-10 | 967.52 | 253.68 | 503.4 | 471.4 | 15.8 | 2.1 | 2,213.90 | 2.8% |
| 2010-11 | 1,246.75 | 295.59 | 784.6 | 548.7 | 15.5 | 1.8 | 2,892.94 | 30.7% |
| 2011-12 | 1,516.47 | 386.80 | 1053 | 550.6 | 16.11 | 1.8 | 3,524.78 | 21.8% |
| 2012-13 | 1,679.05 | 347.91 | 1050 | 648.8 | 18.02 | 8.7 | 3752.48 | 6.5% |

*Source: YESB Annual Report*

This trend becomes the basis for the demand forecast. However, it is not sufficient to simply extrapolate the current figure. Due to several constraints, the figure is suppressed and represents a lower figure than the actual demand;

- Power cuts due to facilities malfunction and insufficient demand
- Extreme load shedding towards the industrial areas (5 hours supply per day) and the resultant widespread use of self-procured generation

On the other hand, a large part of the recent growth in demand represents a one-time response to the pent-up demand, and not a long term trend. Therefore, how to extrapolate this becomes another issue.

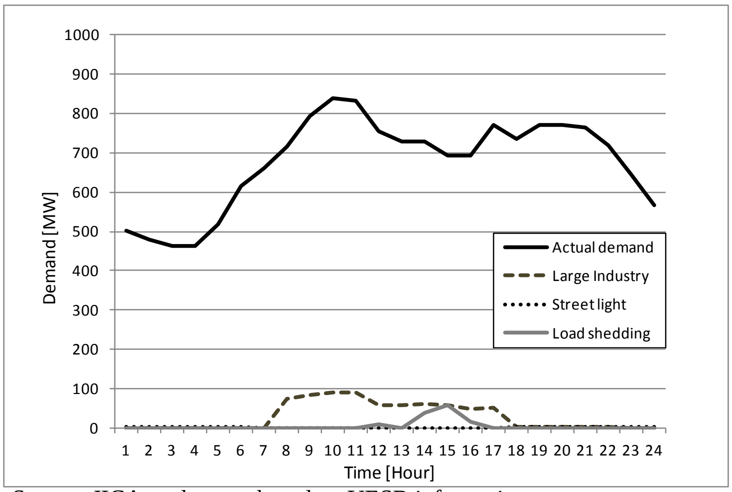
### 2.2.2 Load Shedding/Power Cuts

With demand not being able to respond to the explosion in demand, Yangon has responded by a large scale load shedding. With a large scale demonstration against the power cuts, YESB currently does not shed load to domestic and commercial use. The load shedding is limited to industrial zones. The power supply to the industrial zones are currently limited to 5 hours a day, and in some periods, zero (this point will be touched upon in the next section).

Also, there are irregular power cuts due to machine failures and over loading. These occur intermittently, but it seems that on average, about 2.5% of the total power supply seems to be affected.

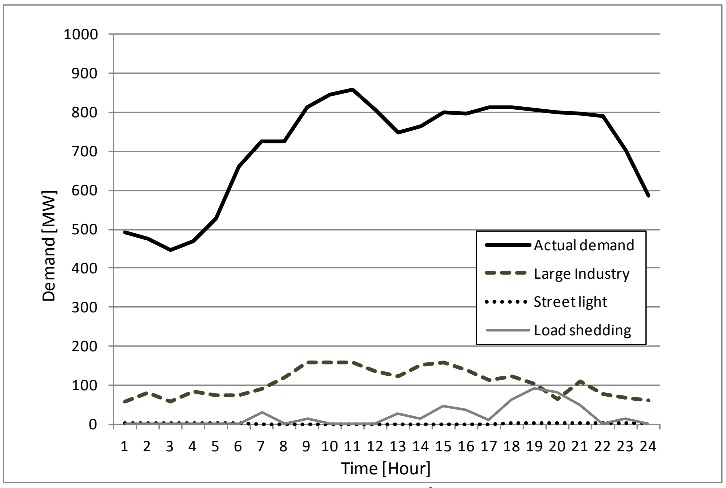
### 2.2.3 Load Curve

Figure 2-6 shows the daily load curve when the maximum demand occurs in a dry season (April 22, 2013: planned outage is implemented). Figure 2-7 shows the daily curve when the maximum demand occurs in a rainy season (June 17, 2013: planned outage is not implemented).




Source: JICA study team based on YESB information

Figure 2-6: Daily Load curve (22/4/2013, dry season, planned outage is implemented)




Source: JICA study team based on YESB information

Figure 2-7: Present Status (17/6/2013, rainy season, planned outage is not implemented)

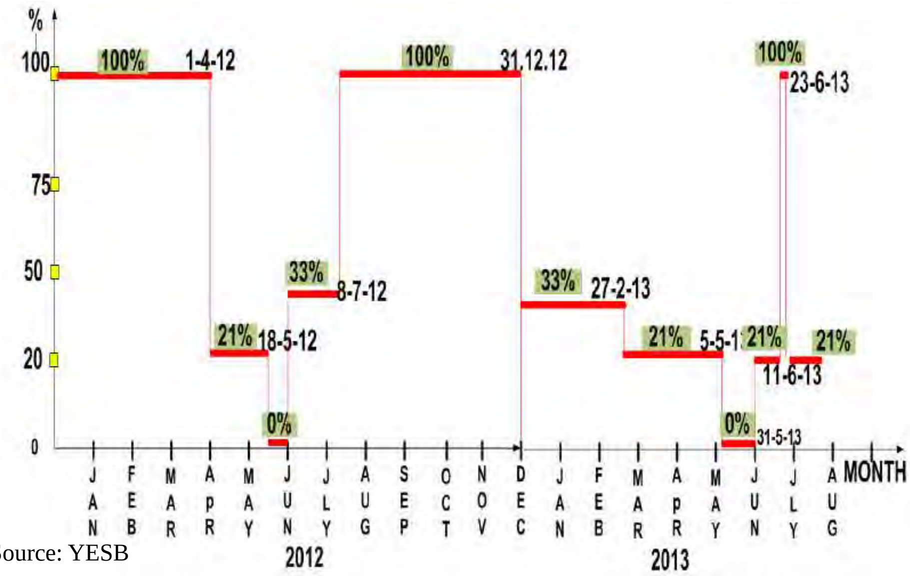
## 2.3 Present status of electric power facilities in YESB

The electric power systems in YESB are roughly divided into two types: the power transmission systems ranged between 66kV and 33kV and the power distribution systems of 11kV or less. Prior to this investigation, the present status of the YESB facilities were surveyed. The report provided in this section will be divided into the former power transmission and transformation facilities and the latter power distribution facilities.

### 2.3.1 Industrial Zones

In the distribution area of YESB, there are 15 industrial zones. As mentioned, however, due to the power shortage, these industrial zones receive very limited supply. Even in the rainy season, the industrial zones receive power for only 5 hours each day. In May 2013, the industrial zones received zero power for a full month.

Since it is impossible to conduct a stable operation under such condition, all factories own their own generators to procure their own power. The level of these self-procured-demand has not been thoroughly studied. The peak demand and installed capacity for each industrial zones are available, though. These can be utilized to estimate demand.




Source: YESB

Figure 2-8: Power supply to the Industrial Zones from YESB

Table 2-2: Industrial Zones in Yangon

| Name | open | area(ha) | No of factories | Capacity (MVA) | Peak Load (MW) |
|---|---|---|---|---|---|
| DagonSeikkan | 1997 | 489.1 | 102 | 30 | 8.99 |
| East Dagon | 2000 | 317.3 | 45 | 25 | 7.08 |
| North Okkalapa | 1998 | 44.4 | 94 | 15 | 4.8 |
| South Dagon | 1992 | 300.8 | 2078 | 100 | 18.1 |
| South Okkalapa | 2000 | 14.2 | 95 | 10 | 2.3 |
| Thaketa | 1999 | 80.9 | 90 | 10 | 2.25 |
| Shwepaukkan | 1998 | 38.3 | 244 | 25 | 5.21 |
| Shwelinpan | 2002 | 445.2 | 203 | 35 | 12.9 |
| HlaingTharYar (1,2,3,4,6,7) | 1995 | 567.1 | 519 | 75 | 42.1 |
| MingaladonPyinmabin *1 | 1996 | 89.8 | 6 | 15 | 5.25 |
| Wartaya | 2004 | 445 | 3 | 10 | 1.8 |
| ShwePyiThar | 1996 | 535.6 | 240 | 55 | 21.2 |
| Yangon Industrial Zone | 2000 | 365.2 | 31 | 20 | 4.5 |
| Myaungtaga (Hmawbi) | 2006 | 411 | 22 | 100 | 32.3 |

Source: YESB and JETRO *1: includes 2 industrial zones

YESB currently has a plan to turn all industrial zones into a semi-independent grid, each with their own generation capacity and operated by a private commercial entity. In July 2013, the plan and bid solicitation for this project has been announced. If this proceeds as planned, these mini-grids will become almost separated from YESB. However, the domestic demand within these mini-grids needs to be maintained at the current YESB tariff, which would require some supply or pass-through agreement with YESB.

With this plan, the industrial demand will be met by these mini-grids themselves, without any burden to YESB. While bids were solicited for all 15 industrial zones, the extent of the plan, and whether there will be bids for all the industrial zones, still remains to be seen. For some zones, however, commercial firms are already undertaking the distribution, and they were willing to bid for their zones.

### 2.3.2 Present status of power transmission and substation facilities

#### (1) Summary of electric power systems in Yangon

The electric power systems of 230kV and 132kV in Myanmar are operated and managed by MEPE. The electric power facilities for the power distribution lines of 66kV and less are operated and managed by MEPE or local public electric power supply corporations. The points to supply electric power to the YESB include Hlawga, Thaketa, Hlaingtharyar, Bayintnaung, Myaungdagar, Thanlyin and Ahlone power stations, which are the 230 kV power stations and substations under the jurisdiction of the MEPE.

The voltage classes the YESB employs include 66kV, 33kV, 11kV, 6.6kV, 400V and 220V. For the purpose of this document, the classes of 11kV and less shall be called power distribution while the classes 66kV and 33kV shall be called power transmission.

#### (2) Transmission lines

#### 1) Summary of transmission lines

Most 66kV transmission lines are overhead transmission lines and employs Aluminum Conductor Steel Reinforced (ACSR) for conductors. The underground cables are introduced in some cases such as crossing road, downtown area where overhead line cannot be installed. Cross-linked polyethylene (XLPE) is applied as electric power cables.

As an example of the 66kV underground cables, Figure 2-9 shows the 66kV transmission lines for Mawtin substation (transformers manufactured in 2011) visited for the first activity. The underground cables are laid between Mawtin substation and Ahlone power station.

Figure 2-9: Cable head for 66kV transmission line service entrances at Mawtin substation

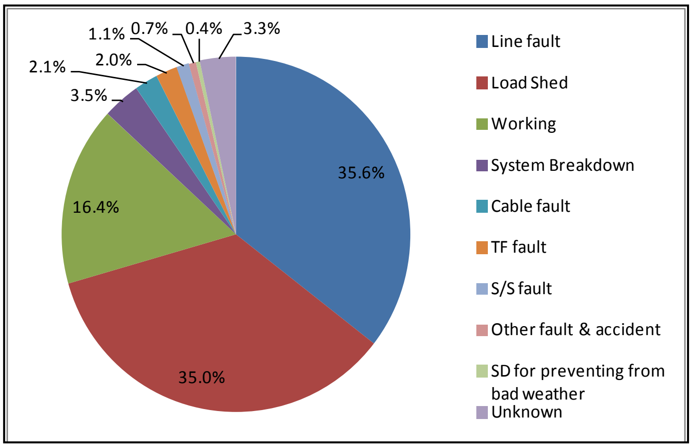
Overhead transmission lines or underground cables are also used for 33kV transmission lines. The ACSR is employed for the overhead lines. The underground XLPE cables are laid mainly in the city. In the downtown area in particular, the use of underground cables is intended for both 66kV and 33kV lines due to the difficulty in securing the site for installing overhead lines and for the purpose of reducing line faults. The underground cables are directly buried.

Overhead transmission lines are supported either by iron towers or concrete poles. Most 33kV transmission lines are supported by concrete poles, and the sites requiring intensity are supported by several concrete poles. Figure 2-10 shows an example of the 33kV transmission lines close to a substation.

Figure 2-10: Khayaebin substation and 33kV transmission lines

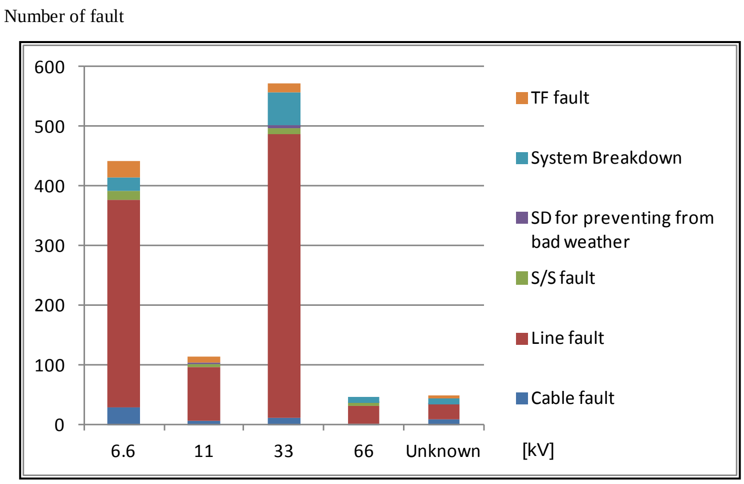
**2) Outage records**

The interruption of the outage records kept by the YESB indicates that the fault of overhead transmission lines is the most frequent cause of power outage and load shedding is also the major cause (see Figure 2-11). Figure 2-12 shows the frequency of power outage by fault at each voltage class. The Figure indicates the frequent occurrence of the fault of 33kV transmission lines and 6.6kV distribution lines. This is explained by the large number of facilities for 33kV transmission lines and 6.6kV distribution lines. The frequent use of naked wires for overhead lines has led to a number of short-circuit and grounding (earthing) faults due to a contact to trees or other wires.




Source: JICA survey team based on YESB information (Report from June 1 to June 30, 2013)

Figure 2-11: Proportions of reasons for power outage (no. of times)




Source: JICA survey team based on YESB information (Report from June 1 to June 30, 2013)

Figure 2-12: Fault frequency at each voltage class

### (3) Substations

#### 1) Substations

This section describes the substations for power distribution owning the power transformers with the primary voltage of 66kV or 33kV.

The list of power transmission substations and transformers as of June 2013 was prepared by collecting data from and interviews with the YESB for the specifications of the substations and transformers controlled by the YESB.

The YESB is preparing the lists associated with transformers, including the list of substations (indicating the substation names, voltage and capacity), the list of transformers (indicating the substation names, voltages, capacities, manufacturers, part of the manufacturing years and the maximum load capacities) and the list of facilities (voltage, manufacturers and quantity of transformers or switchgears, chargers and batteries,). The disorganized information on facilities management possibly means latest information is not managed in an accurate manner. In addition, there is limited availability of the data such as the manufacturer and manufacturing year of transformers, and the information necessary for facility replacement, inspection and maintenance is not sufficient. There is no data available on facilities like switchgears or protection control panels.

The specifications of the power transformers should ideally be organized as the facilities management record as such information as the manufacturing years, manufacturers and types of substations is necessary for equipment replacement, inspection and maintenance, and activities on failure and fault.

Table 2-3 shows the number of substations. All the 66kV substations are manned. The manned 33kV substations account for as high as 62% as they cannot be remotely controlled. Since the YESB substations have yet to introduce Supervisory Control and Data Acquisition (SCADA) and when to introduce is unknown, all 66kV substations could remain constructed as manned substations in contrast to the 33kV substations to be constructed as unmanned substations for a while.

Some of the 33kV substations have been constructed as indoor substations (with the transformers placed indoor), accounting for about 15%.

Table 2-3: Number of Substations

| P-Voltage | Manned | Unmanned |
|---|---|---|
| 66kV | 19 | 0 |
| 33kV | 65 | 42 |

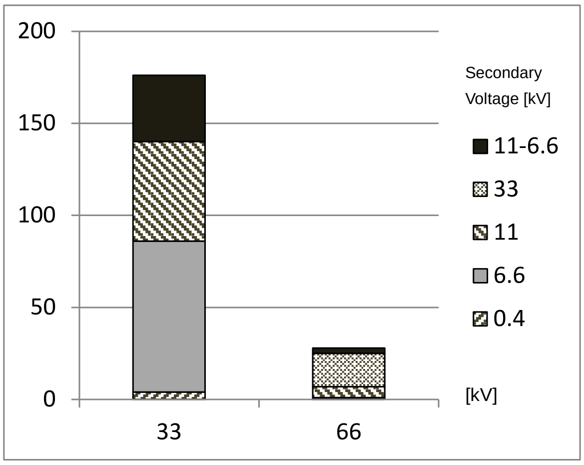
Source: YESB information, as of 19/June/2013

The abnormality of substations is checked by round check, which is carried out by the headquarters at 3 to 4 sites a day and in 2 to 3 days a week. Consequently, a frequency of round check for each substation is about every 3 months. During the round check, the conditions of the power transformers, buildings, lightings and displayed objects (e.g. one-line diagrams) are checked, and reported to the distribution department of the headquarters in the form of the Round Check Report.

No periodical inspection (routine maintenance) is basically carried out. The shutdown maintenance previously done is not implemented at this stage as the majority of transmission lines and substations have the one line service – one transformer configuration which needs to cut electricity for inspections

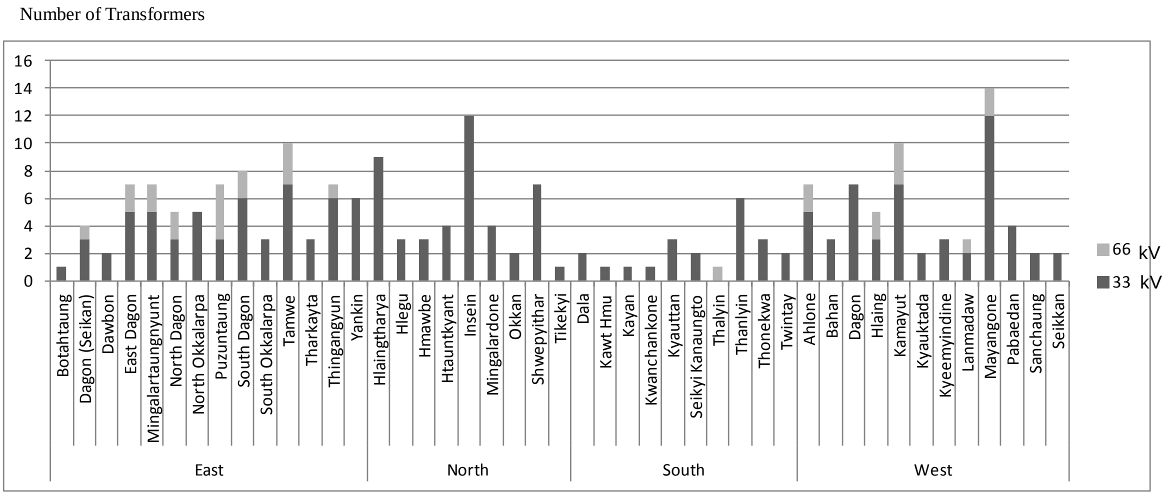
**2) Transformer**

Figure 2-13 shows the number of 33kV and 66kV transformers. The number of 66kV and 33kV transformers YESB owns is 204 (66kV: 28, 33kV: 176, as of June/2013). The majority of the secondary voltage of 66kV transformers is 33kV at present; however, YESB intends to increase the number of 66/11-6.6kV transformer in the future. 6.6kV and 11kV are used as the secondary voltage for 33kV transformers. More than 70% of the 66kV transformers have the capacity of 30 MVA. 43% of the 33kV transformers have the capacity of 10 MVA while 27% have 5 MVA. Figure 2-14 shows the number of transformers in each township.



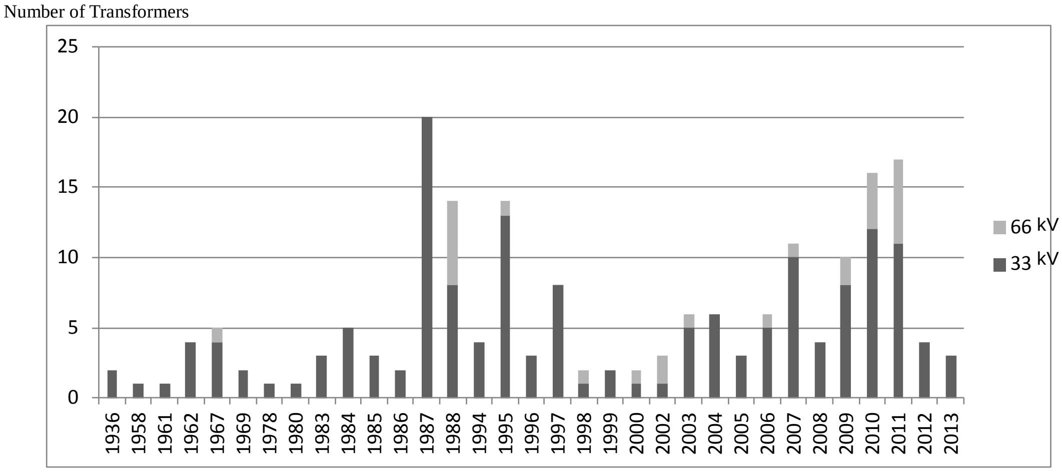

Source: YESB information, as of 19/June/2013

Figure 2-13: Number of transformers



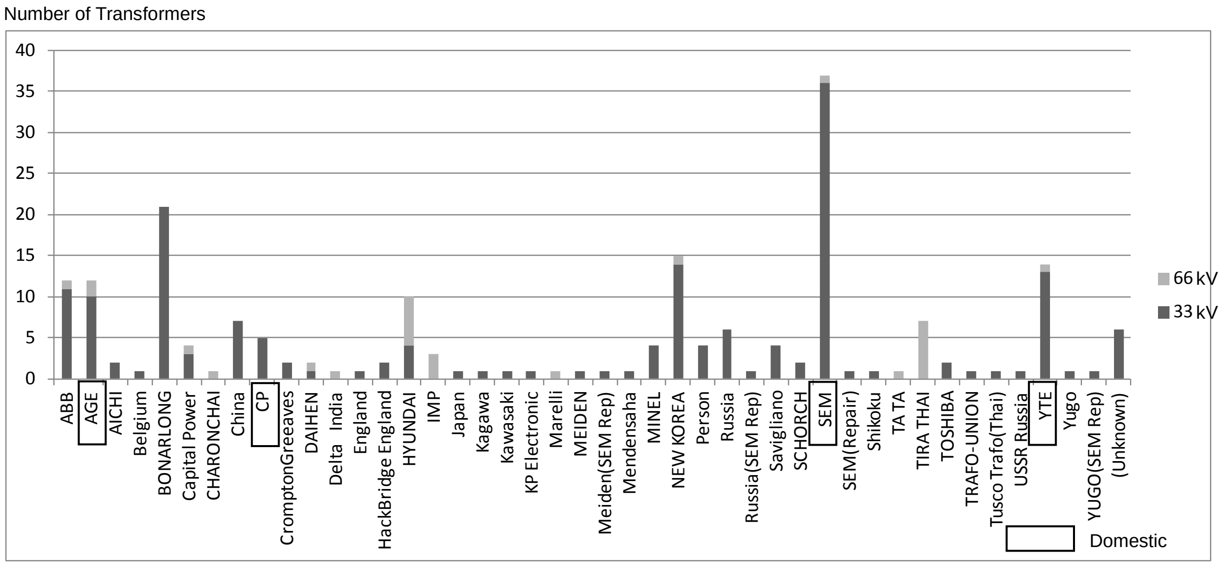

Source: YESB information, as of 19/June/2013

Figure 2-14: Number of transformers in each township




Source: YESB information, as of 19/June/2013

Figure 2-15: Number of transformers in each manufacturing year




Source: YESB information, as of 19/June/2013

Figure 2-16: Number of transformers by each transformer manufacturer

Figure 2-15 shows the number of transformers in each manufacturing year. The number of transformers manufactured and installed in the latter half of 1980s and the former half of 1990s is comparatively large. In addition, the number of transformer installation has been increasing with the growth of demand in recent years.

Figure 2-16 shows the number of transformers delivered by each transformer manufacturer. Some transformers are managed with a country name. Under economic sanctions in recent years, they have been purchased from Burmese manufacturers (about 33% of the transformers have been delivered from domestic manufacturers).

Table 2-4 shows the major specifications of the transformers YESB owns. A few units of On-Load Tap Charger (OLTC) are used currently. This is because the voltage fluctuation of YESB system is very large and frequent, and frequent operation of OLTC is worried.

Table 2-4: Standard Specification of Power Transformer

| Item | Specification |
|---|---|
| Voltage | 66/33kV，66/11-6.6kV, 33/11kV, 33/6.6kV |
| Capacity | 66/33kV: 30MVA,<br>66/11-6.6kV: 10, 20, 30MVA<br>33/11kV, 33/6.6kV: 10MVA, 5MVA |
| Insulation, Cooling | ONAN |
| LTC | No-voltage Tap Changer |
| Incoming / Outgoing | Power cable, connection on bushing |
| Installation | Indoor, Outdoor |

Source: YESB information

Table 2-5: Procedure of action for power transformer breakdown

| Step | Procedure, Action |
|---|---|
| 1 | Break down of power transformer |
| 2 | YESB asks domestic manufacturers whether carry in alternative transformer immediately or not. |
| 3 | Some manufacturer agrees. |
| 4 | (Manufacturer) Preparing alternative transformer<br>(YESB) Dismantlement of fault transformer |
| 5 | Carrying in transformer in substation |
| 6 | Installation, connection, testing |
| 7 | Operating |
| 8 | Tender of repair of fault transformer (domestic manufacturers) |
| 9 | Repair of fault transformer in factory |
| 10 | Installation of repair transformer to original substation.<br>Removal of alternative transformer. |
| 11 | Use removed alternative transformer for another substation project. |

Source: YESB information

The transformers are not subject to inspection. Breakdown Maintenance (BM) is applied to the transformers once any breakdown or defect is found. The shutdown maintenance previously done involved the insulation resistance test and the withstand voltage measurement of insulating oil.

In case of transformer breakdown, the steps shown in Table 2-5 are taken.

**3) Switchgear**

Table 2-6 shows the major types of the switchgears. Figure 2-17 through Figure 2-19 present the photos of the main switchgears. The YESB is calling air insulated switchgear in outdoor "Switch bay".

Table 2-6: Switchgears in YESB

| Switchgear | Equipment |
|---|---|
| 66kV Switch bay | CB (OCB, GCB), DS, ES, CT, PT, LA |
| 33kV Switch bay | CB (OCB, GCB), DS, ES, CT, PT, LA |
| 33kV Switchgear | Cubicle type with built-in protection relays, Indoor installation, LOCB or GCB or VCB |
| 11-6.6kV Switchgear | |

Source: YESB information

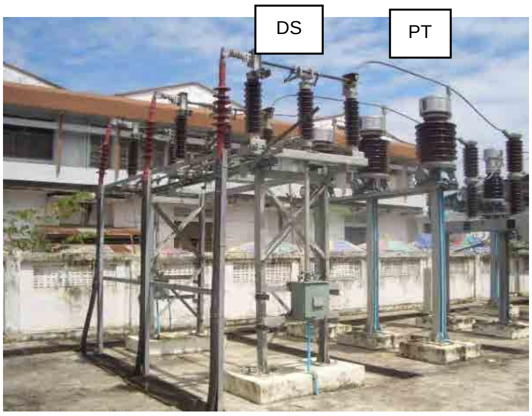



Figure 2-17: 66kV DS (with ES)


Figure 2-18: 66kV PT, GCB, CT, LA


Figure 2-19: 33kV and 11kV Switchgear

The switchgears for 11kV specifications are used for the 6.6kV switchgears as 6.6kV distribution lines are planned to be sequentially uprated to 11kV distribution lines.

The YESB has yet to introduce any Gas Insulated Switchgear (GIS). The first 66kV GIS is to be applied to the Railway S/S currently under construction.

For the 33kV switchgear, there are two kinds of switchgears, air insulated type "switch bay" in outdoor and cubicle type switchgear in indoor. For the 66kV switchgear, switch bay has been applied in outdoor. However, either the GIS or switch bay is selected according to the site conditions of the substations at present.

Most switches are manufactured by foreign manufacturers. There are some Burmese manufacturers of 11-6.6kV switchgears, but they are assembling companies which procure the main components from overseas for assembly.

The switchgears are also not subject to inspection due to the constraints of power outage. The shutdown maintenance previously done implemented an inspection on circuit breakers including greasing the operating mechanism, measuring insulation resistance and checking contacts (check zero or open by means of the contact resistance measurement of the main circuit). Disconnecting switches (DS) and earthing switches (ES) are not inspected as they are manually operated and the lines are being charged even during shut down.

The cases of defective switchgears include malfunctioning and insulation failure of the CB, damages to surge arresters (LA) by lightning stroke and terminal connections overheating. Some aged OCBs are incapable of closing or tripping. Such aged products cannot be repaired because some parts are discontinued. The aged OCBs are being replaced sequentially, but being used as the simple manual switches until they are replaced. In case of line fault, they are interrupted by the CB installed in opposite side substation or the secondary CB of the transformers.

The most frequently seen defects at substations may be flash over resulting from insulation degradation of the CB in the 33kV cubicles. Damp and dust that degrade insulation consequently causes flash over. This type of defect tends to be found in humid, rainy seasons. Moisture or dust coming into ventilating openings or cable ducts into substations seems to be absorbed by insulating materials to finally cause dielectric breakdown. Leak sound was heard from the cubicle of the 33kV CB at Seinpanmying substation visited during the first activity. These 33kV CBs have reportedly been left ON despite an application for power outage for repairing due to a lack of a load destination.

**4) Control panel and protection relay**

Transformers are protected with the current differential relay and Over Current (OC) relay. For protecting the secondary transformers and power distribution lines, the OC relay and Ground Over Current relay (GOC Ry) are used. YESB applies direct grounding systems regardless of the voltage classes from 66 kV to 6.6kV, in which the current as large as short-circuit current is carried in case of grounding faults.

Similar to others, protection relays are not inspected. Their relay performances are verified only in case of their fault operation. The analog relay is visually inspected while the operation of the digital relay is checked with performance verification switch found on the main relay unit. Any defective relays are replaced with spare relays.

For overload protection, transformers are generally configured to be tripped by the OC relay once they pass the load current of 80% of the rated current. Transformers are protected from overload operation in this manner as their load current cannot be remotely monitored. When tripped at an overload (80% of the rated current), the countermeasures are taken for changing the setting of the OC relay and raising the setting value (closer to the rated current).

### 2.3.3 Present status of power distribution facilities

#### (1) Medium voltage power distribution lines

Medium-voltage power distribution lines have been maintained to supply electric power to medium-voltage customers and to supply low-voltage electric power of 400(230)V through YESB transformers. YESB employs the three-phase three-wire system by solid neutral grounding. The two types of voltage, i.e. 11kV or 6.6kV, are available for the secondary medium voltage distribution lines of distributing substations, distributing electric power with the either voltage feeder depending on areas.

Overhead lines and underground cables are mixed to almost the same extent in downtown areas. Voltage drop by medium voltage lines has not been a serious problem due to high in load density and relatively short in the length of medium voltage distribution lines although it is difficult to maintain the proper voltage on a constant basis due to a significant influence of voltage fluctuation including the upper systems. The ACSR bare wires of 150, 120, 95, 70, 50 or 35 $mm^2$ are used for medium voltage overhead distribution lines, which often come in contact with trees to cause fault on a frequent basis. The cross-linked polyethylene-insulated cables of 300, 240, 185, 150, 120, 95, 70, 50 or 35$mm^2$ etc. are used for underground medium voltage cables, with a possible fault resulting from insulation failure as the lines are deteriorated after several decades from installation and the fault sites are removed and reused by connection in case a fault occurs.

#### (2) Transformers for low-voltage distribution

Figure 2-20 shows a pole-mounted transformer with three sets of drop out fuses, disconnection switches and arrestors. The 11-6.6/0.4kV three-phase transformers of various capacities including 2,000, 1,250, 1,000, 750, 500, 400, 315, 300, 250, 200, 160, 150, 100 and 50kVA etc. are used for 400(230)V power distribution. The transformers accepting both 11kV and 6.6kV primary taps are mostly used in installation on the 6.6kV distribution lines considering future voltage rising to 11kV.

The 11-6.6/0.4kV transformer comes with the 5-step tap changer, but overvoltage by a fluctuation in the voltage of upper systems must be noted in addition to voltage drop. Therefore, the transformer taps are not systematically made use of from the upstream to downstream sides, and the taps of individual transformers are changed in case the significant influence of voltage drop leads to a problem.

As for the transformers for power distribution lines, those of large capacity are installed in general, with the low-voltage lines extending to the scattered loads for power distribution. This has resulted in significant voltage drop in low-voltage lines and failure to ensure proper voltage (some consumers receive electricity of 100V or less), causing frequent power loss in long low-voltage lines. In dealing with these problems, the YESB is thinking about establishing the facilities that distribute the transformers of relatively small capacity and shorten the length of low-voltage lines (called the multi-transformer system) as is the case in Japan although the most appropriate method has yet to reach the stage of considerations in detail.

Figure 2-20: Transformer with a set of drop out fuses, disconnection switches and arrestors mounted on two poles

**(3) Low-voltage power distribution lines**

Hard drawn copper wires of 3/0, 2/0, 1/0, No1, 2, 4, 6, 8 of Imperial Standards Wire Gauge or hard drawn copper stranded wires of 100, 60, 50, 35, 25 or 7/12 $mm^2$ etc. are currently used for overhead low-voltage lines, many of which are bare wires with some spots in contact with trees. The cross-linked polyethylene-insulated cables of 240, 185, 150, 120, 95, 70 or 35 $mm^2$ etc. are used for underground low-voltage cables. The service wires from low-voltage line supports to consumers are the properties of the consumers, and employ the covered stranded wires. Most service wires are connected to the structures in a random manner (Figure 2-21). Contact with trees often seen should be a problem to be solved in addition to the excessive voltage drop or power loss at the abovementioned long low-voltage lines.

Figure 2-21: Service wire connection in a random manner

### (4) Measuring instruments

Power loss includes non-technical losses such as electricity theft, and the YESB considers this as an important problem to be solved. With the possible cases of unauthorized connection to random bare wires or branching at hidden sections of houses as abovementioned, various countermeasures are being considered by sharing the cases of unauthorized power reception and performing visual inspections by the meter reader or by developing the digital measuring instruments of the offset meter reading to be mounted to the power poles at the structures. Figure 2-22 shows offset meter reading mounted on a pole. However, there is no fundamental solution available yet as the countermeasures that may be effective for reducing non-technical losses require additional costs, or even worse, the unauthorized modification of the internal measuring instruments makes it more difficult to detect such theft.

Figure 2-22: Offsite meter reading system on a pole

## 2.4 Distribution loss

Table 2-7 shows the changes in distribution loss under the jurisdiction of YESB. The YESB has made the following efforts for reducing loss since 2006, leading to the distribution loss reduced by about 5% from 24.07% in 2006 to 18.65% in FY2012.

- Replace old electromagnetic energy meter with Digital Meter (Offsite meter reading system)
- Replace 400V bare conductor overhead distribution line with insulated thicker conductor
- Upgrade 6.6kV distribution system to 11kV voltage level
- Upgrade 33kV distribution system to 66kV voltage level, etc.

Table 2-7: Distribution loss

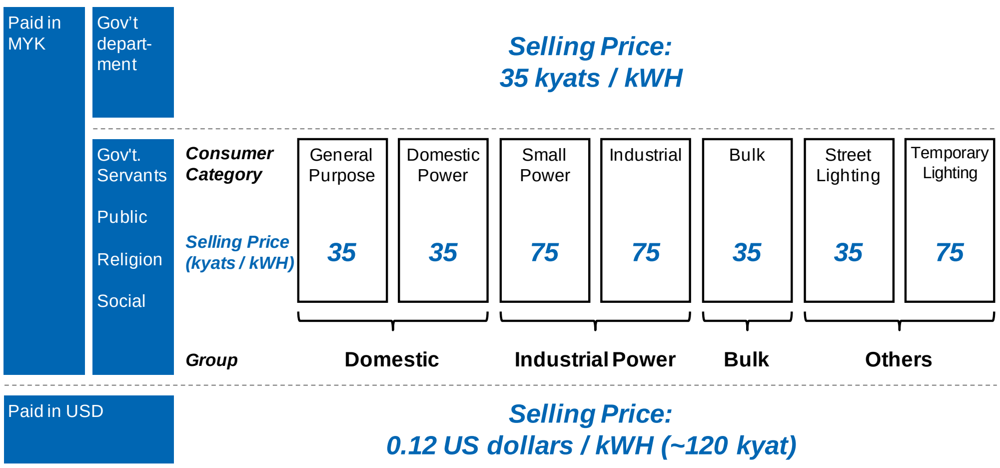
| Year (FY) | Purchase from MEPE | Unit Sold (Million kWh) | Loss | |
|---|---|---|---|---|
| | | | Unit (Million kWh) | % |
| 2006 | 2,623.93 | 1,992.44 | 631.49 | 24.07 |
| 2007 | 2,737.98 | 2,087.62 | 650.36 | 23.75 |
| 2008 | 2,759.74 | 2,153.80 | 605.94 | 21.96 |
| 2009 | 2,843.47 | 2,213.94 | 629.53 | 22.13 |
| 2010 | 3,611.29 | 2,892.94 | 718.35 | 19.89 |
| 2011 | 4,365.15 | 3,524.78 | 840.37 | 19.25 |
| 2012 | 4,612.77 | 3,752.48 | 860.29 | 18.65 |

Source: YESB Statistics

## 2.5 Electricity Tariffs

### 2.5.1 Tariff Structure

YESB's charges different tariffs depending on the type of user. Generally, industrial users are charged 75 Kyats / kWh, while most other users pay 35 Kyats / kWh. YESB's tariff structure as of July 2013 is summarized below[1]:




Source: YESB Statistics

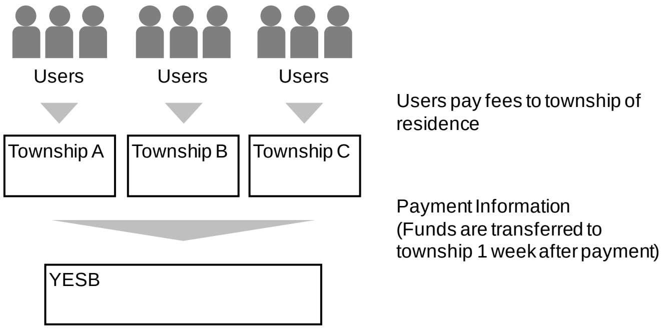
Figure 2-23: YESB's Tariff Structure

Foreign users, who comprise a small minority of YESB's users (around 1,600 users per year, or less than 0.2%), are required to make electricity payments in USD. YESB could not provide a breakdown between USD-paying domestic and industrial users.

[1]YESB has a new tariff structure scheduled to take effect in April 2014, which will be explained later in this chapter.

### 2.5.2 Tariff Collection

Payments to YESB are typically made at the township office where the user resides. Users deposit payments at collection booths inside township offices that are staffed by township office employees. The townships aggregate the payment report and send it to YESB once at the end of the month.

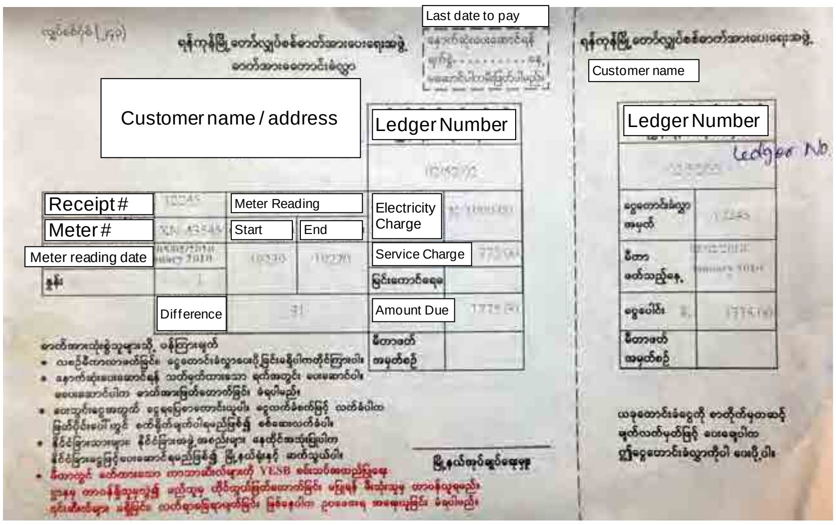



Source: YESB information

Figure 2-24: Typical Tariff Collection Scheme

An alternative payment scheme was recently implemented, which lets users make payments at United Amara Bank, a major commercial bank, by depositing funds in YESB's bank account there. However, this method is not very popular; most users continue to pay their electricity bills at their township offices.

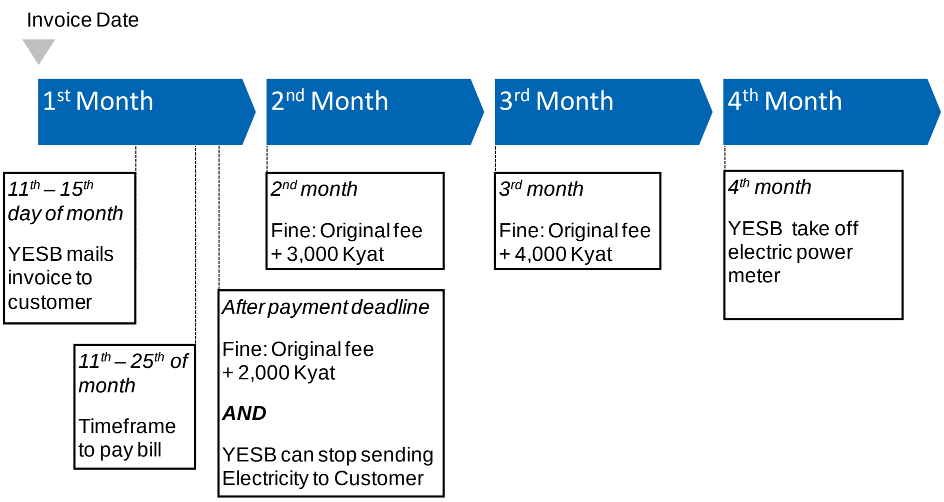
Invoices are sent to users via paper slips. Industrial users and households located in the more densely populated townships receive typewritten invoices. Residents of more sparsely populated areas receive invoices where user-specific information is written by hand.




Source: YESB

Figure 2-25: Invoice Sent to Users

YESB requires users to pay tariffs on a monthly basis. Users receive invoices around the 11th to 15th day of each month, and pay it by 25th day of the month. If the payment is delinquent, then YESB has the authority to stop sending electricity to the user. If, after 4 months, the user still has not made the required payment, then YESB will physicaly remove the electricity meter from the said user's premises.




Source: YESB information

Figure 2-26: Schedule for Payment and Fines

## 2.6 YESB's Financials

### 2.6.1 YESB's Budget

Since the 2011 fiscal year, YESB is run on Myanmar's state budget. From YESB's perspective, this means that a major portion of YESB's income is returned to Myanmar's government at the end of the fiscal year. In return, the government allocates funds for YESB to make capital expenditures, which will be discussed in this section.

In August 2012, the purchase price of electricity (electricity that YESB purchases from MEPE) doubled from 20 Kyats/kWh to 40 Kyats/kWh. In other words, for non-industrial users, YESB would be selling electricity at a loss (for each kWh sold to a residential customer, YESB loses at least 5 Kyats)[2].

Subsequent changes to YESB's revenue structure have resolved this issue, but such changes are often led by the government, and involve little, if any, prior input from YESB.

### 2.6.2 Potential Issues

There are a few areas that should be looked at more closely.

#### (1) Tariff Schedule for FY 2014

In October 2013, MEOP announced further increases in YESB's electricity tariffs. The increase was announced by the Ministry of Electric Power. Unlike the previous tariff structure, the new tariff structure levies a higher per unit charge for heavy users of electricity, but for household users using less than 100 units per month, there will be no change in electricity pricing.

[2]This follows an electricity rate increase effective January 2012. The previous rate, 25 Kyats/kWh for non-industrial use and 50 Kyats/kWh for industrial use, were raised to 35 Kyats/kWh and 75 Kyats/kWh respectively.

1. In order to cover costs of producing and purchasing electricity to a certain extent, Yangon City Electricity Supply Board has set the following unit prices to be charged as of electricity consumption in November, 2013.

(a) Public (household use)

| | |
|---|---|
| (1) From one unit to 100 units | 35 Kyats |
| (2)101 units and above | 50 Kyats[3] |

(b)Public (industry, enterprise, lump sum, temporary)

| | |
|---|---|
| (1) From one unit to 5,000 units | 100 Kyats |
| (2)5,001 units and above | 150 Kyats[4] |

(c)Government Department

| | |
|---|---|
| (1)Office use | 50 Kyats |
| (2)Industrial use | 100 Kyats |

2. It is announced that the electricity bills charging the amount of electricity consumption in November, 2013 in accord with the new unit prices shown in the paragraph -1 will be sent to the public as of December, 2013.

**Yangon City Electricity Supply Board**

Figure 2-27: YESB's tariffs (initial plan for 2014-15 fiscal year)

**(2) Decision-making Process for Electricity Tariff Changes**

YESB's electricity tariff increases are submitted by MOEP to the parliament of Myanmar for approval. A key distinction in this decision-making process is that YESB is not involved in decision-making for its own electricity rate changes.

The most recent tariff increase is a case in point; none of the survey team's counterparts at YESB were aware of the tariff structure change, and as a result of the announcement, expended considerable resources to make sure YESB's users were aware of the change.

Initially, the increases announced on October 28 were to take effect starting in November, but following opposition from the government, YESB delayed the implementation of the new fee structure until FY 2014[5]. MOEP will review the rate hike and report its findings to the parliament on the revised plan before the April 2014, when the fiscal year for 2014 begins.

This example shows that future tariff increases for YESB will be done at the behest of the government of Myanmar, rather than by YESB's own accord. This presents a potential business risk for YESB; if procurement costs from MEPE increase again, there may be a time delay in implementing necessary changes to its tariff structure. That being said, seeing as the government reviews electricity pricing on a yearly basis, YESB would not be forced to maintain a pricing structure where it would be distributing electricity at a loss.[6]

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[3] 50 Kyats per unit for each unit in excess of 100
[4] 150 Kyats per unit for each unit in excess of 5,000
[5] The New Light of Myanmar, "Clarification on motion to review electricity rate rise recorded at Pyidaungsu Hluttaw session." 15 November, 2013.
[6] Eleven Myanmar, "Increase in electricity prices will not be reduced - Minister" URL:

### (3) Outsourcing

Another power-related issue in Yangon is the lack of steady power available for industrial use. Due to capacity issues, planned blackouts are implemented during Myanmar's dry season, leaving factories with only 5 hours per day of electricity supplied by YESB. YESB prioritizes domestic users over industrial users when it comes to supplying electricity, which means that the latter are subject to periodic blackouts.

In response, factories have ramped up in-house power generation, but at the same time have called on YESB to take more steps to provide them with electricity.[7] In response, YESB announced that it will outsource electricity distribution for certain townships to third-party providers, and has issued a call for third parties to submit proposals to that effect. Seeing that YESB extended its original deadline of July 31 to August 15, one could reasonably assume that YESB is quite serious about pursuing this alternative solution.

Some of this outsourcing is already taking place. For instance, in some Yangon townships, YESB subcontracted power generation / distribution activities to third party power companies. While the details of the agreements are still unclear, one possible arrangement is for the power company to purchase electricity from YESB, and then distribute the purchased electricity to local customers (residential and industrial). Since these subcontractors undertake operation and maintenance for the electricity transmission facilities it manages, they could charge industrial customers a price higher than that of YESB, but still lower than what industrial customers would incur should they generate their electricity in-house. [8]

The key issue for YESB is how its revenue stream will be affected by subcontracting electricity generation to third parties. On account of these arrangements, YESB will lose revenue from industrial users, which comprise 40% of YESB's revenues. In turn, it would gain revenues from outsourcing tariffs. Of course, the amount in question will depend on contract terms between YESB and such third parties, which have yet to be finalized.

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http://elevenmyanmar.com/national/3917-increase-in-electricity-prices-will-not-be-reduced-minister (accessed on November 4, 2013)

[7] Myanmar Times: “Factory owners consider private power production.” Aug. 4, 2013. URL: http://www.mmtimes.com/index.php/business/7667-factory-owners-consider-private-power-production.html

[8] From onsite visit to the power company’s Yangon office in June 2013

# Chapter 3 Demand Forecast

## 3.1 Power Demand Forecast

Based on the data, this chapter attempts the forecasting of the demand. It should be noted that all forecast here only refers to the current distribution area of YESB. It does not include the demand for Thilawa SEZ.

### 3.1.1 Current demand growth Estimate of YESB

As seen in section 2.2, the demand in Yangon has seen a sudden explosive growth since 2010. Therefore, setting the baseline for growth trend is a big issue. As with all forecasts, there are no absolutes, and the best that can be hoped for is an informed guess. The trend in the past 3-4 years shows a highly fluctuating growth of 30%, 11%, and 16%. Especially, how to think about the initial 30% growth is a big problem. If this figure is included and considers the trend as beginning from 2009, the annual average growth in power demand is 19.2%.On the other hand, it is also possible to consider the 30% growth in 2010 as a one-time occurrence, and the more recent 11%/16% as the basis for the trend. With the limited number of data points, it would be difficult to decide which is more appropriate.

YESB currently uses an annual growth of 19% till 2020. This is using the growth figure from 2009. The assumption that this level of growth will continue for 10 years seems to be aggressive, but not unthinkable.

YESB does not have estimates after 2020. Ministry of Electric Power, however, has an estimate till 2030. In the estimate, the elasticity between GDP growth and power demand is estimated at 1.4. Based on this, they estimate a 13% growth for peak demand. As a comparison, the elasticity figures for Vietnam around 2000, which is comparable to the current situation in Myanmar, are as follows;

1999-2000: 1.82
2001-2005: 1.62
2006-2010: 1.48
2011-2020: 1.39

An elasticity of 1.4 is roughly comparable to these figures. The official GDP growth prospect for Myanmar is about 8.74%. Based on this figure, 13% demand growth seems plausible.

### 3.1.2 Power Demand Forecast (GWh): Based on YESB assumptions

Based on the YESB's original assumption, for the industrial parks, the current peak demand for each industrial park is assumed, and assumes a relatively flat demand to estimate the potential demand.
The result is as follows;

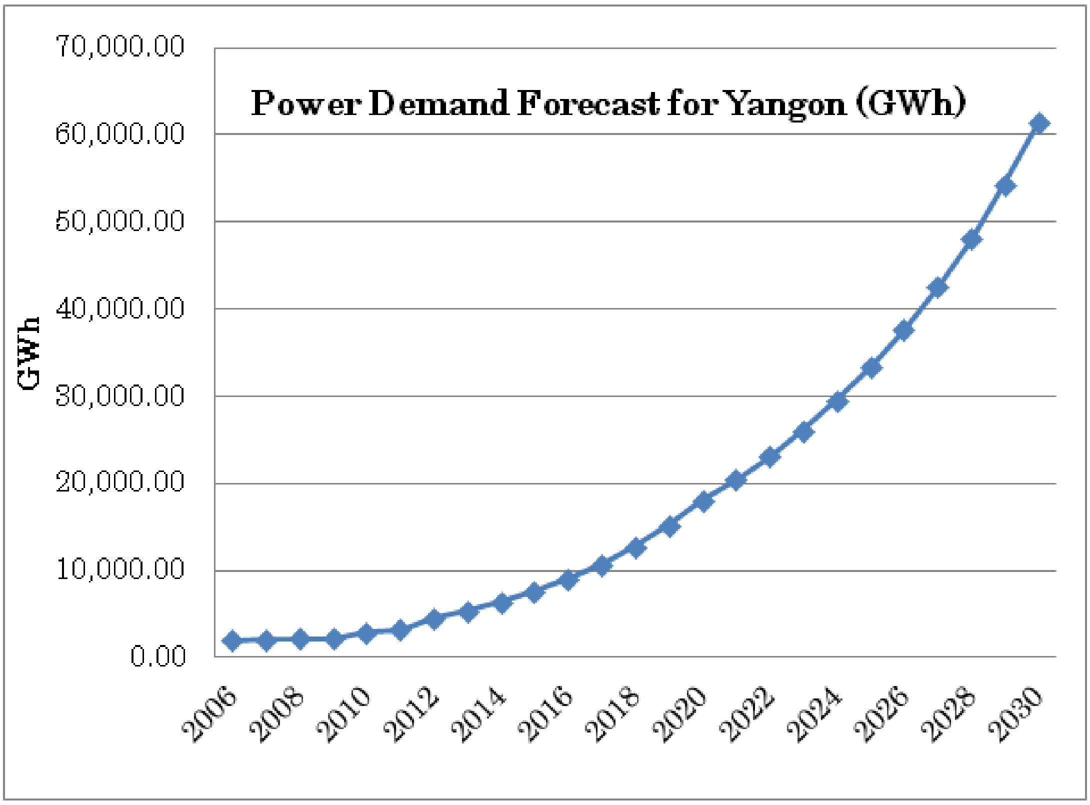



Figure 3-1:Demand forecast based on YESB assumption

The actual demand for 2012-13 was 3,753GWh, but adding in the suppressed potential demand, the real demand is estimated at 4,496GWh. Extrapolating this figure based on the YESB assumption, the demand at 2020 should become 10,801GWh, more than twice the current level, and in 2030, it would be 61,377GWh, about 14 times the current level.

However, the 19% growth till 2020 seems to be on VERY high side of the estimate. On the other hand, after 2020, Yangon City area would have a higher economic growth than the national average, corresponding to more growth in power demand. On the other hand, elasticity between GDP growth and power demand tends to fall with economic growth. This may cause a lower growth in demand.

### 3.1.3 Alternative demand forecast (GWh)

As mentioned, the current YESB forecast seems to be on the higher side of the demand. Some of the major points are:

- 19% annual growth up to 2020-21 seems extremely high.
- 13% annual growth in 2021-22 to 2030-31 is also on the high side.
- The situation with the industrial demand is unclear at the moment.

First, the GWh demand in for the past 3 years did show an annual growth of 19%. However, this reflects the initial 30% and 20% jump in 2010 and 2011, which seems to be a one-time increase cased by the sudden inflow of investment. Yangon has seen significant economic activity growth since then, however, the power demand has dropped to 6%. Average grown for the past 2 years is 14%. It seems unlikely that the growth rate would jump back to 19%, and it seems further unlikely that it will sustain that level for nearly a decade up to 2020-21.

Second, while Myanmar and Yangon is expected to grow at a rapid pace, especially in the coming decade, sustaining 8.75% growth into 2030 would be a struggle. Vietnam during its strong growth in early 2000s amounted to 7.1% annual GDP growth. Even in recent years with its remarkable development, Myanmar's GDP growth is slightly below 7%, and it is likely that future growth would remain in that region. IMF forecasts a growth of 6.7%. Even with higher expected growth as the capital city of Myanmar, 7% growth after 2020 should be more realistic.

Third, the above two points about growth prospects become even more pronounced when one realized that the current demand figure virtually excludes industrial demand. As mentioned in section 3.1.3, for the past few years, extremely limited supply has been provided for industrial demand. Therefore, all the changes in demand should be considered basically as changes in non-industrial use, namely residential, commercial, bulk (schools and hospitals) and street lights.

Another point to consider is the current attempt to separate industrial zones (or rather, townships that contain industrial zones) as self contained independent grids, each with their own generation and distribution capacity. How this will pan out is not clear at the moment. However, if this plan is implemented in the future, the implication for YESB would be different. It would need to be treated separately from the YESB grid.

Therefore, as the alternative demand forecast, the following:

- **Industrial demand will be treated separately**.
  Looking at the industrial demand, it has shown 20% increase over the years. It is assumed that this will continue till 2020. After that, the industrial parks in Yangon will mostly fill up, and the industrial demand growth will be limited to improvements within the existing facilities, with 3% growth annually.

- **Non-industrial demand growth is assumed at a lower level.**
  It is assumed to grow at 14% annually until 2020. After that, the growth will taper down to 9.8% (based on 7% GDP growth and 1.4 demand elasticity).

The result is shown in the next

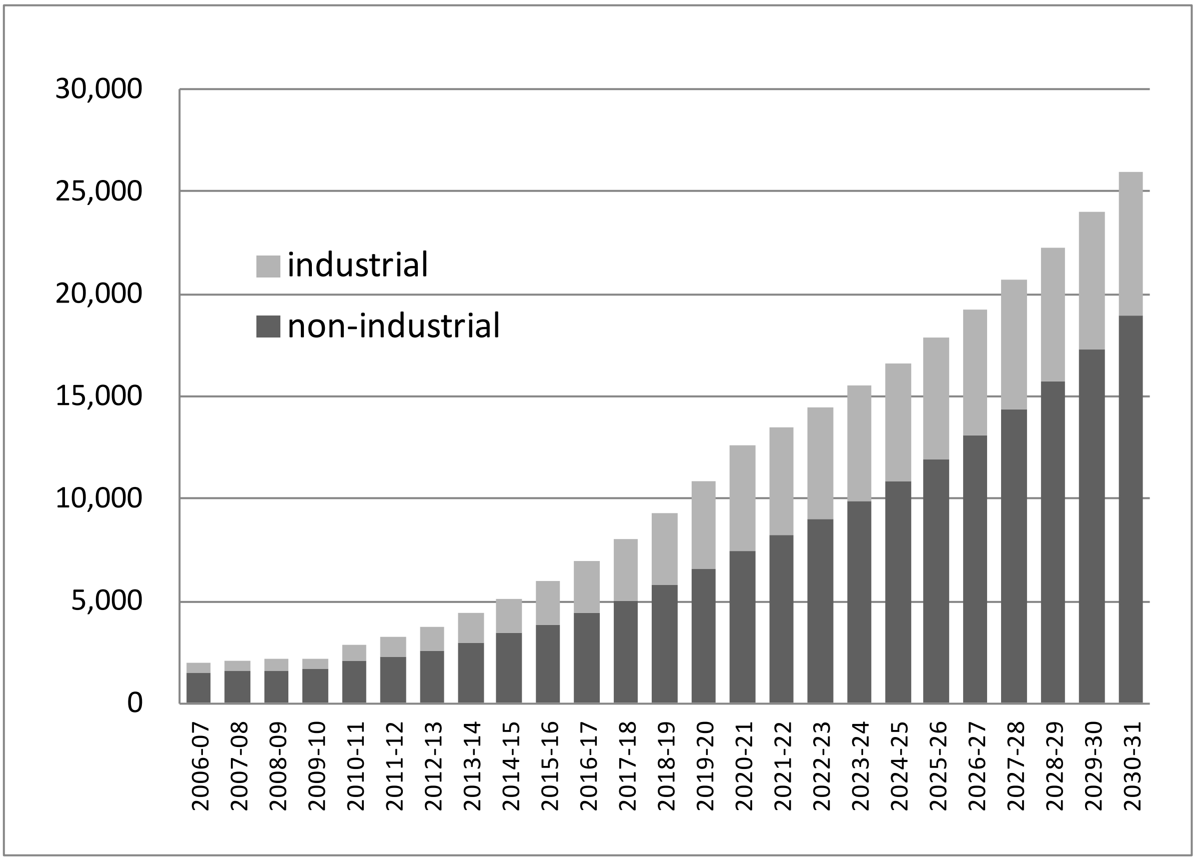



Figure 3-2: Yangon City Power Demand forecast (GWh), Alternative Scenario

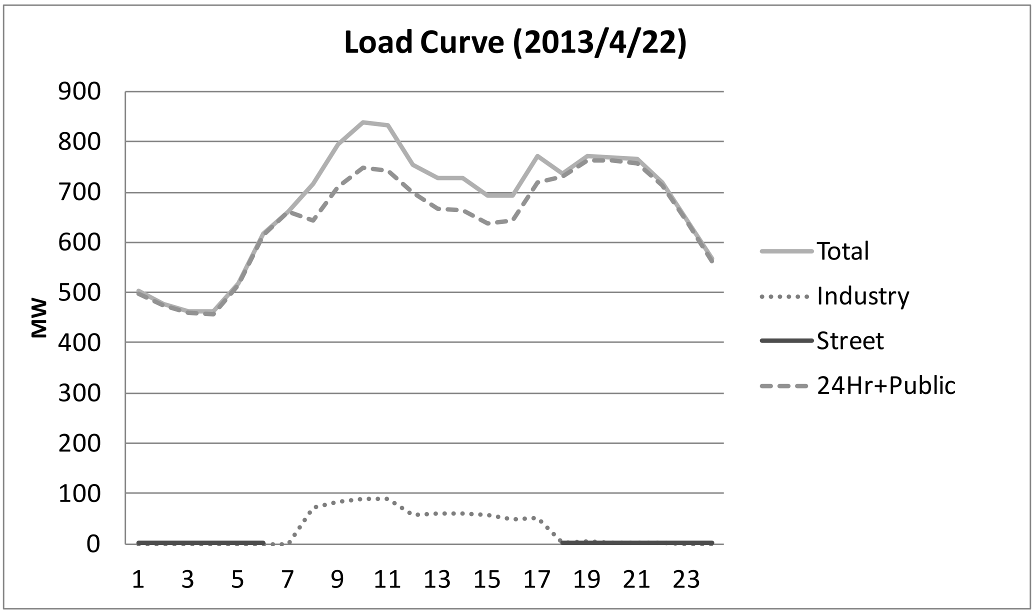
In the alternative scenario, the non-industrial demand in 2020 will be 6,543 GWh, and industrial demand will be 4,307 GWh. The total demand will be 10,850 GWh. This level is very similar to the one based on the YESB assumption (10,801GWh). After that, with significant difference in the growth prospect for both industrial and non-industrial use, the forecast diverges widely. For 2030, the non-industrial demand will be 18,998 GWh, and industrial demand will be 6,946 GWh. The total demand will be 25,944 GWh. This is less than half the one based on the YESB assumption (61,377GWh).

From these results, it seems that the demand for 2020 is probably near the mark. The long term forecast after 2020, however, is highly uncertain. With the limitation on the available data, however, this should be natural. The new phase for Myanmar/Yangon economy only started since 2010, and all growth figures are based on a very few number of data points. Therefore, for the coming years, the demand forecast needs to be constantly revised, since adding a single data should alter the basic assumption significantly.

### 3.1.4 Peak Demand Forecast (MW): Load Curve

Based on this GWh demand forecast, the peak demand is estimated. To do this, the estimate of the load curve is required.

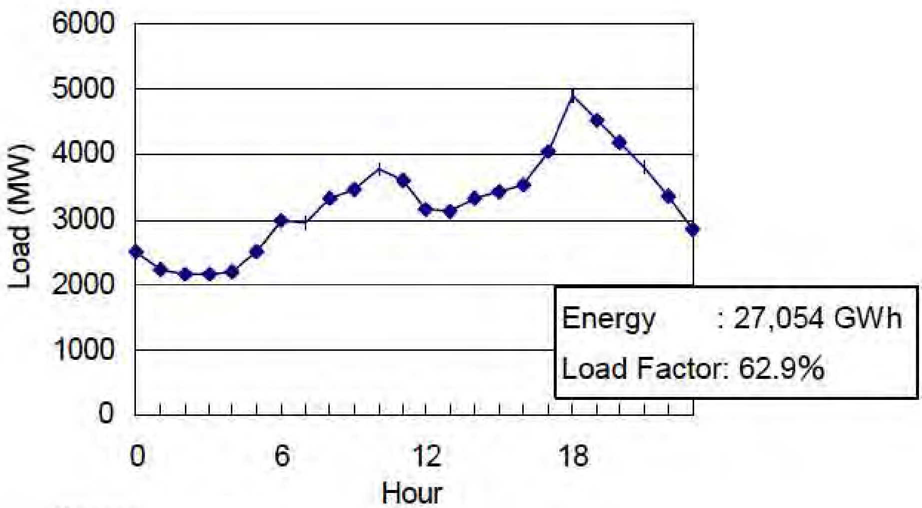
As shown in section 2.2, the current load curve in Yangon has 2 peaks, one in the morning and the other in the evening. This patter is typical in the early stages of economic development.




Source: YESB

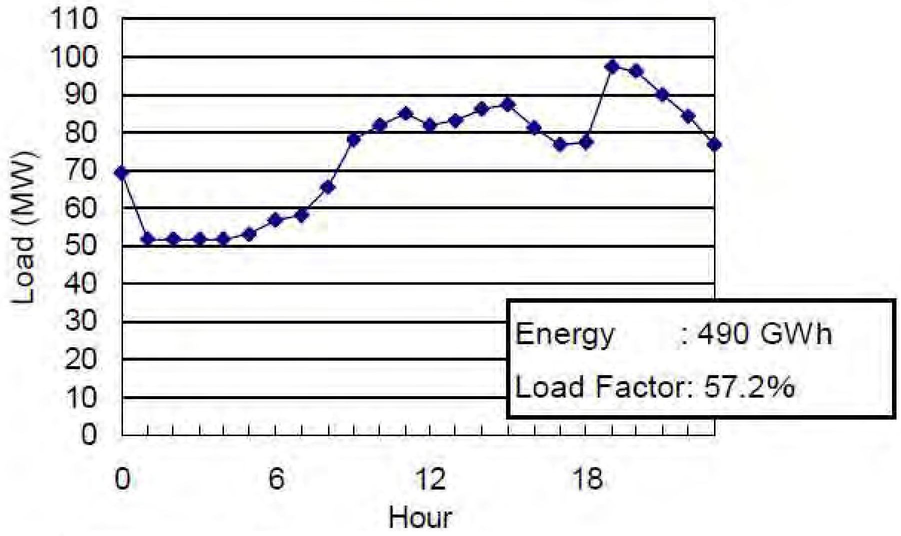
Figure 3-3:Daily Load Curve in Yangon on a Peak Day

With economic development, the pattern of the load curve changes. With increased use of power in households and commercial facilities, especially with air conditioning, the daytime use increases, with the load curve becoming a single peak. For example, the load curve in 2000 at Vietnam or Vientiane (Laos) shows such pattern.




Source: EVN (Electricity of Vietnam) data

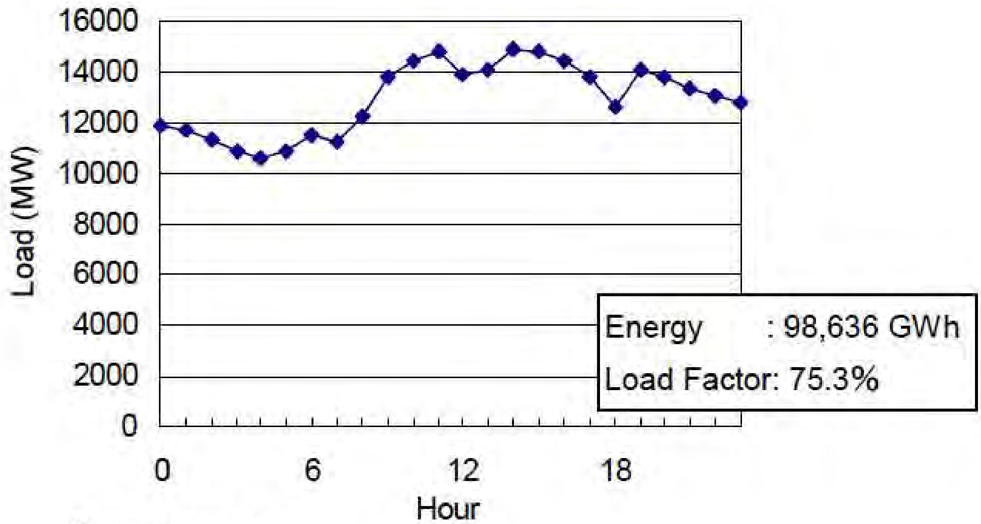
Figure 3-4: Daily Load Curve in Vietnam, 2000




Source: EDL (Electricte Du Laos) data

Figure 3-5: Daily Load Curve in Vientiane, 2000

With further economic development, the daytime air conditioning use rises higher, and this becomes the new peak in the load curve. This is apparent in Thailand in 2000.




Source: EGAT (Electricity Generating Authority of Thailand) data

Figure 3-6:Daily Load Curve in Thailand, 2000

Looking at the GDP per capita figure, Yangon today is at a similar level of economic development as Vietnam 15 years ago. Therefore, the daily load curve looks similar to Vietnam in those days, or to Vientiane in the same period. It is likely that by 2020, it will become similar to Thailand in 2000, and remains at that level indefinitely (Thailand today has a load factor of 75%, which is the same as that of 2000).

Therefore, the load factor for Yangon will be assumed to start from 57% (comparable to those of Vientiane in 2000), to rise from 75% in 2020 (similar to Thailand), and remain at that level afterwards.

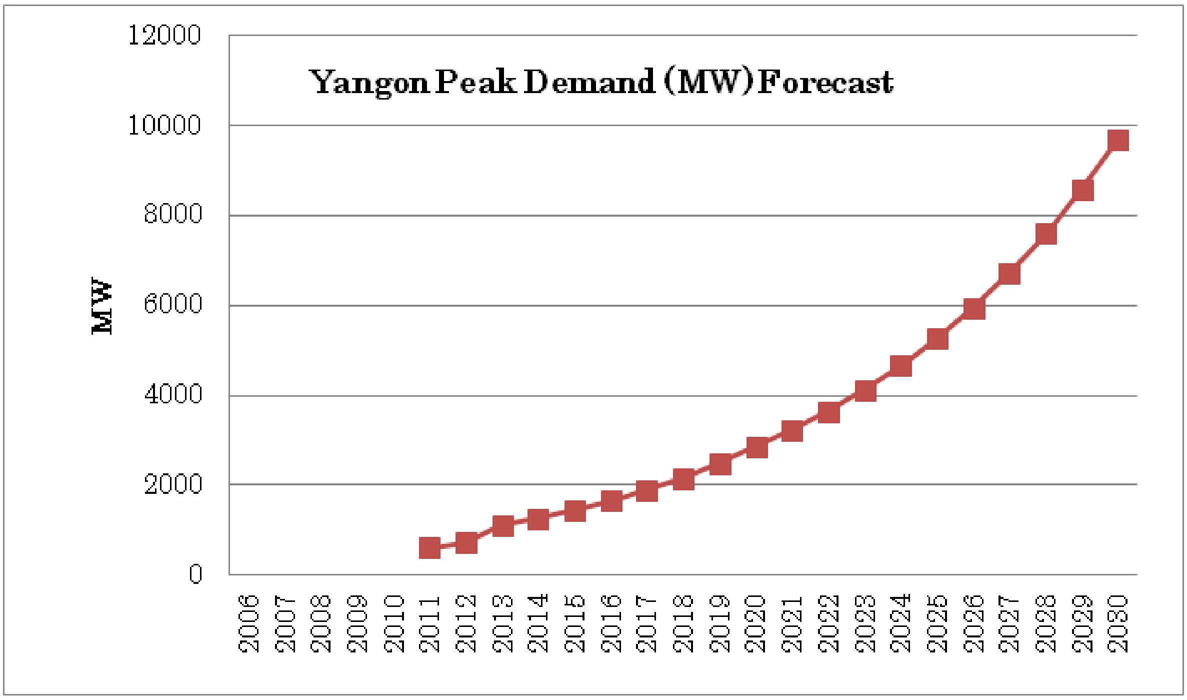



Figure 3-7:Yangon City Peak Demand Forecast under YESB assumption

Under the current YESB assumption, the peak demand is estimated to grow at an annual rate of 15%. In our estimate, the growth is slightly lower at 14.2%, but starts from a higher level due to the consideration of the potential demand. The growth after 2020 is 13%, which is the same as the growth in power demand (GWh) because the load factor remains constant.

For the alternative scenario, the industrial demand is calculated separately. Therefore, the load factor without the industrial demand needs to be considered. Industrial demand is much more stable than the residential and commercial/office demand. In Tokyo, currently, the load factor for the peak day for residential and commercial/office use is about 53%. The current annual load factor in Yangon is extremely low, about 38%. As mentioned, this consists mostly of residential and commercial/office use. It can be expected that this figure will gradually rise to match those of Tokyo, to around 55%.

Industrial demand the case of industry, however, it can be assumed that the load factor will not change significantly. Therefore, the peak demand can be assumed to move with the same rate as the total power demand (GWh).

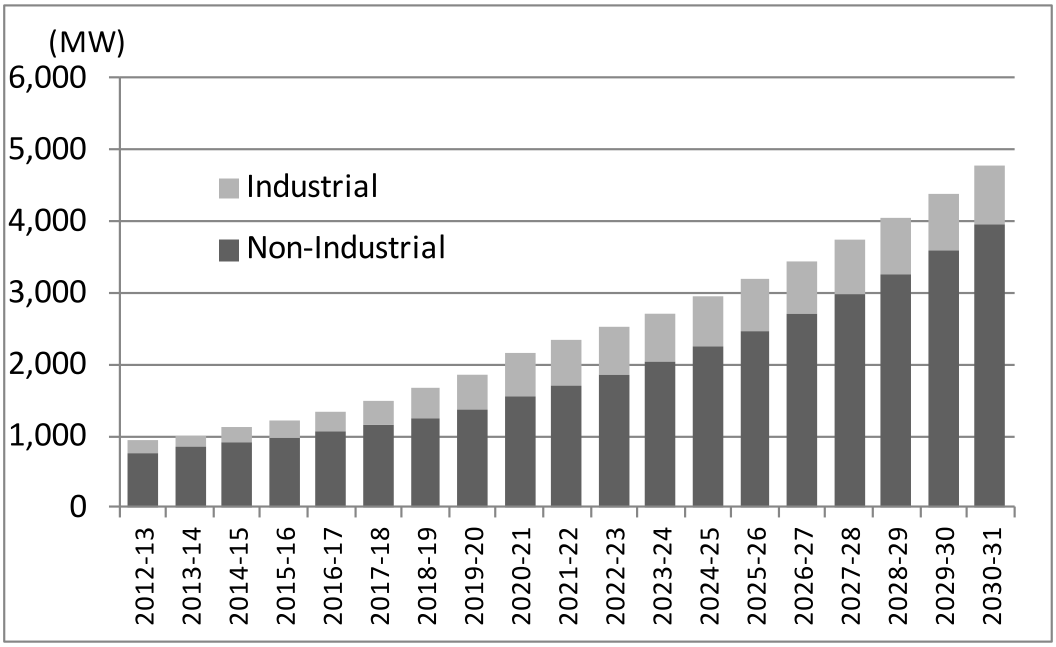



Figure 3-8: Yangon City Peak Demand, alternative scenario

The result for the alternative scenario is similar with the results for power demand (GWh). In 2020, the peak industrial demand is 615MW, while peak non-industrial demand is 1,548MW, with a total of 2261MW. This is similar to the result based on YESB assumption, although slightly lower. After that, the two diverges. For 2030, the non-industrial peak demand will be 3,943 MW, and industrial demand will be 826 MW. The total demand will be 4,769 MW. This is about half the one based on the YESB assumption.

Again, it should be stressed that both forecasts are based on extremely small amount of data. Figures up to 2020 agree with each other, but the result in 2013-14 may change the situation significantly. Also, the load factor is assumed to go up. Depending on the development pattern, this may not be the case. Therefore, the forecast needs to be revised annually for the coming years.

There is also another demand forecast by JICA, as a part of their “The Project for the Strategic Urban Development Plan of the Greater Yangon” (2013) This forecast expects a peak demand of 2,349 MW in 2020, and 6,617 MW in 2030 (excluding Thilawa SEZ). The forecast in our study mostly agrees with this result for 2020. The difference is caused by the separate treatment of the industrial demand within the current YESB area. In the former JICA study, all demand (including industry) is assumed to increase at the same pace, but in this study, industrial growth is assumed to show a lower growth after 2020, due to spatial constraint. Therefore, the result in 2030 is lower than the JICA Urban Development Plan forecast. Since the situation for the industrial parks are in high flux at the moment, it is difficult to assess the relative adequacy of either scenario. However, the similarity for the near term demand shows the robustness for both scenario till 2020.

### 3.2 Peak Demand for each Township

In this section, the peak demand forecast shall be distributed to each township. Although there are differences between each township, YESB's current forecast uniformly extrapolates the current peak demand at the same ratio as the total increase in peak demand. Apparently, as the differences manifest themselves during the planning period, the figures need to be tweaked to reflect the actual situation.

This demand forecast includes the demand for industrial zones. Table 3-1 shows the results.

For the alternative scenario, the peak demand for non-industrial use, and the industrial use, will be shown separately in Table 3-2 and Table 3-3 respectively. As mentioned, however, YESB is currently considering a spin-off of the townships with industrial zones. In this case, it should be noted that the situation for these townships may become significantly different.

Table 3-1: Peak Demand Forecast for each Township under YESB scenario

| | **East District** | | | | | | | | | | | (MW) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Name of Town** | **2013-14** | | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** | **2025-26** | **2030-31** |
| 1 | East Dagon | 13.5 | 1.51% | 16.57 | 18.91 | 21.66 | 24.90 | 28.73 | 33.25 | 39.18 | 51.45 | 69.26 |
| 2 | North Dagon | 20.3 | 2.28% | 25.53 | 27.54 | 29.80 | 32.32 | 35.15 | 38.30 | 43.66 | 69.68 | 111.20 |
| 3 | Sourth Dagon | 19.5 | 2.19% | 23.48 | 27.96 | 33.33 | 39.76 | 47.46 | 56.69 | 67.87 | 79.99 | 94.83 |
| 4 | Dagon Seikkan | 23.171 | 2.60% | 28.62 | 32.18 | 36.35 | 41.22 | 46.92 | 53.60 | 62.71 | 86.02 | 120.97 |
| 5 | North Okkalapa | 12.49 | 1.40% | 15.43 | 17.34 | 19.58 | 22.20 | 25.26 | 28.84 | 33.74 | 46.33 | 65.24 |
| 6 | South Okkalapa | 32 | 3.59% | 39.20 | 44.92 | 51.68 | 59.67 | 69.11 | 80.27 | 94.75 | 122.90 | 163.30 |
| 7 | Dawbon | 15.7 | 1.76% | 19.74 | 21.30 | 23.05 | 25.00 | 27.18 | 29.62 | 33.77 | 53.89 | 86.00 |
| 8 | Pazundaung | 8.44 | 0.95% | 10.61 | 11.45 | 12.39 | 13.44 | 14.61 | 15.92 | 18.15 | 28.97 | 46.23 |
| 9 | Shwe Pauk Kan | 7.3 | 0.82% | 8.88 | 10.34 | 12.07 | 14.13 | 16.58 | 19.50 | 23.16 | 28.82 | 36.54 |
| 10 | Thingangkuun | 13.5 | 1.51% | 16.98 | 18.32 | 19.82 | 21.50 | 23.37 | 25.47 | 29.04 | 46.34 | 73.95 |
| 11 | ThaKeta | 13.5 | 1.51% | 16.85 | 18.50 | 20.40 | 22.58 | 25.08 | 27.94 | 32.26 | 47.96 | 72.46 |
| 12 | Mingalartaungnyunt | 32.33 | 3.63% | 40.40 | 44.24 | 48.63 | 53.65 | 59.38 | 65.94 | 75.98 | 114.22 | 174.12 |
| 13 | Yankin | 23 | 2.58% | 28.92 | 31.20 | 33.76 | 36.62 | 39.82 | 43.39 | 49.47 | 78.95 | 125.99 |
| 14 | Tamwe | 17.1 | 1.92% | 21.50 | 23.20 | 25.10 | 27.23 | 29.61 | 32.26 | 36.78 | 58.70 | 93.67 |
| 15 | Botahtaung | 15 | 1.68% | 18.86 | 20.35 | 22.02 | 23.89 | 25.97 | 28.30 | 32.26 | 51.49 | 82.17 |
| | **Total** | **266.831** | | **331.57** | **367.75** | **409.63** | **458.11** | **514.24** | **579.31** | **672.78** | **965.69** | **1,415.97** |
| | | | | | | | | | | | | |
| | **West District** | | | | | | | | | | | |
| **No** | **Name of Town** | **2013-14** | | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** | **2025-26** | **2030-31** |
| 1 | Bahan | 16.25 | 1.82% | 20.43 | 22.05 | 23.85 | 25.88 | 28.14 | 30.66 | 34.95 | 55.78 | 89.02 |
| 2 | Dagon | 15.21 | 1.71% | 19.13 | 20.64 | 22.33 | 24.22 | 26.33 | 28.70 | 32.71 | 52.21 | 83.32 |
| 3 | Hlaing | 11.5 | 1.29% | 14.46 | 15.60 | 16.88 | 18.31 | 19.91 | 21.70 | 24.73 | 39.47 | 63.00 |
| 4 | Kyeemyindaing | 18.4 | 2.06% | 23.14 | 24.96 | 27.01 | 29.30 | 31.86 | 34.71 | 39.57 | 63.16 | 100.80 |
| 5 | Kamaryut | 18.4 | 2.06% | 23.14 | 24.96 | 27.01 | 29.30 | 31.86 | 34.71 | 39.57 | 63.16 | 100.80 |
| 6 | Kyauktada | 15.76 | 1.77% | 19.82 | 21.38 | 23.13 | 25.10 | 27.29 | 29.73 | 33.90 | 54.10 | 86.33 |
| 7 | Latha | 25.3 | 2.84% | 31.81 | 34.32 | 37.14 | 40.29 | 43.80 | 47.73 | 54.42 | 86.84 | 138.59 |
| 8 | Lanmadaw | 20.72 | 2.32% | 26.06 | 28.11 | 30.41 | 32.99 | 35.87 | 39.09 | 44.56 | 71.12 | 113.50 |
| 9 | Mayangone | 26.45 | 2.97% | 33.26 | 35.88 | 38.83 | 42.12 | 45.80 | 49.90 | 56.89 | 90.79 | 144.89 |
| 10 | Pabedan | 20.72 | 2.32% | 26.06 | 28.11 | 30.41 | 32.99 | 35.87 | 39.09 | 44.56 | 71.12 | 113.50 |
| 11 | Ahlone | 26.45 | 2.97% | 33.26 | 35.88 | 38.83 | 42.12 | 45.80 | 49.90 | 56.89 | 90.79 | 144.89 |
| 12 | Sanchaung | 40.25 | 4.52% | 50.61 | 54.61 | 59.08 | 64.09 | 69.69 | 75.94 | 86.57 | 138.16 | 220.49 |
| 13 | Seikkan | 3.22 | 0.36% | 4.05 | 4.37 | 4.73 | 5.13 | 5.58 | 6.08 | 6.93 | 11.05 | 17.64 |
| | **Total** | **258.63** | | **325.23** | **350.88** | **379.64** | **411.83** | **447.80** | **487.95** | **556.26** | **887.75** | **1,416.77** |
| | | | | | | | | | | | | |
| | **South District** | | | | | | | | | | | |
| **No** | **Name of Town** | **2013-14** | | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** | **2025-26** | **2030-31** |
| 1 | Kawhmu | 15.54 | 1.74% | 19.54 | 21.08 | 22.81 | 24.75 | 26.91 | 29.32 | 33.42 | 53.34 | 85.13 |
| 2 | Tada | 2.5 | 0.28% | 3.14 | 3.39 | 3.67 | 3.98 | 4.33 | 4.72 | 5.38 | 8.58 | 13.69 |
| 3 | Dala | 1.8 | 0.20% | 2.26 | 2.44 | 2.64 | 2.87 | 3.12 | 3.40 | 3.87 | 6.18 | 9.86 |
| 4 | Kyaikhtaw | 2 | 0.22% | 2.52 | 2.71 | 2.94 | 3.18 | 3.46 | 3.77 | 4.30 | 6.86 | 10.96 |
| 5 | Kayan | 0.13 | 0.01% | 0.16 | 0.18 | 0.19 | 0.21 | 0.23 | 0.25 | 0.28 | 0.45 | 0.71 |
| 6 | Thongwa | 4.5 | 0.50% | 5.66 | 6.11 | 6.61 | 7.17 | 7.79 | 8.49 | 9.68 | 15.45 | 24.65 |
| 7 | Kwinchankone | 2.8 | 0.31% | 3.52 | 3.80 | 4.11 | 4.46 | 4.85 | 5.28 | 6.02 | 9.61 | 15.34 |
| 8 | Kyauktan | 1.72 | 0.19% | 2.16 | 2.33 | 2.52 | 2.74 | 2.98 | 3.25 | 3.70 | 5.90 | 9.42 |
| 9 | Latkotkone | 0.78 | 0.09% | 0.98 | 1.06 | 1.14 | 1.24 | 1.35 | 1.47 | 1.68 | 2.68 | 4.27 |
| 10 | Seikgyikanaungto | 0.6 | 0.07% | 0.75 | 0.81 | 0.88 | 0.96 | 1.04 | 1.13 | 1.29 | 2.06 | 3.29 |
| 11 | Thanlyin | 0.21 | 0.02% | 0.26 | 0.28 | 0.31 | 0.33 | 0.36 | 0.40 | 0.45 | 0.72 | 1.15 |
| 12 | Tontay | 0.18 | 0.02% | 0.23 | 0.24 | 0.26 | 0.29 | 0.31 | 0.34 | 0.39 | 0.62 | 0.99 |
| | **Total** | **32.76** | | **41.20** | **44.44** | **48.09** | **52.17** | **56.72** | **61.81** | **70.46** | **112.45** | **179.46** |
| | | | | | | | | | | | | |
| | **North District** | | | | | | | | | | | |
| **No** | **Name of Town** | **2013-14** | | **2014-15** | **2015-16** | **2016-17** | **2017-18** | **2018-19** | **2019-20** | **2020-21** | **2025-26** | **2030-31** |
| 1 | Insein | 64.68 | 7.26% | 81.34 | 87.75 | 94.94 | 102.99 | 111.99 | 122.03 | 139.11 | 222.01 | 354.32 |
| 2 | Mingalardon | 17.1825 | 1.93% | 21.20 | 23.90 | 27.06 | 30.75 | 35.09 | 40.17 | 47.05 | 64.06 | 89.46 |
| 3 | Hlaingtharya | 67.0795 | 7.53% | 84.35 | 91.01 | 98.47 | 106.81 | 116.14 | 126.56 | 144.27 | 230.25 | 367.46 |
| 4 | Shwepyithar | 49.253 | 5.53% | 60.72 | 68.59 | 77.81 | 88.63 | 101.32 | 116.23 | 136.30 | 184.35 | 255.76 |
| 5 | Hlegu | 10.08 | 1.13% | 12.68 | 13.68 | 14.80 | 16.05 | 17.45 | 19.02 | 21.68 | 34.60 | 55.22 |
| 6 | Hmawbi | 46.585 | 5.23% | 56.72 | 65.89 | 76.78 | 89.72 | 105.11 | 123.40 | 146.46 | 183.20 | 233.79 |
| 7 | Taikki | 52.815 | 5.92% | 64.00 | 75.15 | 88.45 | 104.31 | 123.23 | 145.82 | 173.75 | 211.59 | 261.50 |
| 8 | Htantabin | 0.9486 | 0.11% | 1.19 | 1.29 | 1.39 | 1.51 | 1.64 | 1.79 | 2.04 | 3.26 | 5.20 |
| 9 | Htauntkyant | 15.75 | 1.77% | 19.81 | 21.37 | 23.12 | 25.08 | 27.27 | 29.71 | 33.87 | 54.06 | 86.28 |
| 10 | Phaungkyi | 0.3232 | 0.04% | 0.41 | 0.44 | 0.47 | 0.51 | 0.56 | 0.61 | 0.70 | 1.11 | 1.77 |
| 11 | Okkan | 1.919 | 0.22% | 2.41 | 2.60 | 2.82 | 3.06 | 3.32 | 3.62 | 4.13 | 6.59 | 10.51 |
| 12 | Indine | 1.919 | 0.22% | 2.41 | 2.60 | 2.82 | 3.06 | 3.32 | 3.62 | 4.13 | 6.59 | 10.51 |
| 13 | Dar Bain | 0.808 | 0.09% | 1.02 | 1.10 | 1.19 | 1.29 | 1.40 | 1.52 | 1.74 | 2.77 | 4.43 |
| 14 | Aphauk | 3.838 | 0.43% | 4.83 | 5.21 | 5.63 | 6.11 | 6.65 | 7.24 | 8.25 | 13.17 | 21.02 |
| | **Total** | **333.18** | | **413.08** | **460.56** | **515.75** | **579.89** | **654.50** | **741.33** | **863.49** | **1217.62** | **1757.22** |
| | | | | | | | | | | | | |
| | **Total** | 891.40 | | **1111** | **1224** | **1353** | **1502** | **1673** | **1870** | **2163** | **3184** | **4769** |

Table 3-2: Township Peak Demand, non-industrial, under alternative scenario

| | East District | | | | | | | | | | (MW) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
| 1 | East Dagon | 6.42 | 0.89% | 8.07 | 8.71 | 9.42 | 10.22 | 11.12 | 12.11 | 13.81 | 22.04 | 35.17 |
| 2 | North Dagon | 20.3 | 2.82% | 25.53 | 27.54 | 29.80 | 32.32 | 35.15 | 38.30 | 43.66 | 69.68 | 111.20 |
| 3 | Sourth Dagon | 1.4 | 0.19% | 1.76 | 1.90 | 2.06 | 2.23 | 2.42 | 2.64 | 3.01 | 4.81 | 7.67 |
| 4 | Dagon Seikkan | 14.181 | 1.97% | 17.83 | 19.24 | 20.82 | 22.58 | 24.55 | 26.75 | 30.50 | 48.68 | 77.68 |
| 5 | North Okkalapa | 7.69 | 1.07% | 9.67 | 10.43 | 11.29 | 12.25 | 13.31 | 14.51 | 16.54 | 26.40 | 42.13 |
| 6 | South Okkalapa | 13.9 | 1.93% | 17.48 | 18.86 | 20.40 | 22.13 | 24.07 | 26.22 | 29.90 | 47.71 | 76.14 |
| 7 | Dawbon | 15.7 | 2.18% | 19.74 | 21.30 | 23.05 | 25.00 | 27.18 | 29.62 | 33.77 | 53.89 | 86.00 |
| 8 | Pazundaung | 8.44 | 1.17% | 10.61 | 11.45 | 12.39 | 13.44 | 14.61 | 15.92 | 18.15 | 28.97 | 46.23 |
| 9 | Shwe Pauk Kan | 2.09 | 0.29% | 2.63 | 2.84 | 3.07 | 3.33 | 3.62 | 3.94 | 4.50 | 7.17 | 11.45 |
| 10 | Thingangkuun | 13.5 | 1.88% | 16.98 | 18.32 | 19.82 | 21.50 | 23.37 | 25.47 | 29.04 | 46.34 | 73.95 |
| 11 | ThaKeta | 11.25 | 1.56% | 14.15 | 15.26 | 16.51 | 17.91 | 19.48 | 21.22 | 24.20 | 38.62 | 61.63 |
| 12 | Mingalartaungnyunt | 27.83 | 3.87% | 35.00 | 37.76 | 40.85 | 44.31 | 48.19 | 52.51 | 59.86 | 95.53 | 152.45 |
| 13 | Yankin | 23 | 3.20% | 28.92 | 31.20 | 33.76 | 36.62 | 39.82 | 43.39 | 49.47 | 78.95 | 125.99 |
| 14 | Tamwe | 17.1 | 2.38% | 21.50 | 23.20 | 25.10 | 27.23 | 29.61 | 32.26 | 36.78 | 58.70 | 93.67 |
| 15 | Botahtaung | 15 | 2.08% | 18.86 | 20.35 | 22.02 | 23.89 | 25.97 | 28.30 | 32.26 | 51.49 | 82.17 |
| | Total | 197.80 | | 248.74 | 268.35 | 290.35 | 314.97 | 342.48 | 373.18 | 425.43 | 678.95 | 1,083.55 |

| | West District | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
| 1 | Bahan | 16.25 | 2.26% | 20.43 | 22.05 | 23.85 | 25.88 | 28.14 | 30.66 | 34.95 | 55.78 | 89.02 |
| 2 | Dagon | 15.21 | 2.11% | 19.13 | 20.64 | 22.33 | 24.22 | 26.33 | 28.70 | 32.71 | 52.21 | 83.32 |
| 3 | Hlaing | 11.5 | 1.60% | 14.46 | 15.60 | 16.88 | 18.31 | 19.91 | 21.70 | 24.73 | 39.47 | 63.00 |
| 4 | Kyeemyindaing | 18.4 | 2.56% | 23.14 | 24.96 | 27.01 | 29.30 | 31.86 | 34.71 | 39.57 | 63.16 | 100.80 |
| 5 | Kamaryut | 18.4 | 2.56% | 23.14 | 24.96 | 27.01 | 29.30 | 31.86 | 34.71 | 39.57 | 63.16 | 100.80 |
| 6 | Kyauktada | 15.76 | 2.19% | 19.82 | 21.38 | 23.13 | 25.10 | 27.29 | 29.73 | 33.90 | 54.10 | 86.33 |
| 7 | Latha | 25.3 | 3.51% | 31.81 | 34.32 | 37.14 | 40.29 | 43.80 | 47.73 | 54.42 | 86.84 | 138.59 |
| 8 | Lanmadaw | 20.72 | 2.88% | 26.06 | 28.11 | 30.41 | 32.99 | 35.87 | 39.09 | 44.56 | 71.12 | 113.50 |
| 9 | Mayangone | 26.45 | 3.67% | 33.26 | 35.88 | 38.83 | 42.12 | 45.80 | 49.90 | 56.89 | 90.79 | 144.89 |
| 10 | Pabedan | 20.72 | 2.88% | 26.06 | 28.11 | 30.41 | 32.99 | 35.87 | 39.09 | 44.56 | 71.12 | 113.50 |
| 11 | Ahlone | 26.45 | 3.67% | 33.26 | 35.88 | 38.83 | 42.12 | 45.80 | 49.90 | 56.89 | 90.79 | 144.89 |
| 12 | Sanchaung | 40.25 | 5.59% | 50.61 | 54.61 | 59.08 | 64.09 | 69.69 | 75.94 | 86.57 | 138.16 | 220.49 |
| 13 | Seikkan | 3.22 | 0.45% | 4.05 | 4.37 | 4.73 | 5.13 | 5.58 | 6.08 | 6.93 | 11.05 | 17.64 |
| | Total | 258.63 | | 325.23 | 350.88 | 403.51 | 464.03 | 533.64 | 613.69 | 705.74 | 1419.49 | 2855.10 |

| | South District | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
| 1 | Kawhmu | 15.54 | 2.16% | 19.54 | 21.08 | 22.81 | 24.75 | 26.91 | 29.32 | 33.42 | 53.34 | 85.13 |
| 2 | Tada | 2.5 | 0.35% | 3.14 | 3.39 | 3.67 | 3.98 | 4.33 | 4.72 | 5.38 | 8.58 | 13.69 |
| 3 | Dala | 1.8 | 0.25% | 2.26 | 2.44 | 2.64 | 2.87 | 3.12 | 3.40 | 3.87 | 6.18 | 9.86 |
| 4 | Kyaikhtaw | 2 | 0.28% | 2.52 | 2.71 | 2.94 | 3.18 | 3.46 | 3.77 | 4.30 | 6.86 | 10.96 |
| 5 | Kayan | 0.13 | 0.02% | 0.16 | 0.18 | 0.19 | 0.21 | 0.23 | 0.25 | 0.28 | 0.45 | 0.71 |
| 6 | Thongwa | 4.5 | 0.63% | 5.66 | 6.11 | 6.61 | 7.17 | 7.79 | 8.49 | 9.68 | 15.45 | 24.65 |
| 7 | Kwinchankone | 2.8 | 0.39% | 3.52 | 3.80 | 4.11 | 4.46 | 4.85 | 5.28 | 6.02 | 9.61 | 15.34 |
| 8 | Kyauktan | 1.72 | 0.24% | 2.16 | 2.33 | 2.52 | 2.74 | 2.98 | 3.25 | 3.70 | 5.90 | 9.42 |
| 9 | Latkotkone | 0.78 | 0.11% | 0.98 | 1.06 | 1.14 | 1.24 | 1.35 | 1.47 | 1.68 | 2.68 | 4.27 |
| 10 | Seikgyikanaungto | 0.6 | 0.08% | 0.75 | 0.81 | 0.88 | 0.96 | 1.04 | 1.13 | 1.29 | 2.06 | 3.29 |
| 11 | Thanlyin | 0.21 | 0.03% | 0.26 | 0.28 | 0.31 | 0.33 | 0.36 | 0.40 | 0.45 | 0.72 | 1.15 |
| 12 | Tontay | 0.18 | 0.03% | 0.23 | 0.24 | 0.26 | 0.29 | 0.31 | 0.34 | 0.39 | 0.62 | 0.99 |
| | Total | 32.76 | | 37.67 | 44.44 | 48.09 | 52.17 | 56.72 | 61.81 | 70.46 | 112.45 | 179.46 |

| | North District | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
| 1 | Insein | 64.7 | 8.99% | 81.34 | 87.75 | 94.94 | 102.99 | 111.99 | 122.03 | 139.11 | 222.01 | 354.32 |
| 2 | Mingalardon | 10.1 | 1.41% | 12.74 | 13.75 | 14.87 | 16.13 | 17.54 | 19.12 | 21.79 | 34.78 | 55.51 |
| 3 | Hlaingtharya | 67.1 | 9.32% | 84.35 | 91.01 | 98.47 | 106.81 | 116.14 | 126.56 | 144.27 | 230.25 | 367.46 |
| 4 | Shwepyithar | 28.1 | 3.90% | 35.28 | 38.06 | 41.18 | 44.67 | 48.57 | 52.93 | 60.34 | 96.29 | 153.67 |
| 5 | Hlegu | 10.1 | 1.40% | 12.68 | 13.68 | 14.80 | 16.05 | 17.45 | 19.02 | 21.68 | 34.60 | 55.22 |
| 6 | Hmawbi | 14.3 | 1.98% | 17.96 | 19.38 | 20.97 | 22.75 | 24.73 | 26.95 | 30.72 | 49.03 | 78.25 |
| 7 | Taikki | 10.8 | 1.50% | 13.60 | 14.67 | 15.88 | 17.22 | 18.73 | 20.40 | 23.26 | 37.12 | 59.24 |
| 8 | Htantabin | 0.9 | 0.13% | 1.19 | 1.29 | 1.39 | 1.51 | 1.64 | 1.79 | 2.04 | 3.26 | 5.20 |
| 9 | Htauntkyant | 15.8 | 2.19% | 19.81 | 21.37 | 23.12 | 25.08 | 27.27 | 29.71 | 33.87 | 54.06 | 86.28 |
| 10 | Phaungkyi | 0.3 | 0.04% | 0.41 | 0.44 | 0.47 | 0.51 | 0.56 | 0.61 | 0.70 | 1.11 | 1.77 |
| 11 | Okkan | 1.9 | 0.27% | 2.41 | 2.60 | 2.82 | 3.06 | 3.32 | 3.62 | 4.13 | 6.59 | 10.51 |
| 12 | Indine | 1.9 | 0.27% | 2.41 | 2.60 | 2.82 | 3.06 | 3.32 | 3.62 | 4.13 | 6.59 | 10.51 |
| 13 | Dar Bain | 0.8 | 0.11% | 1.02 | 1.10 | 1.19 | 1.29 | 1.40 | 1.52 | 1.74 | 2.77 | 4.43 |
| 14 | Aphauk | 3.8 | 0.53% | 4.83 | 5.21 | 5.63 | 6.11 | 6.65 | 7.24 | 8.25 | 13.17 | 21.02 |
| | Total | 230.63 | | 290.02 | 312.89 | 338.54 | 367.24 | 399.32 | 435.12 | 496.04 | 791.64 | 1263.39 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | 719.82 | | 905 | 977 | 1,057 | 1,146 | 1,246 | 1,358 | 1,548 | 2,471 | 3,943 |

Table 3-3: Township Peak Demand, industrial, under alternative scenario

(MW)

**East District**

| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | East Dagon | 7.08 | 4.13% | 8.50 | 10.20 | 12.23 | 14.68 | 17.62 | 21.14 | 25.37 | 29.41 | 34.09 |
| 2 | North Dagon | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | Sourth Dagon | 18.1 | 10.55% | 21.72 | 26.06 | 31.28 | 37.53 | 45.04 | 54.05 | 64.86 | 75.19 | 87.16 |
| 4 | Dagon Seikkan | 8.99 | 5.24% | 10.79 | 12.95 | 15.53 | 18.64 | 22.37 | 26.84 | 32.21 | 37.34 | 43.29 |
| 5 | North Okkalapa | 4.8 | 2.80% | 5.76 | 6.91 | 8.29 | 9.95 | 11.94 | 14.33 | 17.20 | 19.94 | 23.11 |
| 6 | South Okkalapa | 18.1 | 10.55% | 21.72 | 26.06 | 31.28 | 37.53 | 45.04 | 54.05 | 64.86 | 75.19 | 87.16 |
| 7 | Dawbon | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Pazundaung | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | Shwe Pauk Kan | 5.21 | 3.04% | 6.25 | 7.50 | 9.00 | 10.80 | 12.96 | 15.56 | 18.67 | 21.64 | 25.09 |
| 10 | Thingangkuun | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | ThaKeta | 2.25 | 1.31% | 2.70 | 3.24 | 3.89 | 4.67 | 5.60 | 6.72 | 8.06 | 9.35 | 10.83 |
| 12 | Mingalartaungnyunt | 4.5 | 2.62% | 5.40 | 6.48 | 7.78 | 9.33 | 11.20 | 13.44 | 16.12 | 18.69 | 21.67 |
| 13 | Yankin | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | Tamwe | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | Botahtaung | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total | 69.03 | | 82.84 | 99.40 | 119.28 | 143.14 | 171.77 | 206.12 | 247.35 | 286.74 | 332.41 |

**West District**

| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bahan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Dagon | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | Hlaing | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Kyeemyindaing | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | Kamaryut | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | Kyauktada | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | Latha | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Lanmadaw | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | Mayangone | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | Pabedan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | Ahlone | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | Sanchaung | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | Seikkan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**South District**

| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Kawhmu | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Tada | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | Dala | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Kyaikhtaw | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | Kayan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | Thongwa | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | Kwinchankone | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Kyauktan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | Latkotkone | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | Seikgyikanaungto | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | Thanlyin | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | Tontay | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**North District**

| No | Name of Town | 2013-14 | | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Insein | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | Mingalardon | 7.05 | 4.11% | 8.46 | 10.15 | 12.18 | 14.62 | 17.54 | 21.05 | 25.26 | 29.28 | 33.95 |
| 3 | Hlaingtharya | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Shwepyithar | 21.2 | 12.36% | 25.44 | 30.53 | 36.63 | 43.96 | 52.75 | 63.30 | 75.96 | 88.06 | 102.09 |
| 5 | Hlegu | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | Hmawbi | 32.3 | 18.83% | 38.76 | 46.51 | 55.81 | 66.98 | 80.37 | 96.45 | 115.74 | 134.17 | 155.54 |
| 7 | Taikki | 42 | 24.48% | 50.40 | 60.48 | 72.58 | 87.09 | 104.51 | 125.41 | 150.49 | 174.46 | 202.25 |
| 8 | Htantabin | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | Htauntkyant | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | Phaungkyi | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | Okkan | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | Indine | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | Dar Bain | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | Aphauk | 0 | 0.00% | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Total | 102.55 | | 123.06 | 147.67 | 177.21 | 212.65 | 255.18 | 306.21 | 367.46 | 425.98 | 493.83 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | 171.58 | | 206 | 247 | 296 | 356 | 427 | 512 | 615 | 713 | 826 |

# Chapter 4 Distribution Networks Development Plan

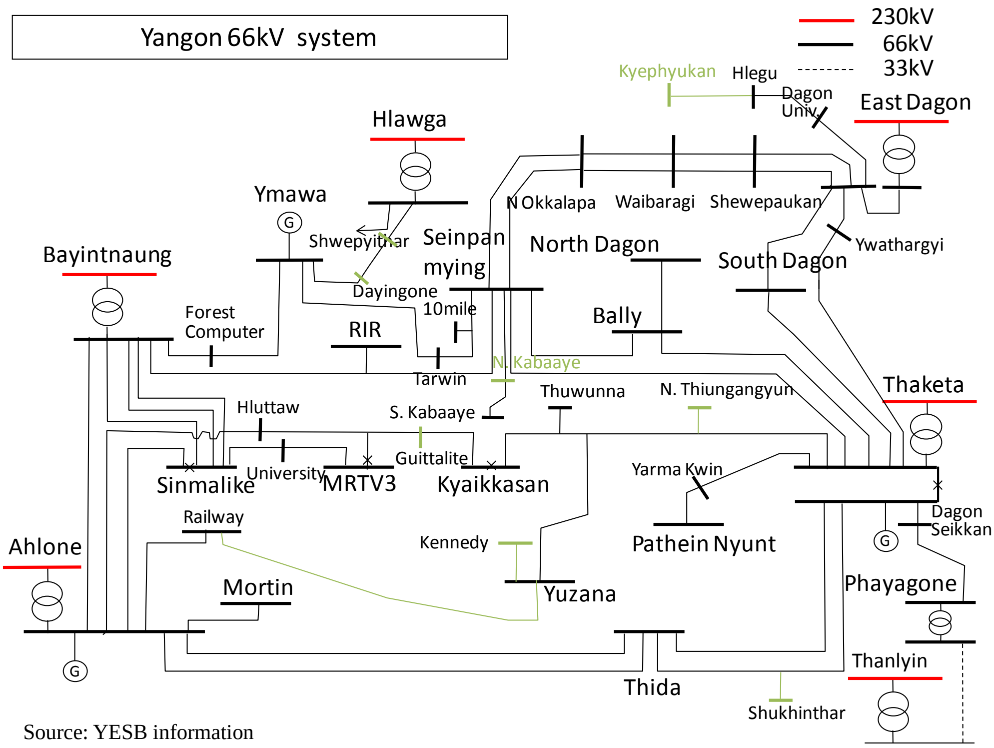
## 4.1 Existing distribution networks development plan

YESB has addressed to raise the voltage of the city distribution network to 66kV, newly build or renovate 33kV substations and install underground cables and overhead transmission lines, according to the 5-year distribution network development plan (FY2011 to FY2015) they developed. As for the longer 30 year plan, there is no particular plan at this stage. The segments FY2014 and FY2015 of this 5 year plan were checked and the future policy for the YESB distribution network development was investigated.

### 4.1.1 Development plan for the YESB systems

#### (1) 66kV systems

Table 4-1 shows the 66kV system diagram when the FY2015 segment of the YESB 5 year plan is completed. The plan intends to upgrade the main power transmission systems to 66kV systems for the YESB distribution network. The 33/6.6kV substations most frequently seen in Yangon will be upgraded to 66/11kV substations in the future. For transmission lines, underground cables will be laid in cities while overhead transmission lines will be installed in suburbs.



Source: YESB information

Figure 4-1: YESB 66kV system diagram (as of April 2016)

### (2) 33kV systems

33kV systems must remain available due to a number of customers charging at 33kV in Yangon. The 5 year plan also intends to build new 33kV substations (including upgraded substations from 6.6/0.4kV power distribution). For transmission lines, underground cables will be laid in cities while overhead transmission lines will be installed in suburbs. (3) 11 kV -6.6kV power distribution systems

33kV systems must remain available due to a number of customers charging at 33kV in Yangon. The 5 year plan also intends to build new 33kV substations (including upgraded from 6.6/0.4kV substations). For transmission lines, underground cables will be laid in cities while overhead transmission lines will be installed in suburbs.

### (3) 11 kV -6.6kV systems

It is intended to sequentially raise the voltage of 6.6kV distribution lines and unify the voltage to 11kV as the standard medium voltage in the future. Therefore, the transformers accepting both 11kV and 6.6kV taps are used in installation on the 6.6kV distribution lines, although the existing 6.6kV transformers owned by customers and the government departments have to be replaced to 11kV or 11-6.6kV transformers in the future.

Low-voltage power distribution systems are intended to be upgraded to the multi-transformer system, the system to distribute a lot of small capacity transformers as is employed in Japan. This aims to reduce power loss by setting the capacity of a transformer for power distribution to 200-300kVA class to shorten the length of low-voltage distribution lines.

Only some of age-old underground distribution lines are intended to be upgraded to underground cables.

## 4.1.2 5 year plan (2011-2015) and latest investment plan (2016-2020)

### (1) Overview of 5 year plan and latest investment plan (2016-2020)

The information on the YESB 5 year plan (from FY2011 to FY2015) and latest investment plan (from FY2016 to FY2020) was obtained and the summary, necessity and other factors of individual projects were verified. Table 4-1 and Table 4-2 show the overall overview of the plan.

Table 4-1: Overview of 5 year plan

| Item | Quantity (No. of sites/projects) | | | |
|---|---|---|---|---|
| | 2013 | 2014 | 2015 | Subtotal |
| 66kV Substations and related subjects | 10 | 7 | 8 | 25 |
| 33kV Substations and related subjects | 10 | 11 | 7 | 28 |
| 66kV UG cable and OH line subjects | 4 | 4 | 3 | 11 |
| 33kV UG cable and OH line subjects | 5 | 4 | 1 | 10 |
| 6.6kV and 0.4kVUG cable and OH line subjects | 13 | 8 | 9 | 30 |
| Maintaining jobs for emergency cases, Replacing jobs for broken poles with concrete poles, Changing with Insulated Wire projects, Transformer Maintaining projects, Maintenance projects for S/S and System Improvement projects in Districts | - | - | - | - |
| Total | 42 | 34 | 28 | 104 |

Source: YESB information

Table 4-2: Overview of latest substation investment plan (for from FY2016 to FY2020)

| Item | Quantity (No. of sites) | | | | | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | Subtotal |
| Construction of 66kV Substations and related projects | 9 | 7 | 7 | 7 | 7 | 37 |
| Replacing aged poles with concrete poles, Installing Insulated Wire, Transformer Maintaining, Maintenance for Substation and Distribution System Improvement | - | - | - | - | - | - |
| Total | 9 | 7 | 7 | 7 | 7 | 37 |

Source: YESB information

**(2) Land acquisition**

The majority of sites for the projects of new construction have yet to be acquired. Some projects for raising voltage might require land acquisition at site.

In case the site is owned by the Yangon City Development Committee (YCDC), an application is made to transfer such site to the mayor. If it does not go well to acquire the land which essentially needs for YESB to expand power system, a minister of Yangon Regions is asked to transfer the site. The acquisition of private site requires negotiations with the owners for purchasing. The duration necessary for the site acquisition varies depending on the situations. It takes two (2) or three (3) months or sometimes more to acquire the site owned by YCDC due to the coordination with relevant organizations and three (3) months to acquire private sites though it requires acquisition cost which is calculated in accordance with value price of the land.

## 4.2 Load status at substations and failure status of the YESB

### 4.2.1 Load status at substations

The mean operation rate of each township to be surveyed was calculated based on the maximum demand data for each distributing substation (66/11-6.6kV and 33/11-6.6kV) of the YESB. Table 4-3 shows the calculation results.

The mean operation rate of the entire township is about 50%. The areas with the current operation rate may include Pabetan (70%) located in the downtown area, and Thigangyun (68%) and Yankin (66%) located to in the north thereof.

Table 4-3: Operating rate of substations for each township in 2012

| District Office | No. | Township (TS) | Peak demand (MW) (a) | Substation capacity (MVA) (b) | Operation rate (a)/(b)/PF(=0.90) | |
|---|---|---|---|---|---|---|
| Eastern district | 1 | North Okkalarpa | 10.4 | 25 | 46% | 47% |
| | 2 | North Dagon | 19.8 | 55 | 40% | |
| | 3 | Shwe Pauk Kan | 9.9 | 25 | 44% | |
| | 4 | South Dagon | 36.8 | 107 | 38% | |
| | 5 | East Dagon | 18.8 | 41 | 51% | |
| | 6 | Dagon Seikkan | 14.4 | 30 | 53% | |
| | 7 | Thaketa | 14.3 | 30 | 53% | |
| | 8 | Thingangyun | 26.6 | 45 | 66% | |
| | 9 | Yankin | 23.0 | 40 | 64% | |
| | 10 | Mingalar Taungnyunt | 23.5 | 50 | 52% | |
| | 11 | Tamwe | 21.9 | 54 | 45% | |
| | 12 | Dawbon | 4.0 | 15 | 30% | |
| | 13 | Botahtaung | 4.4 | 10 | 49% | |
| | 14 | Pazungtaung | 16.1 | 50 | 36% | |
| | 15 | South Okkalarpa | 10.0 | 30 | 37% | |
| Western district | 1 | Mayangone | 26.8 | 70 | 42% | 46% |
| | 2 | Kamaryut | 34.0 | 76 | 50% | |
| | 3 | Bahan | 3.5 | 10 | 39% | |
| | 4 | Latha | 1.6 | 5 | 36% | |
| | 5 | Lanmadaw | 0.6 | 10 | 7% | |
| | 6 | Pabetan | 21.3 | 35 | 68% | |
| | 7 | Dagon | 21.0 | 47 | 50% | |
| | 8 | Ahlone | 23.9 | 50 | 53% | |
| | 9 | Kyimyindaing | 2.5 | 5 | 56% | |
| | 10 | Seikkan | 25.3 | 55 | 51% | |
| | 11 | Kyauktadar | 8.8 | 20 | 49% | |
| | 12 | Sanchaung | 6.6 | 15 | 49% | |
| | 13 | Hlaing | 25.9 | 55 | 52% | |
| Southern district | 1 | Thanlyin | 12.4 | 27 | 51% | 45% |
| | 2 | Kyauk Tan | 9.0 | 28 | 36% | |
| | 3 | Seikkyi Kanaungto | 0.6 | 2 | 33% | |
| | 4 | Dala | 4.6 | 9 | 57% | |
| | 5 | Tontay | 3.4 | 8 | 47% | |
| | 6 | Kwinchankone | 1.4 | 3 | 62% | |
| | 7 | Kawat Hmu | 1.3 | 5 | 29% | |
| | 8 | Thone Gwa | 2.6 | 7 | 44% | |
| | 9 | Khayan | 2.2 | 5 | 49% | |
| Northern district | 1 | Mingalardone | 18.4 | 39 | 52% | 46% |
| | 2 | Innsein | 37.3 | 76 | 55% | |
| | 3 | Hlaingtharya | 44.5 | 100 | 49% | |
| | 4 | Shwepyithar | 26.7 | 55 | 54% | |
| | 5 | Htauntkyant | 3.7 | 10 | 41% | |
| | 6 | Hlegu | 7.4 | 15 | 55% | |
| | 7 | Phaungkyi | 2.0 | 5 | 44% | |
| | 8 | Okkan | 0.5 | 3 | 20% | |
| | 9 | Tikekyi | 4.8 | 10 | 53% | |
| | 10 | Hmawbe | 6.9 | 21 | 37% | |
| Total | | | 645.4 | 1,486 | 46% | |

Source: YESB information

### 4.2.2 Failure status of YESB

**(1) Power outage record management at YESB**

YESB keeps the paper-based record of daily power outage that occurs within the jurisdiction. The power outage status is reported from each township office to the district office and headquarters at 06:00 and 18:00 every day. The report is hand-written. The power outage recorded includes power outage by fault, planned outage and shut down work.

**(2) How to organize and analyze power outage records**

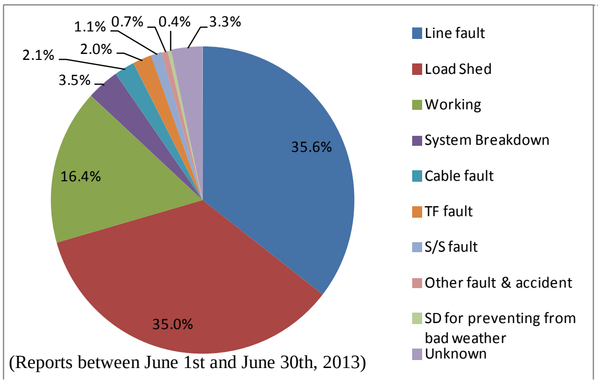
For the purpose investigations on power outage status including fault, the latest monthly power outage records of June 2013 were collected and translated into English, and then the causes of power outage were classified into different items. The power outage status of each township (the number of times, duration and causes) was analyzes from the organized data.

The power outage records are kept for each township. This means a single power outage that affects multiple townships is recorded for each township. This analysis for the evaluation by township evaluates the number of times and durations with the cumulative total values. No analysis by substation will be performed as the power outage record contains the feeder names but no substation names.

**(3) Analysis on power outage records and fault record data**

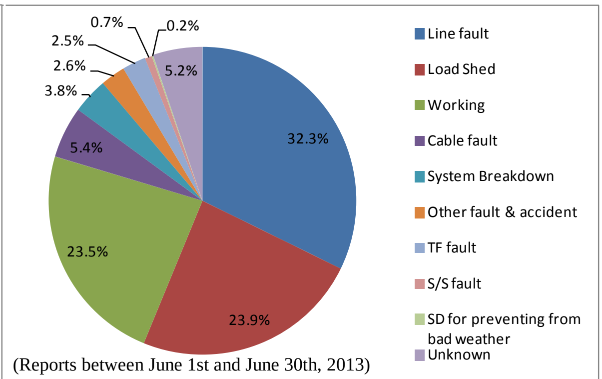
The collected data on the power outage record reported between June 1st and June 30th was analyzed.

To begin with, the fractions of the causes for power outage were calculated. Figure 4-2 and Figure 4-3show the fractions of the number of times and the fractions of the duration, respectively.




Source: JICA survey team based on YESB information

Figure 4-2: Fractions by power outage record type (number of times)

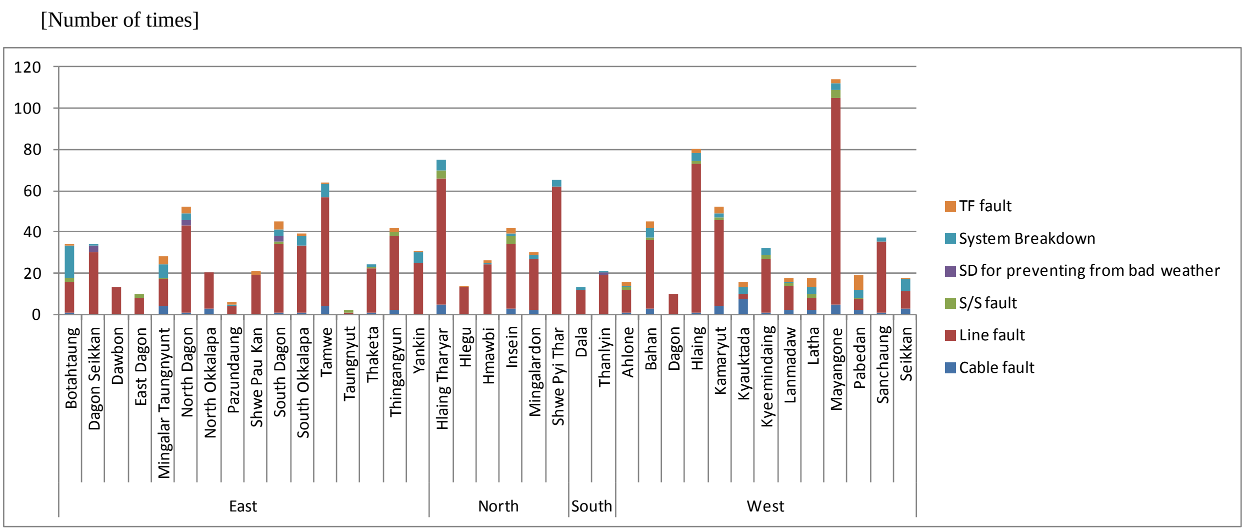



Source: JICA survey team based on YESB information

Figure 4-3: Fractions by power outage record type (duration)

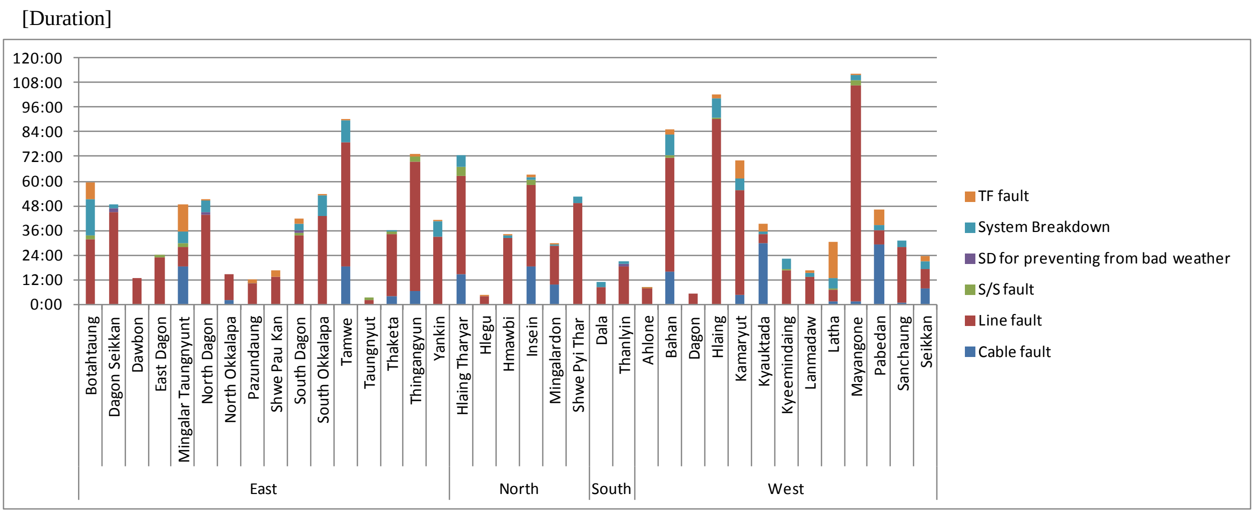
The figure shows the extremely large fraction of the number of times of planned load shedding equal to 35%. This could have probably resulted from failure to generate full power due to the smaller precipitation in June than other years leading to the insufficient amount of water reserved in the dams of hydropower stations (interviews with the YESB members). The sites subject to load shedding are determined by rotation by the operators of Mayangone substation (playing a role as the core dispatch control station).

The sites with the frequent fault records are picked up in the current distribution networks in order to develop the priority investment plan. The power outage records include load shedding and shut down work. In addition to shut down work, the sites subject to load shedding determined by rotation seem not to affect priority setting. Thus, the number of times and duration of power outage by fault among other power outage records were analyzed. Figure 4-4 and Figure 4-5 show the analysis results.




Source: JICA survey team based on YESB information (Reports between June 1st and June 30th, 2013)

Figure 4-4: Number of times of power outage by fault in each township



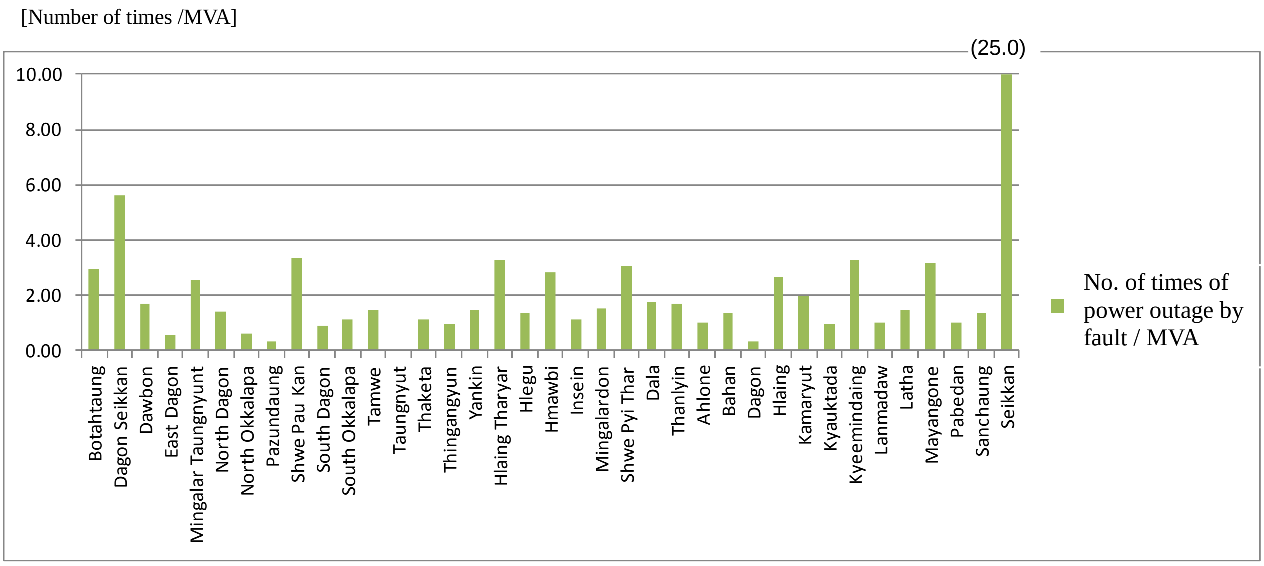

Source: JICA survey team based on YESB information (Reports between June 1st and June 30th, 2013)

Figure 4-5: Duration of power outage by fault in each township

The fault of overhead lines accounts for the substantial proportion of the causes for fault. The frequent use of bare wires has led to a number of short-circuit or grounding faults where the wires come in contact with trees or other wires.

Each township has the significantly different number of times and duration of power outage by fault. This is largely dependent on the capacity of power distribution facilities each township retains. The status of power outage by fault per unit facility was calculated by dividing the status by the total capacity of the transformers in a township. The capacity of the transformer with the secondary voltage of 0.4kV (primary voltage of 11kV or 6.6kV) was used from the list of facility capacities obtained from the YESB. Figure 4-6 shows the number of times of power outage by fault per capacity while Figure 4-7 shows the duration of power outage by fault per capacity.

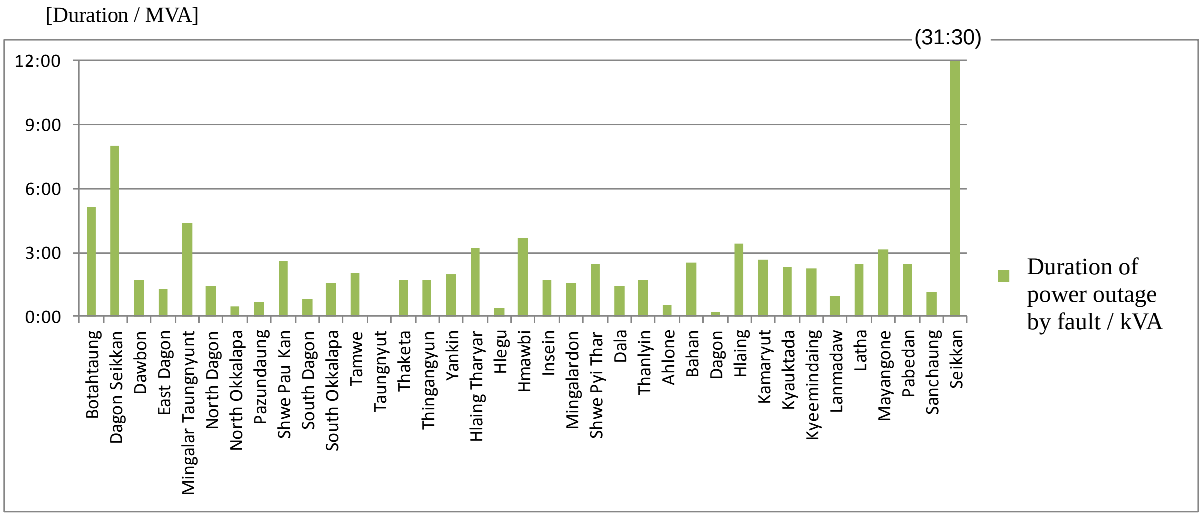
A large difference is seen by township. The Seikan Township or Dagon Seikan Township shows the large number of times and longer duration of power outage by fault with respect to the smaller facility capacity. Due to the smaller facility capacity, i.e. the smaller number of feeders, the fault that occurs in a feeder results in a broader range subject to power outage in a township. The fault will be limited and the range of power outage may be made smaller by increasing the number of facilities (the number of feeders and transformers).




Source: JICA survey team based on YESB information

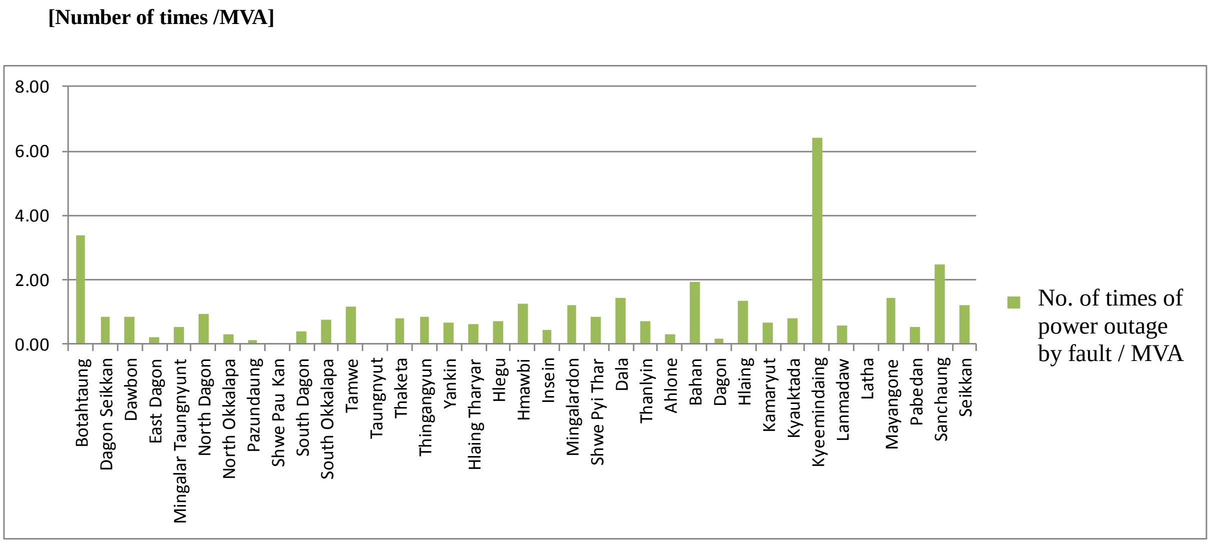
(Reports between June 1st and June 30th, 2013)

Figure 4-6: Number of times of power outage by fault per unit capacity
(Based on secondary voltage 0.4kV of transformers)




Source: JICA survey team based on YESB information (Reports between June 1st and June 30th, 2013)

Figure 4-7: Duration of power outage by fault per unit capacity
(Based on secondary voltage of 0.4kV of transformers)




(Shwe Pau Kan and Latha have no transformer of the secondary voltage of 11-6.6kV among the transformers retained by the YESB)

Source: JICA survey team based on YESB information (Reports between June 1st and June 30th, 2013)

Figure 4-8: Number of times of power outage by fault per unit capacity
(Based on secondary voltage of 11-6.6kV of power transformers)

Then, the number of times of power outage by fault was calculated using the capacity of the transformer with the secondary voltage of 11kV or 6.6kV (primary voltage of 66kV or 33kV) (Figure 4-8). In this case, the Kyeemindaing Township showed the larger number of times of power outage by fault with respect to the number of facilities because the township has the smaller number of the main transformers than other townships. Considering the fact that a fault in the transformation unit leads to power outage in wide areas, it is expected to increase the transformer capacity and the number of feeders.

**(4) Summary of analysis on the data on power outage records and fault records**

The data on power outage records were analyzed to consider what township needs the measures for facilities from the perspective of fault.

The factor analysis on power outage revealed that load shedding accounted for less than half the number of times of power outage. As this is dependent on the voltage source capacity, it is expected to improve the power generation facilities that can cover demands in Yangon. The second most significant factor following load shedding was the fault of lines. The fault of overhead lines accounts for the substantial proportion of the causes for fault. The frequent use of bare wires has led to a number of short-circuit or grounding faults where the wires come in contact with trees or other wires. The number of times of power outage by fault can be reduced by covering lines.

The analysis by township analyzed the number of times and duration of power outage by fault per facility capacity to eliminate the influence of the size of the facility capacity. This extracted the townships (Seikan Township, Dagon Seikan Township and Kyeemindaing Township) with the frequent power outage by fault with respect to the facility capacity they retain. The fault will be limited and the range of power outage may be made smaller by increasing the number of facilities (the number of feeders and transformers).

## 4.3 Policies for formulating the distribution networks development plan

In this survey, the 5-year plan concerning the development of YESB's distribution networks and the long-term plan up to 2030 will be reviewed. In the review, as shown in Figure 4-9, the projects that have been already completed and that are still going on are excluded from the existing 5-year plan (2011 to 2015), and the plan from 2015 to 2030 will be formulated. Also, the short-term plan for 5 years from 2015 to 2019 will be formulated, and the particularly high-priority projects will be sorted out and formulated as the priority investment plan.

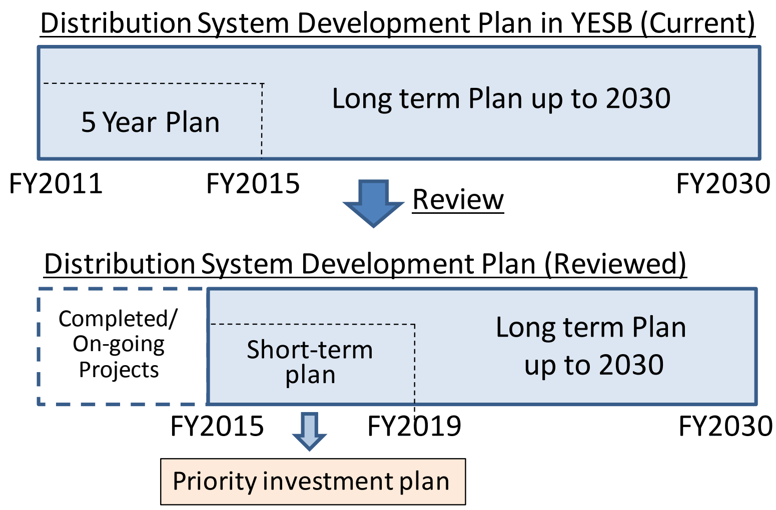



Figure 4-9: Flow of reviewing the distribution networks development plan and priority investment plan

The distribution networks development plan in this survey targets the YESB's power facilities and consists of the following two plans.

- 66/33kV substations, 66/11 or 66/6.6kV substations and transmission lines development plan
- 11kV or 6.6kV, 400(230)V distribution networks development plan

Under the 66/33kV substations, 66/11kV or 66/6.6kV substations and transmission lines development plan, the plan is formulated for newly constructing and reinforcing facilities to maintain the appropriate operation rates based on demand for each township estimated in Chapter 3. Under the 11kV or 6.6kV, 400(230)V distribution networks development plan, the plan is formulated for newly constructing, updating the aging facilities and reinforcing targeting 11kV or 6.6kV, 400(230)V distribution lines.

Table 4-4: Definitions of power facilities that are the subjects of planning in this study

| Power facilities | Definitions |
|---|---|
| Transmission line | 33kV or 66kV power transmission lines between another 66kV or 33kV substations |
| Grid substation | 66kV/33kV substation |
| Distribution substation | 66kV/11kVsubstation, 33kV/6.6kV substation |
| Medium-voltage (MV) distribution line | 11kV or 6.6kV distribution line |
| Low-voltage (LV) distribution line | 400(230)V distribution line |

### 4.3.1 Planning methodology for grid/distribution substation and transmission line

#### (1) System planning standards of YESB

YESB's power system is to be planned so as to maintain the limitation of the power facilities and normal voltage without causing power outages. In the current situation, YESB does not have the specified guideline for power system planning. YESB's power system is planned in accordance with the consideration that corresponds to technical criteria shown as below.

1) Load flow
   Operating rate should be less than 80% of capacity of the facilities

2) Voltage
   The bus voltage at any connection points shall be between 90% and 110% of the Nominal Voltage.

The YESB currently has no system planning standards as to electric supply reliability. As a result of consultation with the YESB, however, the plans aiming that the future system consists of the facilities that meet the "N-1 standards[9]" are formulated.

### (2) System planning standards in this survey

Following the consultation with the YESB as to the system planning standards in this survey, the system planning standards are shown in Table 4-5.

Table 4-5 :System planning standards in this survey

| | | Contents |
|---|---|---|
| Capacity | Normal | No more than 80% of the normal power flow |
| | At times of single failure (N-1) | No more than 100% of the power flow at times of single failure |
| Review period | | From 2013 to 2030 |
| Demand forecast | | Reviewed the demand forecast data with latest information (chapter 3, alternative demand forecast) |
| System planning | | Reviewed based on the YESB's existing mid-term plan |

### (3) Procedure for formulating projects

The individual projects in the 5-year distribution network development plan (FY2011 to FY2015) and latest investment plan (FY2016-2020) have been developed to deal with overload, demand increase, voltage drop, and supply to important facilities. To help review the YESB development plan, the items to

[9] The standard that no hindrance of supply occurs when one facility unit has troubles (when one transmission line or one transformer has troubles)

be implemented in 2016 and later were studied according to the following procedure, based on the demand record in 2012 and the alternative demand forecast by the survey team.

The procedure for formulating projects is as follows.

1) The survey team calculates the growth rate for each district from the alternative peak demand forecast from 2013 to 2020 by YESB.

2) Based on the track record of peak demand of each transformer in 2012 and the growth rate as mentioned above, the future operating rate of transformers for each township is calculated. (The operation rate for formulating the individual projects is shown in Table 4-12.

3) From the viewpoints of operating rate, the best countermeasure for each individual projects is studied including the consideration of the presence of important facilities and the possibility to strengthen the interconnection with neighboring substations.

    - Capacity and the number of transformers
    - Assessment of new installation of the substation and reinforcement of the transformer.
    - Necessity of the power transmission lines

The project priorities are set according to the procedure in Table 4-6. In priority setting, voltage rising to 66kV or supply to important facilities shall take precedence which could lead to reduced transmission loss.

Table 4-6: Procedure for project priority setting

| Step | Contents |
|---|---|
| (i) | Calculate the transformer capacity that needs to be added to the areas with the overall operation rate exceeding 80% based on the overall substation operation rate for each township |
| (ii) | Give priority to the townships with the higher operation rate |
| (iii) | Set priority for areas with the equivalent operation rates considering the following points:<br>- Substations supplying to important facilities (consider providing two lines or two power supplies)<br>- Areas in which voltage may be raised to 66kV (close to the existing 66kV systems)<br>- Areas where power facilities have been deteriorated (aged or frequent fault occurrence) |

Source: JICA study team

See below for the number of substations and feeders that supply important facilities (hospital, parliament, military office, international airport and railway station):

Table 4-7: Substations supplying to important facilities

| Important facilities | Township | Number of substations | Number of feeders |
|---|---|---|---|
| Hospital | Dagon, Lanmadaw, etc | 17 | 21 |
| Parliament | Dagon | 1 | 2 |
| Military office | Dagon | 1 | 3 |
| International airport | Mingalardone | 1 | 2 |
| Railway station | Mingalartaungnyunt | 1 | 1 |

Source: YESB information

Regarding the transmission system plan, the voltage is raised from the 33kV system to the 66kV system as the measures against transmission line overload and for improving voltage drop and reducing transmission loss. Since there are many customers who currently receive power at 33kV, it is necessary to maintain the 33kV system for the time being. However, to unify the whole systems to the 66kV system configuration is aimed. Moreover, from the viewpoint of enhancing electric supply reliability, the 66kV transmission system is considered to be developed in loop configuration.

### 4.3.2 Medium- and low-voltage distribution lines development plan

Regarding the distribution system plan, the raise of the system voltage from 6.6kV to 11kV continues to be conducted in the medium-voltage (MV) distribution lines as the measures for reducing the loss. The 6.6kV and 11kV dual taps on the primary side to most of the YESB distribution transformers have been installed already. Since there are many customers who currently receive power using 6.6 kV-dedicated transformers, it is necessary to maintain the 6.6kV system for the time being. However, unifying the whole systems to the 11kV system is aimed.

Moreover, from the viewpoint of enhancing electric supply reliability, the MV distribution system will be developed considering future loop configuration and the facilities will be formed so that they can be used when distribution lines are automated in the future.

Most of the MV and the low-voltage (LV) distribution lines are bare wires and their aged deterioration has advanced under current conditions. Therefore, in order to secure public safety and restrain failure due to contacting trees, cable deterioration, etc., it is planned to apply insulated conductors to all the MV and LV distribution lines.

In consideration of urgency in insufficient power sources, in order to reduce the loss resulting from the long-range LV lines from the current high-capacity transformer, it is planned to introduce the multi-transformer system where low-capacity transformers are installed dispersedly and the LV line length is shorten. Since the demand for electric power is expected to largely increase in the future, the facilities to be introduced in facility renewal will be basically strengthen in consideration of the increase of demand in each township estimated in Chapter 3 and the increase of demand based on individual on-site conditions.

## 4.4 Standardization of the specifications and configurations of electric power facilities

The primary voltage of distributing substations currently is 66kV or 33kV, and the secondary voltage is 11kV or 6.6kV. In the future, the primary and secondary voltages are intended to be sequentially raised to 66kV and 11kV as the standard voltages respectively, and the power distribution facilities must be standardized accordingly.

Because distribution facilities and transformation facilities consist of an enormous amount of facilities, it is inefficient to individually study the specifications and organization of each facility, and the inconsistency of specifications makes maintenance and operations more complicated. For the purpose of efficient improvement of facility construction, maintenance and operation, the standardization of the specifications of facilities and system under the control of YESB (transformers, conductors, poles, etc.), was studied and the results of study into the formulation of the priority investment plan was incorporated upon consultations with the YESB counterpart.

### 4.4.1 Standardization of power distribution facilities

#### (1)Medium-voltage distribution lines

It seems beneficial to configure the MV distribution lines considering the improved supply reliability by introduction of the N-1 concept at the upper systems and interconnection among distribution line feeders in the future. To this end, the standardization of wire and cable specifications can be of advantage.

It is recommended that the number of standard line sizes for use be limited so that plan, design, procurement, maintenance, management and stock of distribution facilities be ensured in an efficient and easy manner as the future increase in demands is expected, though the overhead lines or underground cables of various sizes are used currently. In planning and designing especially, it is recommended that a standard size of distribution facilities be selected considering not only estimated final demand in future but also demand allowance for backward power supply to a standardized section of surrounding MV feeders in future.

While the ratio of existing underground cables is not very low, it is recommended that new installation of underground cable be limited to special occasions such as the case when landscape conservation is necessary. And the rule for its application should be established considering the current situations of construction budget and fault frequency, because it costs higher and takes more time to repair it in case of failure compared with overhead line.

#### (2) Transformers for low-voltage distribution

In consideration of urgency in insufficient power sources, it is recommended that a low-loss type transformer such as amorphous core type be actively adopted as standard to reduce loss caused in a transformer. Especially in case of an amorphous transformer, its total cost can be lower than that of conventional silicon type transformer in lifecycle comparison. It is agreed that similar to the cases in Japan, the transformers of small capacity and shortened low-voltage lines are standardized to seek to restrict voltage drop and reduce power loss, as is called the multiple transformer system by YESB to indicate a direction in the situations where the transformers of relatively large capacity are located with the low-voltage lines extending in broad areas for distribution.

For how to design the optimal multi-transformer system, it seems necessary to train or support the YESB designers by for instance taking into account the future demand assumption in the divided supply areas, etc.

The standard specifications such as the size, number and maximum length of the secondary cables of a transformer, fuse capacity, and the allowable current and number of cables are established for each transformer capacity. However, considering the situations where these are not well recognized by the YESB, thorough announcement or education might be required so the YESB will comply with the standard design specifications.

**(3) Low-voltage distribution lines**

The measures for voltage control in LV lines are necessary, because voltage drops between transformers and ends of LV lines are currently much higher in some areas and there are no rules or guidelines which would define the allowable range of service voltage. A voltage management system in LV lines would help not only to improve voltage drop but also to reduce power loss in LV lines. Acquiring and managing the information both distribution facility and the load are required to establish the LV management system and control voltage in LV lines.

With a view to establish proper voltage management system, information about which load is connected to which specific pole is necessary as well as the information about the length of LV line, and the information must be properly managed.

It is recommended as in the cases of the MV lines previously mentioned, that the number of standard line sizes for use be limited so that plan, design, procurement, maintenance, management and stock of distribution facilities are ensured in an efficient and easy manner, though the overhead lines or underground cables of various sizes are used. Using the values of resistance obtained through standardized specifications data of overhead wire or underground cable and considering the formations of reactance, voltage drop and power loss can be estimated. The public security also has to be ensured by employing covered wires for overhead lines, the majority of which are bare wires currently.

For the load management, it is recommended that the factor of demand set be introduced based on the results of relation between maximum demand and consumed electric energy or contracted electric power capacity, etc., since the total loads can be estimated less than the sum of each load and it helps distribution facilities be operated efficiently. Furthermore, the service wire connection phase management is useful, as load balancing in three phases improves voltage drop and reduce power loss.

**(4) Switches, etc.**

Since few on-load switch is installed in the distribution line, power outage in the entire area covered by the distribution line lasts for a long period of time or it takes much time to disconnect the fault sections from the connection in case a fault occurs. In contrast, the middle-voltage lines directly grounded carries large current even when a ground fault occurs. Therefore, it is recommended that the standard facilities be configured by combining the switch useful for the disconnection of the fault section or early transmission in the sound section, and the over-current detector effective for the detection of fault sections. These configurations still require thorough technical considerations as they should take into account economic performances or the future establishment of power distribution systems.

For those feeders supplying electricity to important facilities in particular, it is recommended that the section switch with the time-dependent sequential transmission functions be installed as the standard equipment that enables the automatic detection of fault sections and the early automatic transmission in sound sections. However, when to introduce the switch requires mutual coordination as it is closely related to the protection coordination and reclosing of the substation circuit breakers. The introduction to the facilities should seek to configure effective facilities considering the future automation of distribution lines, which might need to train or support the YESB.

### 4.4.2 Standardization of substation facilities

#### (1) Configuration of substation

The configuration of many substations in YESB is one transmission line and one power transformer because YESB does not introduce N-1 policy. The reliability of the configuration of substation is low. If one of transformer lines faulted, there would be outage in the whole area to which the substation supplies. In addition, it is impossible to carry out shut down maintenance or repair work due to interruption limitation. YESB is going to forward new installation and reinforcement projects of substations based on 5 year project plan as the countermeasure against overload and load increase. It is recommended that the configuration of two transmission lines and two units of transformer in a substation is adopted in the future. Therefore, survey team study the layout of substation which makes it possible to have two transmission lines and two transformers when newly installing or reinforcing substation or replacing equipment. Desirable substation configuration (single line diagram) is shown in Figure 4-10.

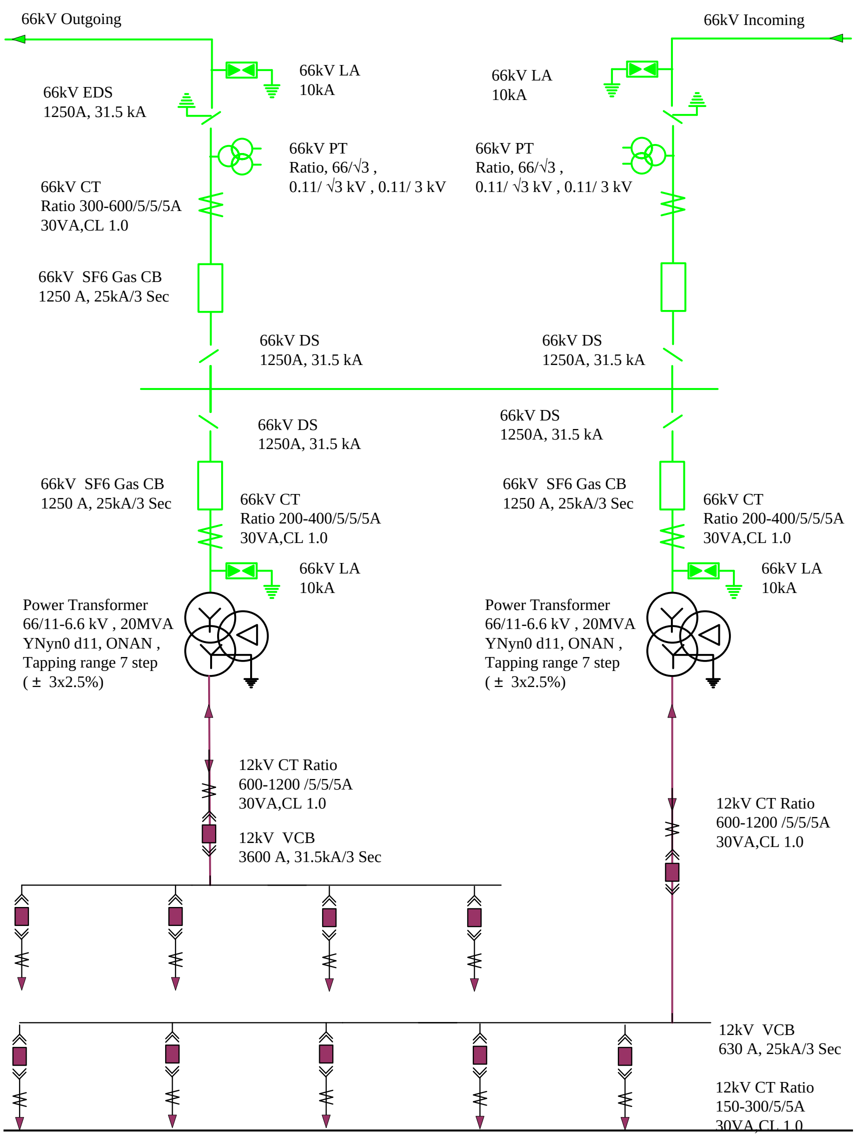



Figure 4-10: Single line diagram of desirable 66/11-6.6kV standard substation

### (2) Power transformer

YESB has standard specifications of transformers such as voltage and capacity. The standard voltages are 66/33kV, 66/11kV, and 33/11kV. The standard capacities are 30MVA for 66kV transformer and 10MVA for 11kV, however, there are other capacities for planed transformers in 5 year projects. The capacity of installing transformers in a substation is influenced in demand increase at the supply area and the land size of the substation. However, the large capacity of transformers is necessary in the future according to present demand increase. Therefore, it is recommend to plan the installation of 30MVA transformer for 66kV and 10MVA transformer for 33kV as a standard and to prepare the space to install these transformers at least.

Cooling method of transformer is ONAN (Oil Natural Air Natural Type). YESB has some examples to add cooling fans on radiators of transformer by itself. It is possible that some of existing substations are lacking spaces fit for uprating capacity of transformers. In such cases, the application of ODAN (Oil

Directed Air Natural Type) transformer using oil pump and OFAN (Oil Forced Air Natural Type) transformer using cooling fan will be studied.

Tap changer of transformer in YESB is No-voltage Tap Changer (NVTC). On-Load Tap Changer (OLTC) is recommended to be adopted to deal with the voltage fluctuation, however, is not adopted in YESB because the voltage fluctuation of YESB system is very large and frequent operation of OLTC is worried. It is necessary to introduce SCADA and to control and monitor the voltage of Myanmar power system at first.

There is no mention about sound specification in transformer standard specification because there is no noise regulation in Myanmar. It is necessary to pay attention to transformer sound because transformers are installed near boundary line in many substations. Low noise transformer is better to be installed for aiming future noise regulation.

**(3) Switchgear**

This is the first time to install 66kV GIS in the railway substation under construction. It is estimated that the number of GIS substation is increasing in the future because it is difficult to acquire the land of substation in downtown area in Yangon. There are mainly three types of GIS, double bus tank type GIS, single bus tank type GIS, and cubicle type GIS. Double bus type GIS is applied for important transmission substations in general. It is installed in 66kV Railway substation in YESB. Single bus GIS including cubicle type is applied for distribution substations.

For the 33kV switchgear, there are two kinds of switchgears, air insulated type "switch bay" in outdoor and cubicle type switchgear in indoor, mentioned in Chapter 2. Cubicle type 33kV switchgear is air insulated bus switchgear (AIS). 11kV switchgears are also indoor cubicle type switchgear. In present, 11kV switchgear is manufactured in domestic manufacturing company. (Main parts and components are made by foreign manufacturers.) It is expected that 33kV switchgear is also manufactured in domestic manufacturers in the future. For the small land space of substation, the application of compact switchgear makes possible to reduce installation space.

Regarding circuit breakers, Vacuum Circuit Breaker (VCB) is applied for 33kV and less voltage, and Gas Circuit Breaker (GCB) or Oil Circuit Breaker (OCB) is applied for 33kV and above. For 66kV and 33kV switch bay in outdoor, GCB or OCB is applied in YESB. For the replacement of 33kV OCB in outdoor, 33kV VCB can be applied. YESB has been replacing from 33kV OCB to 33kV VCB in outdoor. GCB or OCB is used for 33kV switchgear.

**(4) Checking points for procurement of equipment**

It is necessary to check the possibility of long term continuous parts supply at the procurement of substation equipment. In addition, quick parts arrangement and supervisor support of manufacturers at the accident, failure and abnormality of equipment are necessary. Therefore, parts supply framework and maintenance and repair support framework by supervisor are to be checked at the first procurement of equipment.

## 4.5 Review of the distribution network development plan

### 4.5.1 Substation expansion plan

Table 4-8 shows a list of the YESB's substation expansion plans as of July 2013. On the assumption that the substations will be expanded according to the substation expansion plan in Table 4-8, Table 4-9 shows the results of calculation of the operation rates against the capacity of transformers in substations by township, which reflects the demand by township based on the alternative demand forecast made in Chapter 3. Among the results of calculation, the parts that show that the operation rate exceeds 80% are shaded. The results of calculation show that, even if YESB's expansion plans shown in Table 4-8 are implemented, the townships with the operation rates exceeding 80% will remain. Therefore, to maintain appropriate substation operation rates, it is recommended to further expand substations.

Table 4-8: The YESB's current 5-year plan, the latest substation investment plan (from FY2016 to FY2020) and 2030 year plan

| District Office | No. | Township | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | | 2020 | | 2021-25 | | 2026-30 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA |
| Eastern district | 1 | North Okkalarpa | North Okkalarpa | 30 | Thudama road(33kV) | 10 | | | | | | | | | | | | | | | Khamarthi St/Mandine St | 30 |
| | | | Waibargi | 20 | | | | | | | | | | | | | | | | | Tudamar St/Kantharyar St | 30 |
| | | | Khaymarthi road(33kV) | 10 | | | | | | | | | | | | | | | | | | |
| | 2 | North Dagon | Bobahtoo road(33kV) | 10 | | | Bobahtoo st(33kV) | 10 | | | | | Bobahtoo st | 20 | | | | | Shwe Pin Lone | 30 | Bobahtoo St/Yadana St | 30 |
| | | | | | | | | | | | | | | | | | | | | | Kungpadatha | 30 |
| | 3 | Shwe Pauk Kan | Shwepaukkan | 20 | | | | | | | | | | | | | | | | | | |
| | 4 | South Dagon | | | Ywathargyi | 20 | Manisithu St(33kV) | 10 | | | Industry zone(2) | 30 | | | Innwa Villa | 30 | | | | | | |
| | | | | | No7 road/Yaynantthar(33kV) | 10 | Hlawga road(33kV) | 10 | | | | | | | Dagon south office | 30 | | | | | | |
| | 5 | East Dagon | | | Dagon University | 30 | | | | | | | | | Dagon University | 30 | | | | | Dagon East | 30 |
| | 6 | Dagon Seikkan | | | Dagon Seikkan(2) | 20 | | | | | | | | | Innwa Villa | 30 | | | | | Dagon seikkan(1) | 30 |
| | 7 | Thaketa | | | Ayyawun/Minnada(33kV) | 10 | Shukhinthar | 20 | | | Natwarat | 30 | | | | | | | | | | |
| | | | | | | | | | | | Myintawthar | 30 | | | | | | | | | | |
| | 8 | Thingangyun | Thuwunna | 30 | Kamarkyi Ward (completed)(33kV) | 5 | North Thingangyun | 20 | Township office | 30 | | | | | | | | | Kaesitan | 30 | | |
| | 9 | Yankin | | | | | Guittitlit | 20 | | | Kokkai | 30 | | | | | | | Shweownepin | 30 | | |
| | 10 | Mingalar Taungnyunt | Patheinnyunt | 30 | | | Kanayde | 30 | | | | | | | Theinpyu | 30 | | | | | Patheinnyunt | 30 |
| | 11 | Tamwe | Yarma | 20 | | | | | | | | | | | | | Mayepadathar | 30 | Nutchaung | 30 | | |
| | | | Kyaikkasan | 30 | | | | | | | | | | | | | | | | | | |
| | 12 | Dawbon | | | | | | | | | | | Dawbon | 30 | | | | | | | | |
| | 13 | Botahtaung | | | | | | | | | | | | | | | | | | | 41th street | 30 |
| | 14 | Pazungtaung | | | | | | | | | | | | | | | | | Laekan | 30 | | |
| | 15 | South Okkalarpa | | | | | | | | | | | Waizayantar | 30 | | | Thanthumar | 30 | | | Thitsar street | 30 |
| Western district | 1 | Mayangone | Tawwin | 30 | South Kabaaye | 30 | North Kabaraye | 20 | Mayangone | 30 | | | | | | | Seinpanmyain | 30 | | | Hlaing Univ./Pyay road | 30 |
| | | | Bayintnaung | 30 | | | | | Goneshaw | 30 | | | | | | | | | | | | |
| | 2 | Kamaryut | | | University | 30 | | | | | Sinmalike | 30 | | | Tikegerahle | 30 | | | MRTV | 30 | | |
| | 3 | Bahan | | | ITS(33kV) | 10 | Old university road(33kV) | 10 | | | | | Shwegondine | 30 | | | | | Thu Ye Kaung Sithat | 30 | | |
| | | | | | Myanpadatha(33kV) | 10 | | | | | | | | | | | | | U htunt Bo | 30 | | |
| | 4 | Latha | | | | | | | | | | | | | | | | | | | | |
| | 5 | Lanmadaw | | | | | | | | | | | | | | | | | 220 Bed hospital | 30 | | |
| | 6 | Pabetan | | | | | Kannaar Road and | 10 | | | | | | | | | | | 35th street | 30 | | |
| | 7 | Dagon | | | Hluttaw | 30 | | | | | | | | | Warmuseum | 30 | | | Medical research | 30 | | |
| | | | | | | | | | | | | | | | | | | | Pyay road | 30 | | |
| | 8 | Ahlone | YESB head office(33kV) | 10 | | | | | FID | 30 | | | | | | | | | Honhai | 30 | | |
| | | | | | | | | | Forest | 30 | | | | | | | | | Lower kyi myint daing | 30 | | |
| | 9 | Kyimyindaing | Lower kyimyintdaing road(33kV) | 10 | | | | | | | | | | | | | | | No1 Thitset | 30 | | |
| | 10 | Seikkan | | | | | | | | | | | | | | | | | Container(2) | 30 | | |
| | 11 | Kyauktadar | | | | | | | | | | | | | | | | | 25street | 30 | | |
| | | | | | | | | | | | | | | | | | | | Seikkanthar street | 30 | | |
| | 12 | Sanchaung | | | | | | | | | | | | | | | | | Shinsawpu | 30 | Hanthawadi | 30 |
| | 13 | Hlaing | | | Hlaing university(33kV) | 10 | | | | | | | Yangon-Insein Road (RIR) | 30 | | | | | Aung Myay Tha Se | 30 | | |
| | | | | | | | | | | | | | | | | | | | Middle Parrami | 30 | | |
| Southern district | 1 | Thanlyin | Township office | 5 | | | | | | | | | | | | | Bayargone | 30 | | | Thanlyin township | 30 |
| | 2 | Kyauk Tan | | | | | | | | | | | | | | | | | | | Kyauttan | 30 |
| | 3 | Seikkyi Kanaungto | | | | | | | | | | | | | | | | | | | Jaungwinelay | 30 |
| | | | | | | | | | | | | | | | | | | | | | Khanaungto | 30 |
| | | | | | | | | | | | | | | | | | | | | | Jaungwinelay | 30 |
| | 4 | Dala | | | | | | | | | | | | | | | | | | | Dala | 30 |
| | 5 | Tontay | | | | | | | | | | | | | | | | | | | Tontay | 30 |
| | 6 | Kwinchankone | | | | | | | | | | | | | | | | | | | Konchankone | 30 |
| | 7 | Kawat Hmu | | | | | | | | | | | | | | | | | | | Kawmu | 30 |
| | 8 | Thone Gwa | | | | | | | | | | | | | | | | | | | Thonegwa | 30 |
| | 9 | Khayan | | | | | | | | | | | | | | | | | | | Khayan | 30 |
| Northern district | 1 | Mingalardone | | | 12 mile(33kV) | 10 | 13 mile | 10 | | | Khayaepin | 30 | | | | | 14 mile | 30 | Palare | 30 | Htauntkyant | 30 |
| | | | | | | | | | | | | | | | | | | | | | 12 mile | 30 |
| | | | | | | | | | | | | | | | | | | | | | Khayaepin | 30 |
| | 2 | Innsein | Thitaw computer | 30 | | | Dayingone | 20 | | | | | Khattayar | 30 | | | | | Inn sein township | 30 | | |
| | | | | | | | | | | | | | | | | | | | 10 mile | 30 | | |
| | | | | | | | | | | | | | | | | | | | YCDC | 30 | | |
| | | | | | | | | | | | | | | | | | | | Aungzaya housing | 30 | | |
| | | | | | | | | | | | | | | | | | | | Technical Univ. | 30 | | |
| | 3 | Hlaingtharya | Meekhwat Market(33kV) | 10 | Kyansitthar/ Mahabandoola(33kV) | 10 | | | Zone No(1) | 30 | | | Shwelinpan | 30 | | | | | Zone(5) | 30 | Zone(5) | 30 |
| | | | | | | | | | Zone No(2) | 30 | | | | | | | | | Office house | 30 | | |
| | | | | | | | | | Zone No(7) | 30 | | | | | | | | | | | | |
| | 4 | Shwepyithar | Hlawga road(33kV) | 10 | | | Shwepyithar Zone (1) | 30 | Township office | 30 | | | | | | | | | Shwepryithar | 30 | Indutrial zone(4) | 30 |
| | | | | | | | | | | | | | | | | | | | Thar Du Kan | 30 | Hlawga St/No4 St | 30 |
| | | | | | | | Wartayar Ind. Zone(33kV) | 10 | | | | | | | | | | | Kuu Chaung | 30 | | |
| | 5 | Htaunkkyant | Pyi road & corner pearl road(33kV) | 10 | | | | | | | | | | | | | | | | | Parel street corner | 30 |
| | 6 | Hlegu | | | Hlegu township office | 30 | | | | | | | | | | | | | Inn Tin | 30 | Phaung gyi | 30 |
| | | | | | Phaunggyi road(33kV) | 10 | | | | | | | | | | | | | | | Phaung gyi St/Highway road | 30 |
| | 7 | Phaungkyi | | | | | | | | | | | | | | | | | | | | |
| | 8 | Okkan | | | | | | | | | | | | | | | | | Okkan | 30 | | |
| | 9 | Tikegyi | | | | | | | | | Tikegyi | 30 | | | | | | | | | | |
| | 10 | Hmawbe | | | Pyi road & No4 road(33kV) | 10 | Kyetphyukan | 20 | | | | | | | | | Oaksat | 30 | | | Phoogyi communication | 30 |
| | | | | | | | | | | | | | | | | | Kyatphyukan | 30 | | | Pyay road/No4 St | 30 |
| | 11 | Htantapin | Htantapin(33kV) | 10 | | | | | | | | | | | | | | | | | Htantapin | 30 |

*xxAx: 66kV project planned by YESB, xxBx: 33kV project planned by YESB

## Table 4-9: Operation rates of transformers in each township in case of YESB development plan

| District Office | No. | Township (TS) | 2012 Peak demand (MW) (a) | 2012 Substation capacity (MVA) (b) | Capacity operating rate ((a)+demand increase)/((b)+(c))/(pf=0.90) 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eastern district | 1 | North Okkalarpa | 10.4 | 25 | 53% | 57% | 62% | 67% | 73% | 84% | 131% | 78% |
| | 2 | North Dagon | 19.8 | 55 | 47% | 51% | 55% | 47% | 51% | 59% | 71% | 77% |
| | 3 | Shwe Pauk Kan | 9.9 | 25 | 70% | 76% | 82% | 90% | 98% | 111% | 173% | 284% |
| | 4 | South Dagon | 36.8 | 107 | 44% | 47% | 43% | 46% | 38% | 43% | 69% | 125% |
| | 5 | East Dagon | 18.8 | 41 | 54% | 59% | 64% | 69% | 51% | 58% | 92% | 111% |
| | 6 | Dagon Seikkan | 14.4 | 30 | 64% | 69% | 75% | 81% | 89% | 101% | 159% | 147% |
| | 7 | Thaketa | 14.3 | 30 | 42% | 46% | 25% | 27% | 29% | 34% | 53% | 171% |
| | 8 | Thingangyun | 26.6 | 45 | 67% | 51% | 55% | 60% | 66% | 75% | 118% | 146% |
| | 9 | Yankin | 23.0 | 40 | 102% | 110% | 68% | 74% | 52% | 59% | 73% | 150% |
| | 10 | Mingalar Taungnyunt | 23.5 | 50 | 52% | 56% | 61% | 66% | 53% | 60% | 95% | 120% |
| | 11 | Tamwe | 21.9 | 54 | 52% | 57% | 62% | 67% | 73% | 59% | 73% | 117% |
| | 12 | Dawbon | 4.0 | 15 | 47% | 51% | 56% | 20% | 22% | 25% | 39% | 64% |
| | 13 | Botahtaung | 4.4 | 10 | 78% | 84% | 92% | 100% | 109% | 124% | 183% | 79% |
| | 14 | Pazungtaung | 16.1 | 50 | 57% | 62% | 67% | 73% | 79% | 91% | 90% | 144% |
| | 15 | South Okkalarpa | 10.0 | 30 | 59% | 64% | 69% | 38% | 41% | 31% | 50% | 60% |
| Western district | 1 | Mayangone | 26.8 | 70 | 30% | 23% | 25% | 28% | 30% | 30% | 63% | 69% |
| | 2 | Kamaryut | 34.0 | 76 | 57% | 62% | 52% | 57% | 51% | 58% | 78% | 147% |
| | 3 | Bahan | 3.5 | 10 | 16% | 17% | 18% | 11% | 12% | 14% | 12% | 19% |
| | 4 | Latha | 1.6 | 5 | 57% | 61% | 67% | 72% | 79% | 90% | 129% | 229% |
| | 5 | Lanmadaw | 0.6 | 10 | 11% | 12% | 12% | 14% | 15% | 17% | 7% | 11% |
| | 6 | Pabetan | 21.3 | 35 | 69% | 74% | 81% | 88% | 96% | 70% | 83% | 133% |
| | 7 | Dagon | 21.0 | 47 | 65% | 71% | 77% | 83% | 60% | 68% | 64% | 102% |
| | 8 | Ahlone | 23.9 | 50 | 71% | 40% | 43% | 47% | 51% | 58% | 89% | 98% |
| | 9 | Kyimyindaing | 2.5 | 5 | 30% | 32% | 35% | 38% | 41% | 47% | 25% | 40% |
| | 10 | Seikkan | 25.3 | 55 | 82% | 88% | 96% | 104% | 113% | 129% | 132% | 213% |
| | 11 | Kyauktadar | 8.8 | 20 | 78% | 84% | 92% | 100% | 109% | 124% | 49% | 79% |
| | 12 | Sanchaung | 6.6 | 15 | 78% | 84% | 92% | 100% | 109% | 124% | 65% | 63% |
| | 13 | Hlaing | 25.9 | 55 | 84% | 90% | 98% | 69% | 75% | 86% | 80% | 128% |
| Southern district | 1 | Thanlyin | 12.4 | 27 | 69% | 74% | 81% | 88% | 96% | 56% | 89% | 97% |
| | 2 | Kyauk Tan | 9.0 | 28 | 57% | 62% | 67% | 73% | 79% | 90% | 141% | 111% |
| | 3 | Seikkyi Kanaungto | 0.6 | 2 | 53% | 58% | 62% | 68% | 74% | 84% | 106% | 5% |
| | 4 | Dala | 4.6 | 9 | 91% | 98% | 106% | 116% | 126% | 144% | 208% | 84% |
| | 5 | Tontay | 3.4 | 8 | 75% | 82% | 88% | 96% | 105% | 119% | 174% | 64% |
| | 6 | Kwinchankone | 1.4 | 3 | 99% | 107% | 117% | 127% | 138% | 157% | 180% | 31% |
| | 7 | Kawat Hmu | 1.3 | 5 | 46% | 50% | 54% | 59% | 64% | 73% | 107% | 27% |
| | 8 | Thone Gwa | 2.6 | 7 | 71% | 77% | 83% | 91% | 99% | 112% | 162% | 51% |
| | 9 | Khayan | 2.2 | 5 | 78% | 84% | 92% | 100% | 109% | 124% | 171% | 45% |
| Northern district | 1 | Mingalardone | 18.4 | 39 | 67% | 72% | 48% | 53% | 57% | 47% | 59% | 66% |
| | 2 | Innsein | 37.3 | 76 | 65% | 70% | 76% | 64% | 70% | 79% | 75% | 86% |
| | 3 | Hlaingtharya | 44.5 | 100 | 61% | 39% | 42% | 40% | 44% | 50% | 91% | 86% |
| | 4 | Shwepyithar | 26.7 | 55 | 59% | 47% | 51% | 55% | 60% | 68% | 70% | 74% |
| | 5 | Htauntkyant | 3.7 | 10 | 33% | 35% | 39% | 42% | 46% | 52% | 82% | 53% |
| | 6 | Hlegu | 7.4 | 15 | 29% | 32% | 34% | 37% | 41% | 46% | 44% | 39% |
| | 7 | Phaungkyi | 2.0 | 5 | 71% | 77% | 28% | 30% | 33% | 37% | 57% | 41% |
| | 8 | Okkan | 0.5 | 3 | 32% | 35% | 38% | 41% | 45% | 51% | 7% | 11% |
| | 9 | Tikekyi | 4.8 | 10 | 85% | 92% | 25% | 27% | 30% | 34% | 53% | 344% |
| | 10 | Hmawbe | 6.9 | 21 | 30% | 32% | 35% | 38% | 42% | 19% | 31% | 31% |
| Total | | | 645.4 | 1,486 | | | | | | | | |

(Source) JICA Survey team based on YESB information.

Regarding the review of substation expansion plans by the survey team, the reinforcement of substations in townships where the operation rates are high and the overload of transformer is expected, should be given the highest priority.

As a result of the review by the survey team, in the short-term plan from FY2015 to FY2019, the names of substations, which were added on top of the YESB's plan in order to eliminate the overload of substations in the townships, are shown in Table 4-10. In addition, in order to select the locations suitable for the substation expansion, frequency of power outage as shown in Figure 4-8 is also considered as well as the operation rate of substations which are overly high.

Table 4-10: Substation expansion plan in addition to YESB Plans from 2015 to 2019

| Item | Substation expansion plan |
|---|---|
| Elimination of overloading of substations | (Upgrading from 33kV to 66kV)<br>Railway*1, Container(1), 35th Street, Hanthawady*2, Aungmyaytharsi, 41th Street*3<br>(Reinforcement of transformers)<br>Mawtin, RIR, Seikkan(2), Thida, Hluttaw*4, Dagon university*5 |

*1,*4,*5: Substations supplying to important facilities

*2,*3: Substations belonging to the township of the higher number of times of power outage

Table 4-11 shows the reviewed plan for the substation expansion plan. The shaded parts in Table 4-11 show changes from the YESB plan. Moreover, Table 4-12 shows the operation rates of transformers in substations in each township when the review plan is implemented. Some of the townships are still left untouched in this plan despite of the high operation rates of 80% or more due to the limitation of the number of projects capable to be implemented within a year.

Table 4-13 shows the difference of the capacity of transformers between the YESB's substation expansion plans and the review plan drawn up this time. As a result of the review by the survey team, the addition of the capacity of transformers (+130MVA) in the short-term plan (FY2015 to FY2019) and the addition of the capacity of transformers (+1,640MVA) in the long-term plan (FY2020 to FY2030) are proposed against the YESB's original plan.

Table 4-11: Revised substation expansion plans by the survey team

| District Office | No. | Township | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | | 2020 | | 2021-25 | | 2026-30 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA | Substation | MVA |
| Eastern district | 1 | North Okkalarpa | North Okkalarpa | 30 | Thudama road (33kV) | 10 | | | | | | | | | | | | | Township Office | 30 | Khamarthi St/Mandine St | 30 |
| | | | Waibargi | 20 | | | | | | | | | | | | | | | | | | |
| | | | Khaymarthi road (33kV) | 10 | | | | | | | | | | | | | | | | | | |
| | 2 | North Dagon | Bobahtoo road (33kV) | 10 | | | Bobahtoo st(33kV) | 10 | | | | | | | | | | | Shwe Pin Lone | 60 | Bobahtoo St/Yadana St | 60 |
| | 3 | Shwe Pauk Kan | Shwepaukkan | 20 | | | | | | | Shwe Pauk Kan | 30 | | | | | | | Shwe Pauk Kan | 60 | | |
| | 4 | South Dagon | | | Ywathargyi | 20 | Manisithu St(33kV) | 10 | | | | | | | | | | | Innwa Villa | 30 | South Dagon(3) | 60 |
| | | | | | No7 road/Yaynantthar (33kV) | 10 | Hlawga road(33kV) | 10 | | | | | | | | | | | Dagon south office | 60 | South Dagon(4) | 60 |
| | 5 | East Dagon | | | Dagon University | 30 | | | | | | | | | Dagon University | 30 | | | Dagon East(2) | 60 | Dagon East(3) | 30 |
| | 6 | Dagon Seikkan | | | Dagon Seikkan(2) | 20 | | | | | | | Dagon Seikkan(2) | 30 | | | | | Dagon seikkan(1) | 30 | Dagon seikkan(1) | 60 |
| | 7 | Thaketa | | | Ayyawun/Minnada (33kV) | 10 | | | | | Natwarat | 30 | | | | | | | Shukhinyhar | 30 | Shukhinyhar | 30 |
| | | | | | | | | | | | Myintawthar | 30 | | | | | | | | | | |
| | 8 | Thingangyun | Thuwunna | 30 | Kamarkyi Ward (completed)(33kV) | 5 | North Thingangyun | 30 | Township office | 60 | | | | | | | | | Kaesitan | 60 | Township office(2) | 90 |
| | 9 | Yankin | | | | | | | Guittitlit | 60 | | | | | Kokkaine | 30 | | | Shweownepin | 30 | Guittitlit | 90 |
| | 10 | Mingalar Taungnyunt | Patheinnyunt | 30 | | | Kanayde | 30 | | | | | | | Theinpyu | 30 | | | Kanayde | 60 | Shwe Myayar | 60 |
| | 11 | Tamwe | Yarma | 20 | | | | | | | | | | | | | Mayepadathar | 30 | Nutchaung | 30 | PatheinNyunt(2) | 90 |
| | | | Kyaikkasan | 30 | | | | | | | | | | | | | | | | | | |
| | 12 | Dawbon | | | | | | | | | | | | | | | Dawpon | 30 | | | | |
| | 13 | Botahtaung | | | | | | | | | 41th street | 30 | | | | | | | 41th street(2) | 30 | | |
| | 14 | Pazungtaung | | | | | | | | | | | Thida | 30 | | | | | Laekan | 30 | Thida | 90 |
| | 15 | South Okkalarpa | | | | | | | | | | | Waizayantar | 30 | | | Thanthumar | 30 | | | Thitsar street | 60 |
| Western district | 1 | Mayangone | Tawwin | 30 | South Kabaaye | 30 | North Kabaraye | 20 | | | | | | | | | | | | | Seinpanmyain | 60 |
| | | | Bayintnaung | 30 | | | | | | | | | | | | | | | | | Hlaing Univ./Pyay road | 30 |
| | 2 | Kamaryut | | | University | 30 | | | | | Aung Myay Tharsi | 30 | | | | | Tikegerahle | 30 | MRTV | 60 | University(2) | 120 |
| | 3 | Bahan | | | ITS(33kV) | 10 | Old university road(33kV) | 10 | | | | | | | | | | | | | | |
| | | | | | Myanpadatha(33kV) | 10 | | | | | | | | | | | | | | | | |
| | 4 | Latha | | | | | | | | | | | | | | | | | | | | |
| | 5 | Lanmadaw | | | | | | | | | | | | | | | 220 Bed hospital | 30 | | | | |
| | 6 | Pabetan | | | | | | | Railway | 30 | | | | | | | Kannaar road | 30 | Kannaar road(2) | 30 | Railway(2) | 90 |
| | 7 | Dagon | | | Hluttaw | 30 | | | Warmuseum | 30 | | | | | Hluttaw | 30 | | | Warmuseum | 30 | Medical research | 30 |
| | | | | | | | | | | | | | | | | | | | | | Pyay road | 60 |
| | 8 | Ahlone | YESB head office (33kV) | 10 | | | | | FID | 30 | | | | | | | | | Honhai | 60 | Lower kyi myint daing | 90 |
| | 9 | Kyimyindaing | Lower kyimyintdaing road (33kV) | 10 | | | | | | | | | | | | | | | | | No1 Thitset | 30 |
| | 10 | Seikkan | | | | | | | Container (1) | 30 | Mawtin | 30 | | | | | | | Container(2) | 60 | Mortin(2) | 60 |
| | 11 | Kyauktadar | | | | | | | | | | | 35th street | 30 | | | | | Seikkanthar street | 30 | Kyauktadar(New) | 30 |
| | 12 | Sanchaung | | | | | | | | | Hanthawady | 30 | | | | | | | Shinsawpu | 30 | | |
| | 13 | Hlaing | | | Hlaing university(33kV) | 10 | | | | | Yangon-Insein Road (RIR) | 30 | | | | | | | Middle Parrami | 30 | Yangon-Insein Road (RIR) | 90 |
| | | | | | | | | | | | | | | | | | | | Yangon-Insein Road (RIR) | 30 | | |
| Southern district | 1 | Thanlyin | Township office (33kV) | 5 | | | | | | | Township office | 10 | | | | | Bayargone | 30 | | | Thanlyin township | 60 |
| | 2 | Kyauk Tan | | | | | | | | | | | | | | | Township office | 10 | Kyauttan | 30 | Kyauttan(2) | 30 |
| | 3 | Seikkyi Kanaungto | | | | | | | | | | | | | | | Township office | 10 | Jaungwinelay | 30 | | |
| | 4 | Dala | | | | | Dala | 10 | | | | | | | | | | | Dala | 30 | | |
| | 5 | Tontay | | | | | | | Tontay | 20 | | | | | | | | | | | Tontay | 30 |
| | 6 | Kwinchankone | | | | | Kwinchankone | 10 | | | | | | | | | | | | | | |
| | 7 | Kawat Hmu | | | | | | | | | | | | | | | | | Kawmu | 30 | | |
| | 8 | Thone Gwa | | | | | | | | | Thone Gwa | 10 | | | | | | | | | Thonegwa | 30 |
| | 9 | Khayan | | | | | | | Khayan | 10 | | | | | | | | | | | Khayan | 30 |
| Northern district | 1 | Mingalardone | | | 12 mile(33kV) | 10 | 13 mile(33kV) | 10 | | | Khayaepin | 30 | 14mile | 30 | | | | | Palare | 30 | Htauntkyant | 60 |
| | 2 | Innsein | Thitaw computer | 30 | | | Dayingone | 20 | | | | | Khattayar | 30 | | | | | Inn sein township | 60 | 10 mile | 60 |
| | | | | | | | | | | | | | | | | | | | | | YCDC | 60 |
| | | | | | | | | | | | | | | | | | | | | | Aungzaya housing | 30 |
| | | | | | | | | | | | | | | | | | | | Technical Univ. | 30 | | |
| | 3 | Hlaingtharya | Meekhwat Market(33kV) | 10 | Kyansitthar/ Mahabandoola(33kV) | 10 | | | Zone No(1) | 30 | | | Shwelinpan | 30 | | | | | | | Zone(5) | 120 |
| | | | | | | | | | Zone No(2) | 30 | | | | | | | | | Office house | 60 | | |
| | | | | | | | | | Zone No(7) | 30 | | | | | | | | | | | | |
| | 4 | Shwepyithar | Hlawga road(33kV) | 10 | | | Shwepyithar Zone (1) | 30 | Township office | 30 | | | | | | | Thar Du Kan | 30 | | | Indutrial zone(4) | 60 |
| | | | | | | | | | | | | | | | | | | | Thar Du Kan | 30 | Hlawga St/No4 St | 30 |
| | | | | | | | Wartayar Ind. Zone(33kV) | 10 | | | | | | | | | | | Kuu Chaung | 30 | | |
| | 5 | Htaunkkyant | Pyi road & corner pearl road(33kV) | 10 | | | | | | | | | | | | | | | Parel street corner | 30 | | |
| | 6 | Hlegu | | | Hlegu township office | 30 | | | | | | | | | | | | | | | Inn Tin | 30 |
| | | | | | Phaunggyi road(33kV) | 10 | | | | | | | | | | | | | | | | |
| | 7 | Phaungkyi | | | | | | | | | Phaungkyi | 10 | | | | | | | | | Phaungkyi | 30 |
| | 8 | Okkan | | | | | | | | | | | | | | | | | Okkan | 30 | | |
| | 9 | Tikegyi | | | | | Tikegyi | 20 | | | | | | | | | | | | | Tikegyi | 30 |
| | 10 | Hmawbe | | | Pyi road & No4 road(33kV) | 10 | Kyetphyukan | 20 | | | | | | | | | | | | | Phoogyi communication | 30 |
| | 11 | Htantapin | Htantapin (33kV) | 10 | | | | | | | | | | | | | | | | | Htantapin | 30 |

*xxAx : 66kV project planned by YESB, xxBx : 33kV project planned by YESB, xxJx : 66kV or 33kV project proposed by the survey team

(Source) JICA Survey team

Table 4-12 : Operating rate of transformer for each township by proposed plans

| District Office | No. | Township (TS) | 2012 | | Capacity operating rate ((a)+demand increase)/((b)+(c))/(pf=0.90) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Peak demand (MW) (a) | Substation capacity (MVA) (b) | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2025-26 | 2030-31 |
| Eastern district | 1 | North Okkalarpa | 10.4 | 25 | 41% | 44% | 48% | 52% | 57% | 65% | 62% | 71% |
| | 2 | North Dagon | 19.8 | 55 | 47% | 51% | 55% | 60% | 65% | 74% | 66% | 73% |
| | 3 | Shwe Pauk Kan | 9.9 | 25 | 70% | 76% | 37% | 41% | 44% | 51% | 39% | 62% |
| | 4 | South Dagon | 36.8 | 107 | 44% | 47% | 51% | 56% | 61% | 69% | 69% | 73% |
| | 5 | East Dagon | 18.8 | 41 | 54% | 59% | 64% | 69% | 51% | 58% | 56% | 74% |
| | 6 | Dagon Seikkan | 14.4 | 30 | 64% | 69% | 75% | 47% | 51% | 58% | 65% | 64% |
| | 7 | Thaketa | 14.3 | 30 | 63% | 69% | 43% | 46% | 50% | 57% | 64% | 79% |
| | 8 | Thingangyun | 26.6 | 45 | 67% | 42% | 46% | 50% | 55% | 62% | 66% | 70% |
| | 9 | Yankin | 23.0 | 40 | 51% | 55% | 60% | 65% | 67% | 76% | 90% | 80% |
| | 10 | Mingalar Taungnyunt | 23.5 | 50 | 52% | 56% | 61% | 66% | 58% | 66% | 66% | 76% |
| | 11 | Tamwe | 21.9 | 54 | 52% | 57% | 62% | 67% | 73% | 59% | 73% | 70% |
| | 12 | Dawbon | 4.0 | 15 | 47% | 51% | 56% | 60% | 66% | 75% | 40% | 64% |
| | 13 | Botahtaung | 4.4 | 10 | 78% | 84% | 31% | 33% | 36% | 41% | 33% | 53% |
| | 14 | Pazungtaung | 16.1 | 50 | 57% | 62% | 67% | 46% | 50% | 57% | 66% | 58% |
| | 15 | South Okkalarpa | 10.0 | 30 | 59% | 64% | 69% | 75% | 82% | 47% | 75% | 60% |
| Western district | 1 | Mayangone | 26.8 | 70 | 30% | 32% | 35% | 38% | 41% | 47% | 75% | 77% |
| | 2 | Kamaryut | 34.0 | 76 | 57% | 62% | 67% | 73% | 79% | 70% | 78% | 77% |
| | 3 | Bahan | 3.5 | 10 | 16% | 17% | 18% | 20% | 22% | 25% | 39% | 63% |
| | 4 | Latha | 1.6 | 5 | 57% | 61% | 67% | 72% | 79% | 13% | 21% | 33% |
| | 5 | Lanmadaw | 0.6 | 10 | 11% | 12% | 12% | 14% | 15% | 17% | 27% | 43% |
| | 6 | Pabetan | 21.3 | 35 | 69% | 48% | 52% | 57% | 62% | 52% | 66% | 65% |
| | 7 | Dagon | 21.0 | 47 | 65% | 52% | 57% | 62% | 48% | 55% | 69% | 66% |
| | 8 | Ahlone | 23.9 | 50 | 71% | 54% | 59% | 64% | 69% | 79% | 74% | 65% |
| | 9 | Kyimyindaing | 2.5 | 5 | 30% | 32% | 35% | 38% | 41% | 47% | 75% | 40% |
| | 10 | Seikkan | 25.3 | 55 | 82% | 65% | 50% | 55% | 59% | 68% | 69% | 81% |
| | 11 | Kyauktadar | 8.8 | 20 | 78% | 84% | 92% | 50% | 54% | 62% | 56% | 63% |
| | 12 | Sanchaung | 6.6 | 15 | 78% | 84% | 39% | 43% | 47% | 53% | 46% | 73% |
| | 13 | Hlaing | 25.9 | 55 | 84% | 90% | 54% | 59% | 65% | 74% | 73% | 74% |
| Southern district | 1 | Thanlyin | 12.4 | 27 | 69% | 74% | 61% | 67% | 73% | 48% | 77% | 67% |
| | 2 | Kyauk Tan | 9.0 | 28 | 57% | 62% | 67% | 73% | 79% | 67% | 59% | 66% |
| | 3 | Seikkyi Kanaungto | 0.6 | 2 | 53% | 58% | 62% | 68% | 74% | 14% | 6% | 10% |
| | 4 | Dala | 4.6 | 9 | 43% | 46% | 50% | 55% | 60% | 68% | 42% | 67% |
| | 5 | Tontay | 3.4 | 8 | 75% | 23% | 25% | 27% | 30% | 34% | 54% | 42% |
| | 6 | Kwinchankone | 1.4 | 3 | 20% | 21% | 23% | 25% | 28% | 31% | 50% | 80% |
| | 7 | Kawat Hmu | 1.3 | 5 | 46% | 50% | 54% | 59% | 64% | 73% | 17% | 27% |
| | 8 | Thone Gwa | 2.6 | 7 | 71% | 77% | 33% | 36% | 39% | 44% | 71% | 40% |
| | 9 | Khayan | 2.2 | 5 | 78% | 28% | 31% | 33% | 36% | 41% | 66% | 35% |
| Northern district | 1 | Mingalardone | 18.4 | 39 | 67% | 72% | 78% | 53% | 57% | 65% | 76% | 78% |
| | 2 | Innsein | 37.3 | 76 | 65% | 70% | 76% | 64% | 70% | 79% | 75% | 72% |
| | 3 | Hlaingtharya | 44.5 | 100 | 61% | 39% | 42% | 46% | 50% | 57% | 71% | 80% |
| | 4 | Shwepyithar | 26.7 | 55 | 59% | 57% | 62% | 67% | 73% | 63% | 67% | 71% |
| | 5 | Htauntkyant | 3.7 | 10 | 33% | 35% | 39% | 42% | 46% | 52% | 33% | 53% |
| | 6 | Hlegu | 7.4 | 15 | 29% | 32% | 34% | 37% | 41% | 46% | 74% | 71% |
| | 7 | Phaungkyi | 2.0 | 5 | 71% | 77% | 28% | 30% | 33% | 37% | 60% | 32% |
| | 8 | Okkan | 0.5 | 3 | 32% | 35% | 38% | 41% | 45% | 51% | 7% | 11% |
| | 9 | Tikekyi | 4.8 | 10 | 28% | 31% | 33% | 36% | 39% | 45% | 72% | 57% |
| | 10 | Hmawbe | 6.9 | 21 | 30% | 32% | 35% | 38% | 42% | 48% | 76% | 70% |
| Total | | | 645.4 | 1,486 | | | | | | | | |

(Source) JICA Survey team

Table 4-13 : Difference between YESB original substation expansion plans and proposed plans

| Item | Additional substation capacity | |
|---|---|---|
| | Short-term (2015-2019) | Long-term (2020- 2030) |
| YESB original substation expansion plan | 1,140MVA | 2,250MVA |
| Proposed substation expansion plan | 1,270MVA | 3,890MVA |
| Difference | +130MVA | +1,640MVA |

### 4.5.2 System analysis

Based on the long term power demand forecast formulated in the survey, the analysis of power flow conditions of transmission and distribution systems from 2012 to 2030 was performed to check if they meet the N-1 standards[10]. If problems were found as a result of analysis, the countermeasure was studied in the revision of development plan. When incorporating such countermeasures into the plan, the survey team shared the information and adjustment with the MEPE that controls the 230kV substations and the survey team regarding "The Project for Formulation of the National Electricity Plan". In this survey, the analysis software ‘PSS/E’, which is an extensively and internationally used for system planning are used.

#### (1) General condition

Based on the alternative demand forecast in Chapter 3, the survey team analyzed the power flow and voltage of future power system. The conditions of analysis are as follows:

1) Demand forecast: alternative demand forecast in this survey
2) Generation : existing 33kV and 66kV power generation in Yangon region
3) Power system development: revised substation development plan
4) Period of analysis: from 2013 to 2020, 2025, 2030

#### (2) Consideration of transmission line

Conductors of transmission lines and line constants, which are input as the PSS/E data, are chosen from the list of the standardized conductors provided by YESB as shown in Table 4-14 and Table 4-15, respectively.

[10] The standard that no hindrance of supply occurs when one facility unit has troubles (when one transmission line or one transformer has troubles)

Table 4-14: Standardized conductors

| Voltage (kV) | Type | Conductor size | Capacity (MW,PF=0.95) |
|---|---|---|---|
| 66kV | ACSR | 400 mm$^2$ | 89 |
| 66kV | ACSR | 300 mm$^2$ | 71 |
| 66kV | ACSR | 200 mm$^2$ | 55 |
| 33kV | ACSR | 200 mm$^2$ | 27 |
| 33kV | ACSR | 150 mm$^2$ | 21 |
| 33kV | ACSR | 100 mm$^2$ | 14 |
| 66kV | XLPE | 1C 500 mm$^2$ | 83 |
| 66kV | XLPE | 1C 400 mm$^2$ | 74 |
| 33kV | XLPE | 1C 400 mm$^2$ | 37 |

Source: JICA Survey team based on YESB information

(Source) JICA Survey team based on YESB information.

Table 4-15: Line constants in PSS/E

| Type | Size | Positive-phase-sequence Impedance | | |
|---|---|---|---|---|
| | | Line R(Ω/km) | Line X(Ω/km) | Charging(uF/km) |
| 66kV Overhead line | 400 mm$^2$ | 0.0894 | 0.3951 | 0.0092 |
| 66kV Underground cable | 500 mm$^2$ | 0.0502 | 0.1758 | 0.27 |

(Source) JICA Survey team

### (3) Consideration of Transformer

Specified impedance of transformer provided by YESB are as shown in Table 4-16.

Table 4-16: Standardized transformers

| Voltage (kV) | Capacity (MW) | Impedance (Capacity base) |
|---|---|---|
| 66kV/33kV | 30MVA | 10.31% |
| 66kV/11kV | 30MVA | 10.31% |
| 33kV/11kV | 10MVA | 8% |
| 33kV/6.6kV | 10MVA | 8% |
| 33kV/6.6kV | 5MVA | 8% |
| 33kV/0.4kV | 3MVA | 7% |
| 11kV/6.6kV(0.4kV) | 100kVA | 4.5% |

Source:JICA Survey team based on YESB information.

### (4) Peak load forecast

Peak load forecast was examined as mentioned in Chapter 3. The peak load from 2012 to 2030is indicated in Table 4-17.

Table 4-17: Peak demand in Yangon region from 2012 to 2030

(Unit: MW)

| Year | 2012 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Peak demand | 758 | 1,224 | 1,353 | 1,502 | 1,673 | 1,870 | 2,163 | 3,186 | 4,769 |

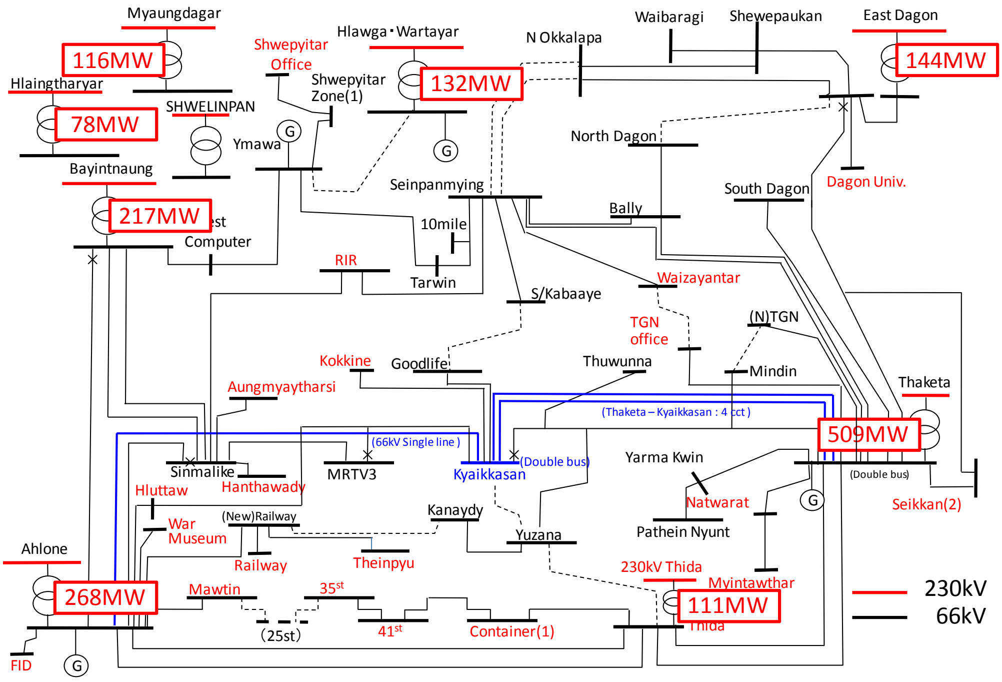
(Source) JICA Survey team

## (5) Result of system analysis

1) Transmission development plan

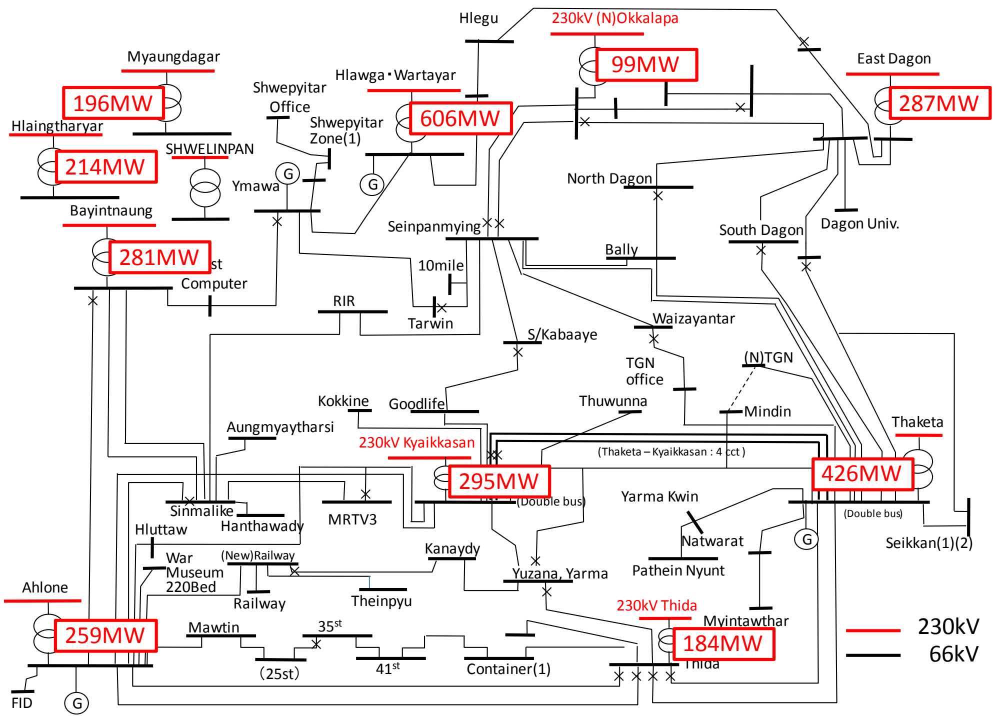
Figure 4-11, Figure 4-12 and Figure 4-13 illustrate the results of power flow and bus voltage analysis under normal operating conditions in 2020, 2025 and 2030.

As a result of the system analysis, transmission line overload is likely to happen in whole system and a lot of 66kV transmission lines are required in accordance with the substation development. The list of transmission line development plan which studied by survey team is indicated in Table 4-18. Moreover, a lot of changes are necessary in the transmission plan mainly due to the changes of installation timings of substation and routes of transmission line. 230kV/33kV and 230kV/66kV substations which need the additional transformers are described in section 4.5.



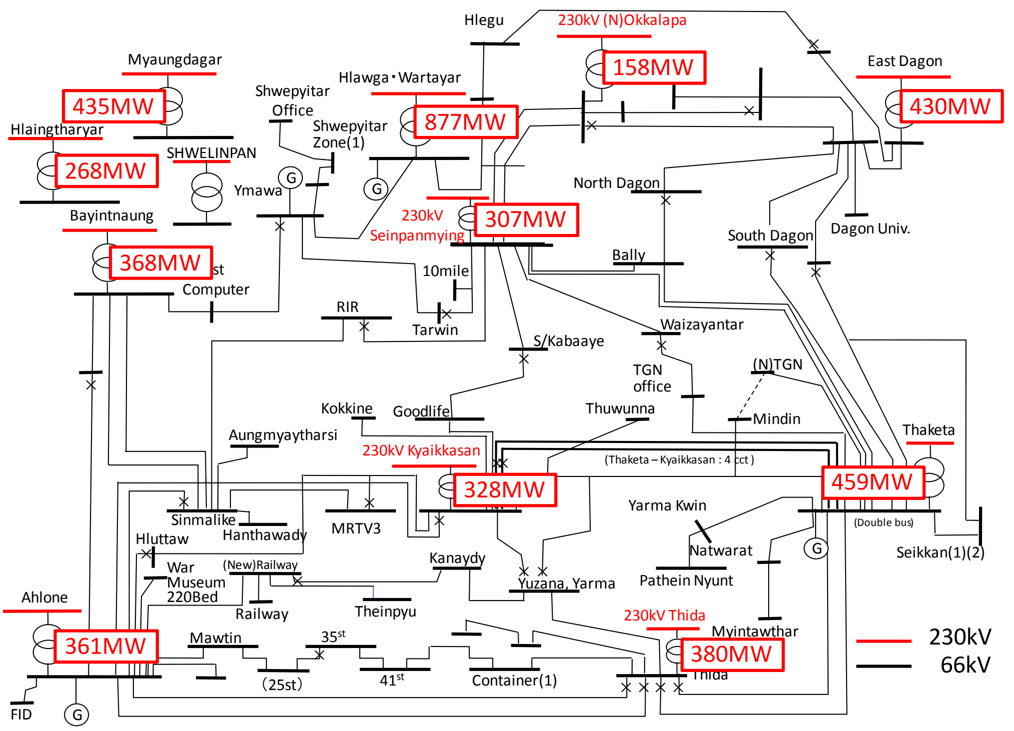

(Source) JICA Survey team based on YESB information.

Figure 4-11: Load flow diagram of Yangon distribution power system in 2020




(Source) JICA Survey team based on YESB information.

Figure 4-12: Load flow diagram of Yangon distribution power system in 2025




(Source) JICA Survey team based on YESB information.

Figure 4-13: Load flow diagram of Yangon distribution power system in 2030

# Table 4-18 : Transmission line development plan studied by the survey team

| FY | Transmission line | | ID | Voltage | TL Type | Number of circuit | Conductor Size | Township | S/S |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| 2013 | Shwepaukkan | North Okkalarpa | 13A6 | 66kV | OH | 1 | 400mm2 | North Okkalarpa | North Okkalapa |
| 2013 | East Dagon | Waibaige | 13A7 | 66kV | OH | 1 | 400mm2 | North Okkalarpa | Waibargi |
| 2013 | (T-off) | Bobahtoo | 13B6 | 33kV | UG | 1 | 185mm2 | North Dagon | Bobahtoo |
| 2013 | East Dagon | Shwe Pauk Kan | 13A5 | 66kV | OH | 1 | 400mm2 | Shwe Pauk Kan | Shwe Pauk Kan |
| 2013 | (T-off) | Thuwunna | 13A2 | 66kV | OH | 1 | 400mm2 | Thingangyun | Thuwunna |
| 2013 | Thaketa | PatheinNyunt | 13A3 | 66kV | OH | 1 | 400mm2 | Mingalar Taungnyunt | PatheinNyunt |
| 2013 | PatheinNyunt | Yarma | 13A1 | 66kV | OH | 1 | 400mm2 | Tamwe | Yarma |
| 2013 | (T-off) | Bayintnaung | 13A9 | 66kV | OH | 1 | 400mm2 | Mayangone | Bayintnaung |
| 2013 | (T-off) | Tawwin | 13A4 | 66kV | OH | 1 | 400mm2 | Mayangone | Tawwin |
| 2013 | Honhine | YESB Office | 13B1 | 66kV | UG | 1 | 500mm2 | Ahlone | YESB Office |
| 2013 | Hantharwaddy | Kunywaltan Road | 13B8 | 33kV | UG | 1 | 185mm2 | Kyimyindaing | New |
| 2013 | Bayintnaung | Forest Computer | 13A8 | 66kV | OH | 1 | 400mm2 | Innsein | Thitaw Computer |
| 2013 | Hlawga | Htauntkyant | 13B3 | 33kV | OH | 1 | 185mm2 | Htauntkyant | Htauntkyant |
| 2014 | North Okkalarpa | Thudama road | 14B3 | 66kV | OH | 1 | 400mm2 | North Okkalarpa | Thudama road |
| 2014 | East Dagon | Ywathargy | 14A6 | 66kV | OH | 1 | 400mm2 | South Dagon | Ywathargy |
| 2014 | South Dagon | No7 road/Yaynantthar | 14B9 | 33kV | OH | 1 | 185mm2 | South Dagon | No7 road/Yaynantthar |
| 2014 | East Dagon | Dagon Univ | 14A5 | 66kV | OH | 1 | 400mm2 | East Dagon | Dagon Univ |
| 2014 | Thaketa | Dagon Sekkan (2) | 14A7 | 66kV | OH | 1 | 400mm2 | Dagon Seikkan | Dagon Sekkan (2) |
| 2014 | Thaketa | Ayyawun/Minnada | 14B10 | 33kV | OH | 1 | 185mm2 | Thaketa | Ayyawun/Minnada |
| 2014 | Thingangyun | Kamarkyi Ward | 14B1 | 33kV | OH | 1 | 185mm2 | Thingangyun | Kamarkyi Ward |
| 2014 | Seinpanmying | South Kabaraye | 14A1 | 66kV | OH | 1 | 400mm2 | Mayangone | South Kabaraye |
| 2014 | Bayintnaung | Kamaryut University | 14A2 | 66kV | OH | 1 | 400mm2 | Kamaryut | Kamaryut University |
| 2014 | Tiger Ally | ITS | 14B5 | 66kV | UG | 1 | 500mm2 | Bahan | ITS |
| 2014 | U HtaungBo | Myanpadatha | 14B6 | 66kV | UG | 1 | 500mm2 | Bahan | Myanpadatha |
| 2014 | (T-off) | Hluttaw | 14A3 | 66kV | UG | 1 | 500mm2 | Dagon | Hluttaw |
| 2014 | Sepin | 12mile | 14B4 | 66kV | OH | 1 | 400mm2 | Mingalardone | 12mile |
| 2014 | Hlaingtharya | Kyansitthar/ Mahabandoola | 14B11 | 33kV | OH | 1 | 185mm2 | Hlaingtharya | Kyansitthar/ Mahabandoola |
| 2014 | Hlawga | Hlegu | 14A4 | 66kV | OH | 1 | 185mm2 | Hlegu | Hlegu |
| 2014 | Hlaingtharyar | Pyi Road | 14B2 | 33kV | OH | 1 | 185mm2 | Hmawbe | Pyi Road |
| 2015 | (T-off) | Bobahtoo | 15B2 | 33kV | OH | 1 | 185mm2 | North Dagon | Bobahtoo |
| 2015 | South Dagon | cornerof Manisithu | 15B3 | 33kV | OH | 1 | 185mm2 | South Dagon | cornerof Manisithu |
| 2015 | South Dagon | Corner of Hlawga road | 15B4 | 33kV | OH | 1 | 185mm2 | South Dagon | Corner of Hlawga road |
| 2015 | Thaketa | North Thingangyun | 15A2 | 66kV | UG | 1 | 500mm2 | Thingangyun | North Thingangyun |
| 2015 | Yuzana | Kannedy | 15A1 | 66kV | UG | 1 | 500mm2 | Mingalar Taungnyunt | Kannedy |
| 2015 | Seinpanmying | Nouth Kabaraye | 15A7 | 66kV | OH | 1 | 400mm2 | Mayangone | Nouth Kabaraye |
| 2015 | Kyaikkasan | Old university | 15B7 | 33kV | UG | 1 | 185mm2 | Bahan | Old university |
| 2015 | Dala | Dala | 15J1 | 33kV | OH | 1 | 185mm2 | Dala | Township office |
| 2015 | Hlaingtharyar | Kwinchankone | 15J2 | 33kV | OH | 1 | 185mm2 | Kwinchankone | Kwinchankone |
| 2015 | Ywama | Danyinggone | 15A4 | 66kV | OH | 1 | 400mm2 | Innsein | Danyinggone |
| 2015 | Hlawga | Shwepyithar Industrial Zone(1) | 15A5 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Industrial Zone |
| 2015 | Wartayar | Wartayar Ind. Zone | 15B5 | 33kV | OH | 1 | 185mm2 | Shwepyithar | Wartayar Ind. Zone |
| 2015 | Myaungdagar | Tikekyi | 17A1 | 66kV | OH | 1 | 400mm2 | Tikekyi | Tikekyi |
| 2015 | Myaungdagar | Kyetphyukan | 15A3 | 66kV | OH | 1 | 400mm2 | Hmawbe | Kyetphyukan |
| 2016 | Thaketa | Thingangyun Township office | 16A6 | 66kV | OH | 1 | 400mm2 | Thingangyun | Thingangyun Township office |
| 2016 | Kyaikkasan | Goodlife | 15A8 | 66kV | UG | 1 | 500mm2 | Yankin | Guittitlit(Goodl ife) |
| 2016 | Ahlone | War museum | 19A3 | 66kV | UG | 1 | 500mm2 | Dagon | War museum |
| 2016 | Ahlone | FID | 16A3 | 66kV | UG | 1 | 500mm2 | Ahlone | FID |
| 2016 | Thida | Container(1) | 16J2 | 66kV | UG | 1 | 500mm2 | Seikkan | Container(1) |
| 2016 | Hlaingtharyar | Tontay | 16J3 | 33kV | OH | 1 | 185mm2 | Tontay | Tontay |
| 2016 | Hlaingtharyar | Khayan | 16J4 | 33kV | OH | 1 | 185mm2 | Khayan | Khayan |
| 2016 | Hlaingtharyar | Industrial Zone1 | 16A2 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Industrial Zone1 |
| 2016 | Hlaingtharyar | Industrial Zone2 | 16A4 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Industrial Zone2 |
| 2016 | Hlaingtharyar | Industrial Zone7 | 16A8 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Industrial Zone7 |
| 2016 | Hlawga | Township office | 16A9 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Township office |
| 2017 | East Dagon | Shwe Pauk Kan | 17J1 | 66kV | OH | 1 | 400mm2 | Shwe Pauk Kan | Shwe Pauk Kan |
| 2017 | Thaketa | Myindawthar | 17A6 | 66kV | OH | 1 | 400mm2 | Thaketa | Myindawthar |
| 2017 | Thaketa | Natwarat | 17A5 | 66kV | OH | 1 | 400mm2 | Thaketa | Natwarat |
| 2017 | Thida | Container(1) | 26A6 | 66kV | UG | 1 | 500mm2 | Botahtaung | 41st |
| 2017 | Sinmalike(A) | Aung Myay Tharsi | 17J2 | 66kV | UG | 1 | 500mm2 | Kamaryut | Aung Myay Tharsi |
| 2017 | Ahlone | Mawtin | 17J3 | 66kV | UG | 1 | 500mm2 | Seikkan | Mawtin |
| 2017 | Sinmalike(B) | Hantharwaddy | 26A1 | 66kV | UG | 4 | 500mm2 | Sanchaung | Hantharwaddy |
| 2017 | Bayintnaung | RIR | 18A6 | 66kV | UG | 1 | 500mm2 | Hlaing | RIR |
| 2017 | Thanlyin | Thanlyin Township Office | 17J4 | 33kV | OH | 1 | 185mm2 | Thanlyin | Thanlyin Township Office |
| 2017 | Thanlyin | Thone Gwa | 17J5 | 33kV | OH | 1 | 185mm2 | Thone Gwa | Thone Gwa |
| 2017 | Hlawga | Khayaypin | 17A2 | 66kV | OH | 1 | 400mm2 | Mingalardone | Khayaypin |
| 2017 | Hlawga | Phaungkyi | 17J6 | 66kV | OH | 1 | 400mm2 | Phaungkyi | Phaungkyi |
| 2017 | Thaketa | Kyaikkasan | 17JST | 66kV | OH/UG<br>UG | 1<br>1 | 400/500mm2<br>500mm2 | Kyaikkasan | Kyaikkasan |
| 2018 | Seinpanmying | Waizayantar | 18A7 | 66kV | OH | 1 | 400mm2 | South Okkalarpa | Waizayantar |
| 2018 | 41st | 35st | 23A4 | 66kV | UG | 1 | 500mm2 | Kyauktadar | 35st |
| 2018 | Hlawga | 14mile | 20A4 | 66kV | OH | 1 | 400mm2 | Mingalardone | 14mile |
| 2018 | Ywama P/S | Khattayar | 18A2 | 66kV | OH | 1 | 400mm2 | Innsein | Khattayar |
| 2018 | Hlaingtharyar | Shwelinpan | 18A4 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Shwelinpan |

| FY | Transmission line | | ID | Voltage | TL Type | Number of circuit | Conductor Size | Township | S/S |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | | | |
| 2019 | Kyaikkasan | Kokkaine | 17A7 | 66kV | UG | 1 | 500mm2 | Yankin | Kokkaine |
| 2019 | Railway | Theinpyu | 19A5 | 66kV | UG | 1 | 500mm2 | Mingalar Taungnyunt | Theinpyu |
| 2020 | Thida | Myaeoadather | 20A6 | 66kV | OH | 1 | 400mm2 | Tamwe | Myaeoadather |
| 2020 | Thaketa | Dawbon | 18A5 | 66kV | OH | 1 | 400mm2 | Dawbon | Dawbon |
| 2020 | South Okkalarpa | Thanthumar | 20A3 | 66kV | OH | 1 | 400mm2 | South Okkalarpa | Thanthumar |
| 2020 | Hluttaw | Thkegerahle | 19A1 | 66kV | UG | 1 | 500mm2 | Kamaryut | Thkegerahle |
| 2020 | Ahlone | 220 Bed hospital | 21A6 | 66kV | UG | 1 | 500mm2 | Latha | 220 Bed hospital |
| 2020 | 220 Bed hospital | Kannaar road | 20J1 | 66kV | UG | 1 | 500mm2 | Pabetan | Kannaar road |
| 2020 | Thanlyin | Phayagone | 20A2 | 66kV | OH | 1 | 400mm2 | Thanlyin | Phayagone |
| 2020 | Thanlyin | Kyauk Tan | 20J2 | 66kV | OH | 1 | 400mm2 | Kyauk Tan | Township office |
| 2020 | Thanlyin | Seikkyi Kanaungto | 20J3 | 33kV | OH | 1 | 185mm2 | Seikkyi Kanaungto | Seikkyi Kanaungto |
| 2020 | Hlawga | Thar Du Kan | 20J4 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Thar Du Kan |
| 2021-2025 | North Okkalarpa | (N) Okkalapa Township | 21J1 | 66kV | OH | 1 | 400mm2 | North Okkalarpa | (N) Okkalapa Township |
| 2021-2025 | North Okkalapa | Shwepinlone | 21A1 | 66kV | OH | 1 | 400mm2 | North Dagon | Shwepinlone |
| 2021-2025 | East Dagon | Shwe Pauk Kan | 21J2 | 66kV | OH | 1 | 400mm2 | Shwe Pauk Kan | Shwe Pauk Kan |
| 2021-2025 | South Dagon | Innwa Villa | 19A2 | 66kV | OH | 1 | 400mm2 | South Dagon | Innwa Villa |
| 2021-2025 | South Dagon | Dagon south office | 19A7 | 66kV | OH | 1 | 400mm2 | South Dagon | Dagon south office |
| 2021-2025 | Thaketa | Dagon Sekkan (1) | 21J4 | 66kV | OH | 1 | 400mm2 | Dagon Seikkan | Dagon Sekkan (1) |
| 2021-2025 | Thaketa | Shukhinthar | 21J5 | 66kV | OH | 1 | 400mm2 | Thaketa | Shukhinthar |
| 2021-2025 | North Thingangyun | Kaesitan | 25A6 | 66kV | OH | 1 | 400mm2 | Thingangyun | Kaesitan |
| 2021-2025 | Kyaikkasan | Shwcownepin | 24A5 | 66kV | UG | 1 | 500mm2 | Yankin | Shweownepin |
| 2021-2025 | Kyaikkasan | Kannedy | 21J6 | 66kV | UG | 1 | 500mm2 | Mingalar Taungnyunt | Kannedy |
| 2021-2025 | Thaketa | Natchaung | 25A1 | 66kV | OH | 1 | 400mm2 | Tamwe | Natchaung |
| 2021-2025 | Thida | 41st(2) | 26A6 | 66kV | UG | 1 | 500mm2 | Botahtaung | 41st(2) |
| 2021-2025 | Thida | Lackan | 25A1 | 66kV | UG | 1 | 500mm2 | Pazungtaung | Lackan |
| 2021-2025 | Kyaikkasan | MRTV(2) | 22A1 | 66kV | UG | 1 | 500mm2 | Kamaryut | MRTV(2) |
| 2021-2025 | Ahlone | HoneHui | 22A7 | 66kV | UG | 1 | 500mm2 | Ahlone | HoneHui |
| 2021-2025 | Thida | Container(2) | 21A2 | 66kV | UG | 1 | 500mm2 | Seikkan | Container(2) |
| 2021-2025 | Container(2) | Seikkantha street | 21A5 | 66kV | UG | 1 | 500mm2 | Kyauktadar | Seikkantha street |
| 2021-2025 | Bayintnaung | Middle parami | 24A4 | 66kV | OH | 1 | 400mm2 | Hlaing | Middle parami |
| 2021-2025 | Thanlyin | Kyauk Tan | 21J10 | 66kV | OH | 1 | 400mm2 | Kyauk Tan | Kyauk Tan |
| 2021-2025 | Hlaingtharyar | Jaungwinelay | 26A3 | 66kV | OH | 1 | 400mm2 | Seikkyi Kanaungto | Jaungwinelay |
| 2021-2025 | Hlaingtharyar | Kawmu | 29A3 | 66kV | OH | 1 | 400mm2 | Kawat Hmu | Kawmu |
| 2021-2025 | Hlawga | Parlac | 25A2 | 66kV | OH | 1 | 400mm2 | Mingalardone | Parlac |
| 2021-2025 | Hlawga | Insein Township | 23A7 | 66kV | OH | 1 | 400mm2 | Innsein | Insein Township |
| 2021-2025 | Hlaingtharya | Technical Univ. | 25A7 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Technical Univ. |
| 2021-2025 | Shwelinpan | Hlaingtharya Town | 24A6 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Office House |
| 2021-2025 | Hlawga | Kuu chaung | 23A6 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Thar Du Kan |
| 2021-2025 | Hlawga | Kuu chaung | 23A5 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Kuu chaung |
| 2021-2025 | Myaungdagar | Parel Street | 27A3 | 66kV | OH | 1 | 400mm2 | Htauntkyant | Parel Street |
| 2021-2025 | Hlawga | Okkan | 25A3 | 66kV | OH | 1 | 400mm2 | Okkan | Okkan |
| 2026-2030 | North Okkalapa | Mandine | 27A5 | 66kV | OH | 1 | 400mm2 | North Okkalarpa | Mandine |
| 2026-2030 | North Okkalapa | Bobahtoo | 27A6 | 66kV | OH | 1 | 400mm2 | North Dagon | Bobahtoo |
| 2026-2030 | East Dagon | South Dagon | 26J1,J2 | 66kV | OH | 1 | 400mm2 | South Dagon | South Dagon |
| 2026-2030 | East Dagon | East Dagon2 | 28A2 | 66kV | OH | 1 | 400mm2 | East Dagon | East Dagon2 |
| 2026-2030 | Thaketa | Dagon Sekkan (1) | 28A7 | 66kV | OH | 1 | 400mm2 | Dagon Seikkan | Dagon Sekkan (1) |
| 2026-2030 | Thaketa | Shukhinthar | 26J3 | 66kV | OH | 1 | 400mm2 | Thaketa | Shukhinthar |
| 2026-2030 | Thaketa | Township office | 26J4 | 66kV | OH | 1 | 400mm2 | Thingangyun | Township office |
| 2026-2030 | Kyaikkasan | Goodlife | 26J5 | 66kV | UG | 1 | 500mm2 | Yankin | Guittitlit(Goodlife) |
| 2026-2030 | Thida | Shwe Myayar | 26J6 | 66kV | OH | 1 | 400mm2 | Mingalar Taungnyunt | Shwe Myayar |
| 2026-2030 | Seinpanmying | Thitsar street | 27A2 | 66kV | OH | 1 | 400mm2 | South Okkalarpa | Thitsar street |
| 2026-2030 | Seinpanmyain | Hlaing Univ./Pyay road | 30A6 | 66kV | OH | 1 | 400mm2 | Mayangone | Hlaing Univ./Pyay road |
| 2026-2030 | Ahlone | Railway(2030) | 26J10 | 66kV | UG | 1 | 500mm2 | Pabetan | Railway(2030) |
| 2026-2030 | Ahlone | Medical reserch, Pyay street | 22A5 | 66kV | UG | 1 | 500mm2 | Dagon | Medical reserch |
| 2026-2030 | Ahlone | Medical reserch, Pyay street | 22A6 | 66kV | UG | 1 | 500mm2 | Dagon | Pyay road |
| 2026-2030 | Ahlone | Lower Kyi Myint daing street | 23A3 | 66kV | UG | 1 | 500mm2 | Ahlone | Lower Kyi Myint daing street |
| 2026-2030 | Ahlone | No1. Thitset | 22A4 | 66kV | UG | 1 | 500mm2 | Kyimyindaing | No1. Thitset |
| 2026-2030 | Ahlone | Mortin(2) | 26J11 | 66kV | UG | 1 | 500mm2 | Seikkan | Mortin(2) |
| 2026-2030 | Seikkantha street | Kyaktadar New | 26J12 | 66kV | UG | 1 | 500mm2 | Kyauktadar | Kyaktadar New |
| 2026-2030 | Bayintnaung | RIR New | 26J13 | 66kV | OH | 1 | 400mm2 | Hlaing | RIR New |
| 2026-2030 | Thanlyin | 230kV Thanlyin | 28A3 | 66kV | OH | 1 | 400mm2 | Thanlyin | 230kV Thanlyin |
| 2026-2030 | Hlaingtharyar | Tontay | 29A2 | 66kV | OH | 1 | 400mm2 | Tontay | Tontay |
| 2026-2030 | Hlaingtharyar | Thone Gwa | 29A6 | 66kV | OH | 1 | 400mm2 | Thone Gwa | Thone Gwa |
| 2026-2030 | Hlaingtharyar | Khayan | 29A7 | 66kV | OH | 1 | 400mm2 | Khayan | Khayan |
| 2026-2030 | Seinpanmying | Htantkyunt | 26A4 | 66kV | OH | 1 | 400mm2 | Mingalardone | Htantkyunt |
| 2026-2030 | Ywama P/S | 10mile | 24A1 | 66kV | OH | 1 | 400mm2 | Innsein | 10mile |
| 2026-2030 | Hlawga | YCDC | 24A2 | 66kV | OH | 1 | 400mm2 | Innsein | YCDC |
| 2026-2030 | Hlawga | Aungzaya housing | 25A4 | 66kV | OH | 1 | 400mm2 | Innsein | Aungzaya housing |
| 2026-2030 | Hlaingtharyar | Hlaingtharya Zone5 | 23A1 | 66kV | OH | 1 | 400mm2 | Hlaingtharya | Hlaingtharya Zone5 |
| 2026-2030 | Hlawga | Shwepyi Zone4 | 26A7 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Shwepyi Zone4 |
| 2026-2030 | Hlawga | Hlawga St/No4 St | 27A7 | 66kV | OH | 1 | 400mm2 | Shwepyithar | Hlawga St/No4 St |
| 2026-2030 | Hlawga | Inn Tin | 22A3 | 66kV | OH | 1 | 400mm2 | Hlegu | Inn Tin |
| 2026-2030 | Hlawga | Phaungkyi | 26A2 | 66kV | OH | 1 | 400mm2 | Phaungkyi | Phaungkyi |
| 2026-2030 | Myaungdagar | Tikekyi | 26J16 | 66kV | OH | 1 | 400mm2 | Tikekyi | Tikekyi |
| 2026-2030 | Hlawga | Phoogyi communication | 30A1 | 66kV | OH | 1 | 400mm2 | Hmawbe | Phoogyi communication |
| 2026-2030 | Hlawga | Htantapin | 27A4 | 66kV | OH | 1 | 400mm2 | Htantapin | Htantapin |

(Source) JICA Survey team.

2) 66 kV system reliability enhancement measures

Based on the expansion plan following the review by the survey team, an analysis on flow load was performed. Figure 4-14shows the load flow diagram of the 66kV system in the Kyaikkasan substation. Due to the voltage boosted to 66kV in the existing 33kV distributing substations, the load flow in 66kV transmission lines will increase. As a result, the 66kV transmission line between Kyaikkasan and Thaketa will be overloaded in FY2017 and the measures for reinforcing transmission line facilities will become necessary.

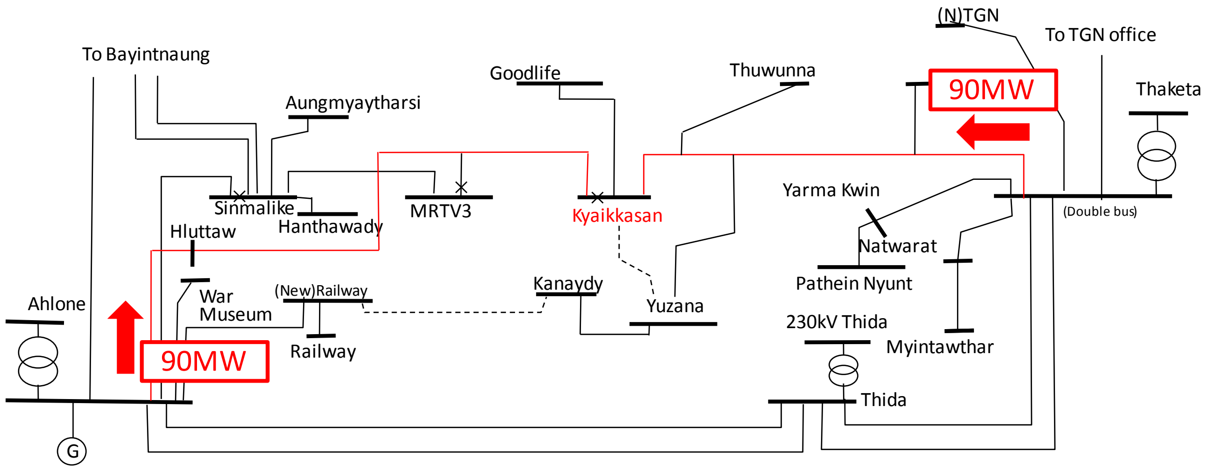



Figure 4-14: Load flow diagram around Kyaikkasan substation in 2017

Since the Kyaikkasan substation is located in the center of the existing 66kV ring transmission system as shown in Figure 4-15, it should be used as the base substation of the 66kV transmission system. Also, to secure the capability for handling an increase of electric power demand in the future, it is necessary to strengthen transmission lines interconnected with existing 230kV substations. When strengthening such interconnection, the relevant 66kV transmission line will becomes important 66kV systems. Therefore, it is necessary to secure the form and capacity of facilities that meet the N-1 standards to improve the reliability of the systems. The projects as measures for improving reliability are shown in Table 4-19, while the load flow diagram of the 66kV system in the Kyaikkasan substation in 2025 is shown in Figure 4-16.

Since the 66kV Thaketa-Kyaikkasan line will have heavy load flow and needs to meet the N-1 standards, three circuits should be newly constructed in 2017 and one more circuit should be added in 2025 to bring the total to four circuits.

Although the construction of four circuits in the Thaketa-Kyaikkasan line until 2025 is one option, it is desirable to boost the voltage of the Kyaikkasan substation to 230kV by 2025 from the perspective of enhancing the reliability of the system and the measures against voltage drop. If the voltage of the Kyaikkasan substation is boosted to 230kV by 2025, the Thaketa-Kyaikkasan line will have no problems with three circuits in the future.

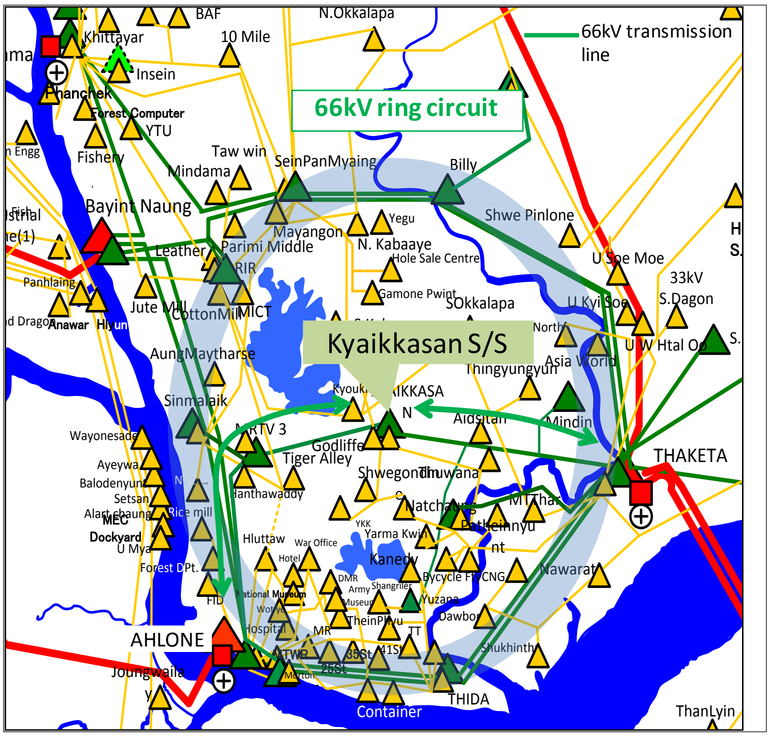



Figure 4-15: Location of Kyaikkasan S/S

Table 4-19: Reliability improvement plans in the vicinity of Kyaikkasan substation

| Countermeasures | | Year |
|---|---|---|
| 66kV Thaketa-Kyaikkasan transmission line | 66kV ACSR410mm$^2$×3 circuits | 2017 |
| 66kV Ahlone-Kyaikkasan transmission line | 66kV CV500×1 circuit | |
| Kyaikkasan substation | Installing double 66kV bus | |
| 66kV Thaketa-Kyaikkasan transmission line | 66kV ACSR410mm$^2$×1 circuit | 2025 |

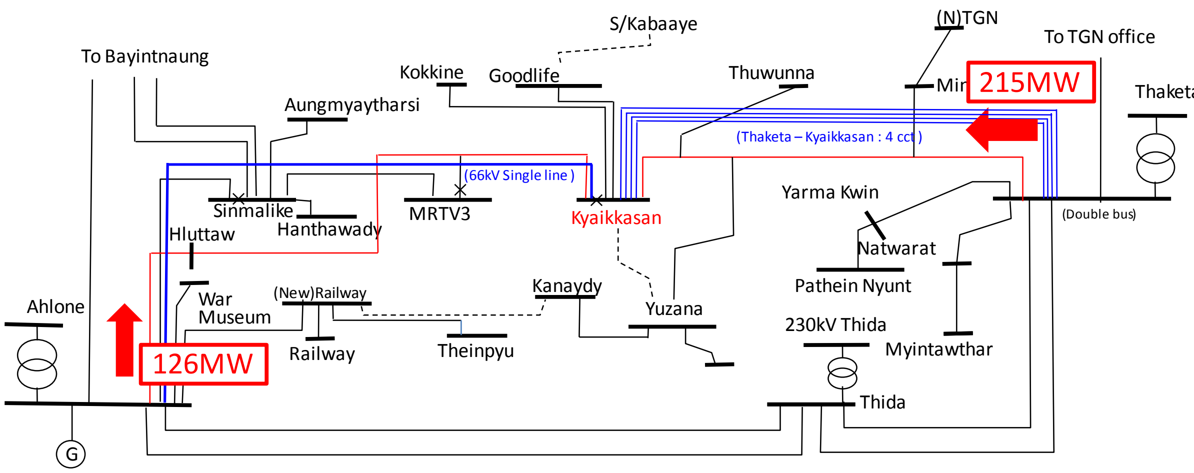



Figure 4-16: Load flow diagram around Kyaikkasan substation in 2025

3) Recommendation for the MEPE power system

As a result of the system analysis by the survey team, 230kV/33kV and 230kV/66kV transformer overload for the whole system is likely to happen. The peak load of the transformers is shown in Table 4-20 and the substations which need the additional transformers are shown in Table 4-21. It will be required to reinforce more than 1300MVA transformers up to 2020.

Table 4-20 : Peak load of 230kV/66kV and 230kV/33kV transformers

| | Township | Name of Substations | Voltage | Com. years | Peak load (MW) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021-2025 | 2026-2030 |
| 1 | Ahlone | **Ahlone** | **230kV/66kV** | | 70.6 | 102.8 | 138.8 | 110.1 | 175.2 | 267.9 | 258.9 | 361.9 |
| 2 | Mayangone | **Bayintnaung** | **230kV/66kV** | | 115.9 | 156.0 | 168.6 | 204.3 | 225.7 | 217.0 | 280.7 | 367.8 |
| 3 | East Dagon | **East Dagon** | **230kV/66kV** | | 28.2 | 44.5 | 69.2 | 77.1 | 86.2 | 144.4 | 286.3 | 429.7 |
| 4 | Hlaingtharyar | **Hlaingtharyar** | **230kV/66kV** | | 82.7 | 48.8 | 54.1 | 60.3 | 67.4 | 77.9 | 213.3 | 267.7 |
| | | **Shwelinpan** | **230kV/66kV** | **2015** | 15.1 | 19.9 | 22.1 | 36.9 | 41.2 | 47.7 | 99.2 | 121.2 |
| 5 | Mingalardone | **Hlawga(33kV)** | **230kV/33kV** | | 111.4 | 110.5 | 111.9 | 133.8 | 145.1 | 117.9 | 144.1 | 23.6 |
| | | **Hlawga(66kV)** | **230kV/66kV** | **2020** | - | - | - | - | - | 14.0 | 271.8 | 473.3 |
| 6 | Shwepyithar | **Wartayar** | **230kV/33kV** | **2013** | - | - | - | - | - | - | 190.0 | 380.0 |
| 7 | Thaketa | **Thaketa(66kV)** | **230kV/66kV** | | 70.7 | 131.0 | 181.7 | 269.3 | 343.2 | 425.4 | 402.8 | 436.3 |
| | | **Thaketa(33kV)** | **230kV/33kV** | | 98.8 | 93.5 | 80.4 | 84.0 | 72.2 | 83.5 | 22.8 | 22.8 |
| 8 | Myaungdagar | **Myaungdagar** | **230kV/33kV** | | 57.7 | 63.8 | 80.3 | 78.8 | 100.0 | 115.7 | 196.4 | 435.0 |
| 9 | Thanlyin | **Thanlyin** | **230kV/33kV** | | 34.6 | 38.2 | 42.2 | 47.3 | 52.8 | 68.8 | 89.9 | 102.7 |
| 10 | Thida | **Thida** | **230kV/66kV** | **2015** | 68.0 | 75.2 | 83.5 | 93.1 | 95.5 | 110.5 | 184.4 | 365.6 |
| 11 | North Okkalapa | **North Okkalapa** | **230kV/66kV** | **2021** | - | - | - | - | - | - | 99.1 | 157.8 |
| 12 | Yankin | **Kyaikkasan** | **230kV/66kV** | **2021** | - | - | - | - | - | - | 295.1 | 333.5 |
| 13 | Mayangone | **Seinpanmying** | **230kV/66kV** | **2026** | - | - | - | - | - | - | - | 306.5 |

(Source) JICA Survey team

Table 4-21 : List of transformers need to be newly installed

(MVA)

| | Township | Name of Substations | Voltage | Com. years | inst. Cap | 2012 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021-2025 | 2026-2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ahlone | **Ahlone** | **230kV/66kV** | | 200 | | | | | | | **200.0** | | |
| 2 | Mayangone | **Bayintnaung** | **230kV/66kV** | | 200 | | | | | **200.0** | | | | |
| 3 | East Dagon | **East Dagon** | **230kV/66kV** | | 100 | | | | | | | **200.0** | | **200.0** |
| 4 | Hlaingtharyar | **Hlaingtharyar** | **230kV/66kV** | | 100 | | | | | | | | **200.0** | |
| | | **Shwelinpan** | **230kV/66kV** | **2015** | - | | **100.0** | | | | | | **100.0** | |
| 5 | Mingalardone | **Hlawga(33kV)** | **230kV/33kV** | | 220 | | | | | | | | | |
| | | **Hlawga(66kV)** | **230kV/66kV** | **2020** | - | | | | | | | | **200.0** | **300.0** |
| 6 | Shwepyithar | **Wartayar** | **230kV/33kV** | **2013** | 100 | | | | | | | | **100.0** | **200.0** |
| 7 | Thaketa | **Thaketa(66kV)** | **230kV/66kV** | | 200 | | | | | **200.0** | | **100.0** | | |
| | | **Thaketa(33kV)** | **230kV/33kV** | | 100 | | | | | | | | | |
| 8 | Myaungdagar | **Myaungdagar** | **230kV/33kV** | | 160 | | | | | | | | **100.0** | **300.0** |
| 9 | Thanlyin | **Thanlyin** | **230kV/33kV** | | 100 | | | | | | | | | **100.0** |
| 10 | Thida | **Thida** | **230kV/66kV** | **2015** | - | | **200.0** | | | | | | | **200.0** |
| 11 | North Okkalapa | **North Okkalapa** | **230kV/66kV** | **2020** | - | | | | | | | | **100.0** | **100.0** |
| 12 | Yankin | **Kyaikkasan** | **230kV/66kV** | **2021** | - | | | | | | | | **400.0** | |
| 13 | Mayangone | **Seinpanmying** | **230kV/66kV** | **2026** | - | | | | | | | | | **400.0** |

(Source) JICA Survey team

(grey box): Additionally required

# Chapter 5 Candidate Project for Japanese ODA Loan

## 5.1 Selection candidate Japanese ODA loan projects based on priority investment plan

### 5.1.1 Workflow of the priority investment plan formulation

Candidate projects for Japanese ODA loan should be essentially selected following the prioritization process after all conditions of facilities (facility operation rates, fault records, etc.) are surveyed. In this survey, the formulation of the priority investment plan and a survey required for Japanese ODA loan projects are simultaneously move forward as shown below.

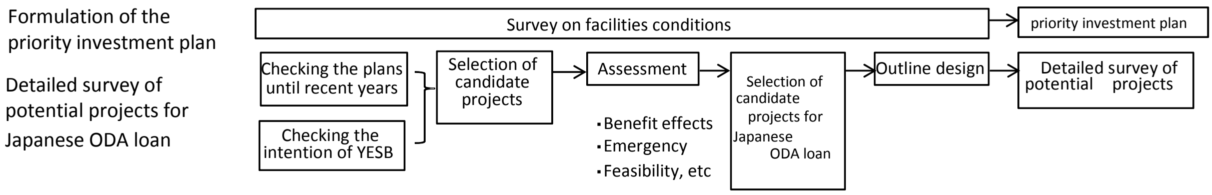



Figure 5-1: Workflow of the priority investment plan formulation and survey for potential sub-projects for the Japanese ODA loan

### 5.1.2 Proposal for improving facilities suitable to the situation of Myanmar

To effectively improve distribution facilities in the Yangon City, it is necessary to make the facilities improvement policies clear and allocate appropriate budgets based on the policies. The candidate projects is selected based on the following basic concept as mentioned before for improving the distribution networks facilities.

Table 5-1: Basic concept for selecting candidate projects for Japanese ODA loan

| Task | Details |
|---|---|
| (i)Measures against overload of facilities | Strengthen transmission and substation system so that the supply load does not exceed installed capacity |
| (ii)Reduction of power losses | Improve distribution facilities so that the supply load does not exceed installed capacity |
| (iii)Measures against troubles | Improve facilities so that they do not cause troubles |
| (iv)Capacity building | Capacity building for YESB engineer by executing the Project |

Source: JICA study team

The 30-year distribution networks development plan formulated by YESB includes the plans concerning the work for replacing electricity meters with ones that allow remote inspection and the smart-grid-related work. The former is effective for reducing non-technical losses, while the latter is effective as measures for early elimination of a hindrance of supply. However, if such measures are taken while the measures of (i) and (ii) are still insufficient, sufficient effects may not be produced. Meanwhile, the execution of (i) and (ii) is effective for reducing technical losses. Therefore, the survey team makes it a basic rule to execute (i) and (ii) on a priority basis. Moreover, high-tech equipment is incorporated into the candidate project based on its cost-effectiveness after studying optimal introduction periods and steps.

### 5.1.3 Selection of the priority investment plan

Considering the abovementioned policy, the candidate projects for Japanese ODA loan were selected. See below for the steps for selecting procedure:

[Step1] Consider the investment plan of the Yangon City Electricity Supply Board (YESB) (FY 2011 to FY 2019) and narrow the target projects:

- Those projects already commenced or to be commenced in FY 2013 are excluded
- Those townships for which other donors such as ADB, NEDA or private companies are thinking about providing support are excluded
- Those townships located in the suburbs of Yangon are excluded

[Step2] Validate the selected plan candidates from the perspectives of:

- Importance (The countermeasures to be taken by townships against frequent overload and faults shall take precedence.)
- Implementation schedule: When to commence and complete
- Land acquisition status

The candidate townships subject to Japanese ODA loan assistance were selected by Step1 from 47 townships in Yangon area. Since YESB places an office for each township and controls these offices, the study team has chosen candidate project areas by unit of township. Because some transmission and distribution lines are stretched across multiple townships, the specific areas for facility improvement should be determined flexibly from the designing stage of Japanese ODA loan assistance.

In the selection of candidate townships, townships that will receive support from other donors such as ADB were taken into consideration. In the South Dagon Township, a local company has decided to operate the power transmission and distribution facilities, supply electricity and collect tariffs in the entire area of the said township, currently improving the implementation schemes and systems.

YESB has been seeking private sectors' participation in electric power supply to several industrial complexes in Yangon area. YESB will close this public offering in August 2013 and review the submitted proposals for electric power supply plans to industrial complexes.

The information about the contents of bits by these private companies and the assessment procedure by YESB cannot be obtained due to confidentiality.

Following the consultation with YESB to narrow down the scope of Japanese ODA loan support to higher-priority townships, the candidate townships were selected in the following processes

**(1) 15 townships in the suburbs of Yangon City were excluded as the priority for capital investment is low compared with those in central city due to low demand for electricity.**

**(2) 5 townships supported by ADB were excluded.**
**(Mayangone, Kamaryut, Mingalardone, Insein, Hlaingtharya)**

**(3) 3 townships supported by NEDA were excluded.**
**(North Okkalarpa, North Dagon, Shwe Pauk Kan)**

**(4) The South Dagon township, which is scheduled to be managed by a private company, was excluded.**

As a result, 23 townships were selected as the candidate townships subject to Japanese ODA loan projects.

Table 5-2 shows the selection result of the candidate townships subject to Japanese ODA loan assistance. The candidate townships subject to Japanese ODA loan assistance are shown with "y" and hatched while those townships not subject to Japanese ODA loan assistance, such as the townships in the suburbs of Yangon, are represented with “n”. After the selection, 23 townships in total are considered as the target for the yen-loan candidate project.

In selecting candidate project for Japanese ODA loan, the projects for FY 2016 and later were selected as the priority projects if the projects require consultants to be employed and require detailed design, considering the duration required for the procurement procedure for the Japanese ODA loan.

As for the construction or replacement of the power distribution lines of 6.6kV and 11kV or less or the replacement or installation of transformers, neither of which requires detailed design, material procurement by the end of FY 2014 was selected as the candidate projects for Japanese ODA loan as it was expected to achieve the support plan for Myanmar as early as possible.

The followings show the components of candidate project for Japanese ODA loan.

component1: Installation of 66kV substations and related transmission lines (FY 2016-2019)

component2: Introduction of multi-transformer system (FY 2016-2019)

component3: Replacement of distribution line (FY 2014-2019)

component4: Renovation of training center and introduction of Utility Vehicles (FY 2016-2017)

In Component 1, among the target 23 townships, a higher-priority substation installation project was extracted in consideration of elimination of overload, supply to important facilities, creation of 66kV transmission system, etc. In Component 2, the townships for which YESB is considering intensive development of distribution lines were selected on a priority basis.

In selecting candidate projects for Japanese ODA loan, it is considered insulating the switches of the 11kV power distribution line section switch, amorphous transformers and power distribution lines, from the perspective of improving the power distribution sector of Myanmar.

Table 5-2: Potential township in the Yangon City for Japanese ODA loan

| No. | Township | Potential TS for Japanese ODA loan | Concerning Agency | Includes investment plan projects after FY2016 | Condition |
|---|---|---|---|---|---|
| **Eastern District of Yangon** | | | | | |
| 1 | North Okkalapa | n | NEDA | | |
| 2 | North Dagon | n | NEDA | yes | |
| 3 | ShwePaukKan | n | NEDA | | |
| 4 | South Dagon | n | Private | yes | |
| 5 | East Dagon | y | | yes | Industrial zone, Hospital |
| 6 | Dagon Seikkan | y | | yes | Industrial zone, Low price housing project |
| 7 | Thaketa | y | | yes | Industrial zone |
| 8 | Thingangyun | y | | yes | Hospital |
| 9 | Yankin | y | | yes | |
| 10 | MingalarTaungnyunt | y | | yes | Yangon station |
| 11 | Tamwe | y | | | |
| 12 | Dawbon | y | | yes | |
| 13 | Botahtaung | y | | | |
| 14 | Pazungtaung | y | | | |
| 15 | South Okkalapa | y | | yes | Industrial zone |
| **Western District of Yangon** | | | | | |
| 1 | Mayangone | n | ADB | yes | |
| 2 | Kamaryut | n | ADB | yes | |
| 3 | Bahan | y | | yes | Hospital, high society housing area |
| 4 | Latha | y | | | Hospital |
| 5 | Lanmadaw | y | | | Hospital |
| 6 | Pabetan | y | | | |
| 7 | Dagon | y | | yes | Hluttaw,Millitary office, Hospital |
| 8 | Ahlone | y | | yes | YESB head office |
| 9 | Kyimyindaing | y | | | Hospital |
| 10 | Seikkan | y | | | |
| 11 | Kyauktadar | y | | | |
| 12 | Sanchaung | y | | | |
| 13 | Hlaing | y | | yes | |
| **Southern District of Yangon** | | | | | |
| 1 | Thanlyin | n | | | out of scope |
| 2 | Kyauk Tan | n | | | out of scope |
| 3 | SeikkyiKhanaungto | n | | | out of scope |
| 4 | Dala | n | | | out of scope |
| 5 | Tontay | n | | | out of scope |
| 6 | Kwinchankone | n | | | out of scope |
| 7 | KawtHmu | n | | | out of scope |
| 8 | ThoneGwa | n | | | out of scope |
| 9 | Khayan | n | | | out of scope |
| **Northern District of Yangon** | | | | | |
| 1 | Mingalardone | n | ADB | yes | Industrial zone, Air port, Hospital |
| 2 | Innsein | n | ADB,PLN | yes | Hospital |
| 3 | Hlaingtharyar | n | ADB | yes | Industrial zone |
| 4 | Shwepyithar | y | PLN | yes | Industrial zone |
| 5 | Htauntkyant | n | | | out of scope |
| 6 | Hlegu | n | | | out of scope |
| 7 | Phaungkyi | n | | | out of scope |
| 8 | Okkan | n | | | out of scope |
| 9 | Tikekyi | n | | yes | out of scope |
| 10 | Hmawbe | n | | | out of scope |

Source: JICA study team

## 5.2 Outline of the candidate projects

Outline of the candidate projects based on 5 year plan is studied. Candidate projects are new installation, reinforcement, and uprating of substations, and the new construction of transmission lines and distribution lines are accompanied.

### 5.2.1 Installation of substations and related transmission lines (Component1)

The substation and related transmission lines project selected by survey team are shown in Table 5-3. All projects are 66kV substation construction. The outline of some of them, which is the standard one, is shown in Table 5-4.

Table 5-3: The 66kV substation project (component1)

| Fiscal Year | Proposed Plan | | | | |
|---|---|---|---|---|---|
| | Township | Substation | Type | Installing Capacity | (Increased Capacity) |
| 2016 | Yankin | Guittilit (Goodlife) | Upgrading 33kV to 66kV | 2x30MVA | 40MVA |
| | Thingangyun | Township office | Upgrading 33kV to 66kV | 2x30MVA | 50MVA |
| | Shwepyithar | Township office | Upgrading 33kV to 66kV | 30MVA | 10MVA |
| | Dagon | Warmuseum | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Pabedan | Railway (Existing) | Upgrading 33kV to 66kV | 30MVA | 30MVA |
| | Seikkan | Container(1) | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| 2017 | Thaketa | Natwarat | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Thaketa | Myintawthar | Upgrading 33kV to 66kV | 30MVA | 10MVA |
| | Tamwe | Kyaikkasan | Double bus & TL | - | - |
| | Seikkan | Mawtin | Reinforcement | 30MVA | 30MVA |
| | Botahtaung | 41th street | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Sanchaung | Hanthawady | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Hlaing | RIR | Reinforcement | 30MVA | 30MVA |
| | Hlaing | Aungmyaytharsi | Upgrading 33kV to 66kV | 30MVA | 14MVA |
| 2018 | South Okkalarpa | Waizayantar | Upgrading 33kV to 66kV | 30MVA | – |
| | Kyakutadar | 35th street | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Dagon seikkan | Seikkan(2) | Reinforcement (Upgrading 33kV to 66kV will be conducted by YESB) | 30MVA | 30MVA |
| | Pazungtaung | Thida | Reinforcement | 30MVA | 30MVA |
| 2019 | Mingalartaungnyunt | Theinpyu | Upgrading 33kV to 66kV | 30MVA | 20MVA |
| | Yankin | Kokkaine | Upgrading 33kV to 66kV | 30MVA | 5MVA |
| | Dagon East | Dagon University | Reinforcement (Upgrading 33kV to 66kV will be conducted by YESB) | 30MVA | 30MVA |
| | Dagon | Hluttaw | Reinforcement (Upgrading 33kV to 66kV will be conducted by YESB) | 30MVA | 30MVA |
| | | | Total | 690MVA | 479MVA |

Table 5-4: Outline of 66kV substation construction project

| Work | Items | | Specification | Number |
|---|---|---|---|---|
| Main equipment | Main transformer | | 66/11-6.6kV, 30MVA | 1 unit<br>(Finally 2 unit) |
| | 66kV Switchgear | Switch bay | 66kV, outdoor | Incoming (1)<br>Outgoing (1)<br>Transformer (1)<br>Future TR (1) |
| | | GIS | 66kV, outdoor or indoor, single bus or double bus | |
| | Switchgear (AIS) | | 12kV, indoor | 8 bays |
| | Other related equipment | | | 1 set |
| Transmission line | 66kV Transmission line | | 66kV UG cable or OH line | 1 set |
| Civil and building | Transformer Plinth | | | 1 set |
| | 66kV Switchgear | Switch bay foundation | | 2 set |
| | | GIS foundation | | 1 set |
| | 66kV switch yard | | | 1 set |
| | Main road and fencing | | 14' x 12', 60' x 80' | 1 set |
| | Extension S/S control room | | If necessary | 1 set |

Source: JICA study team based on YESB information

For the purpose of YESB system improvement, it is necessary to reinforce 66kV system. As a result of the survey and the discussion with YESB, reinforcement projects of existing 66kV substation and uprating projects of existing substation from 33kV to 66kV are proposed. For these construction projects, following points are to be considered.

/ Two transmission lines, two units of transformers including for future ones. (ref. Figure 4-10)

/ Outage period reduction in construction work by using available space.

/ Minimum land acquisition and preparation by utilizing existing substations.

Regarding to control and monitoring system of substation, 66kV control panels are to be installed in the substations. There is no control center in YESB. All substations are operated by manual on site, and they are not able to be monitored from remote offices. There is also no plan to install control center. In this project, control panels which can operate and monitor substation equipment, such as CB and DS, are to be installed in the building of substations. For introducing control center in future, tele-control system is considered in these substations.

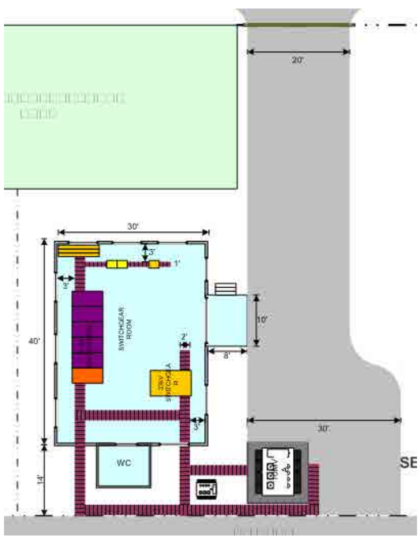
There are many projects of new installation of 33kV substation in YESB's investment plan (FY2014 - FY2015). However, the 33kV substations are removed from the list of candidate projects because the Japanese ODA loan candidate projects this time are limited to those for 66kV substations and related transmission lines. For the reference, the layout of 33/11-6.6kV Seikenthar Street Substation, which is the same scale of the substation in Table 5-5, is shown in Figure 5-2.

Table 5-5: Outline of 33kV substation project

| Work | Items | Specification | Number |
|---|---|---|---|
| Main equipment | Main transformer | 33/11-6.6kV, 10MVA | 1 unit |
| | 1) Switch bay<br>2) Switchgear (*1) | 1) 33kV, outdoor<br>2) 33kV, indoor | 1 bay |
| | Switchgear | 12kV, indoor | 6 bays |
| | Other related equipment | | 1 set |
| Transmission line | 33kV Transmission line | 33kV UG cable or OH line | 1 set |
| Civil and building | Transformer Plinth | | 1 set |
| | 1) 33kV switch bay foundation<br>2) 33kV switchgear foundation | | 1 set |
| | 33kV switch yard | | 1 set |
| | Main road and fencing | 14’ x 12’, 60’ x 80’ | 1 set |
| | New control room | 40’ x 30’ | 1 set |

(*1) 33kV switchgears are applied by “switch bay” type or “switchgear” type.

Source: JICA study team based on YESB information




Source: YESB information

Figure 5-2: Layout of Seikenthar Street Substation

### 5.2.2 Introduction of multi-transformer system (Component 2)

Whereas the electricity is currently supplied by extending LV (low-voltage of 230/400V) distribution lines from the large-capacity distribution transformers of average 500kVA class for a long distance, the multi-transformer system dispersedly arranges several low-capacity distribution transformers to reduce the LV distribution distance from the transformers. An application image of multi-transformer system is shown in Figure 5-3. This system can reduce not only loss but also voltage drop in LV lines.

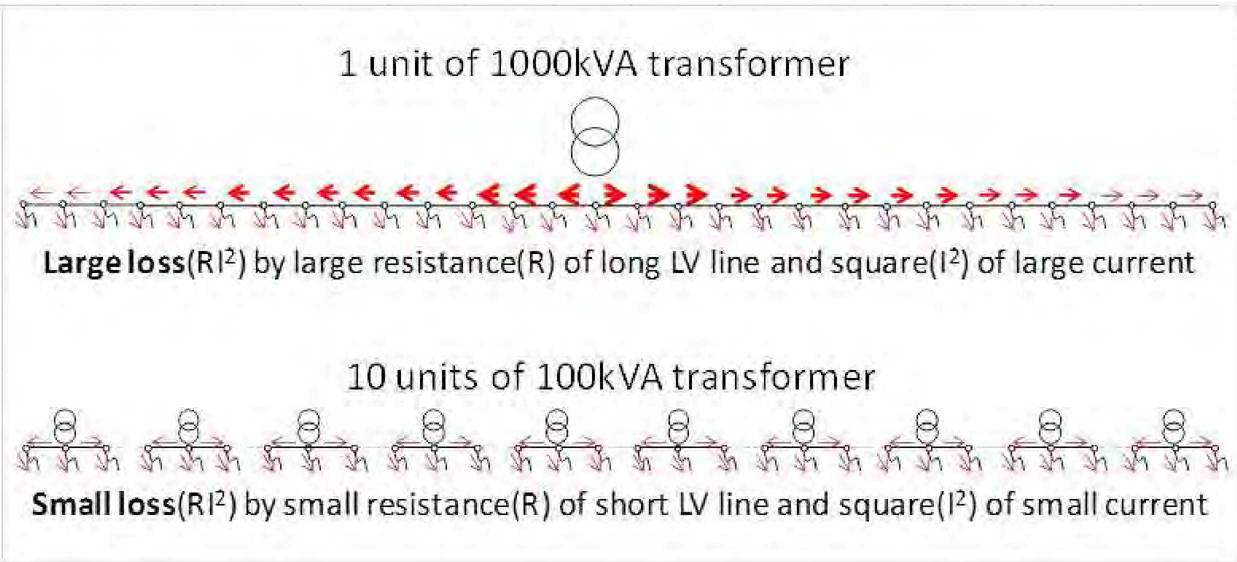



Figure 5-3: Application model of the multi-transformer system and image of LV line losses

Under the multi-transformer system, amorphous transformers that use amorphous alloy for the core parts will be used as distribution transformers. Since amorphous transformers have small iron loss, they can largely reduce the loss compared with normal (silicon type) transformers.

In this component, the multi-transformer system is introduced to distribution transformers in YESB area accordingly with the priority order. Although YESB has known what the multi-transformer system is, the projects for its introduction were not listed in the existing distribution development plan. Therefore, after consulting with YESB as to the area where the multi-transformer system should be introduced in a priority basis considering the priority investment plan it was agreed that transformers and LV lines in the downtown area needs to be improved.

To assess the effects when multi-transformer system is applied, the survey team conducted the on-site survey on the conditions of distribution facilities in three areas - overcrowded residential area, upper-class residential area, and underground downtown area in the Yangon city, and performed the approximate basic design of the system. The examples of the design are shown in Figure 5-4 to Figure 5-6 and Table 5-6 to Table 5-8.

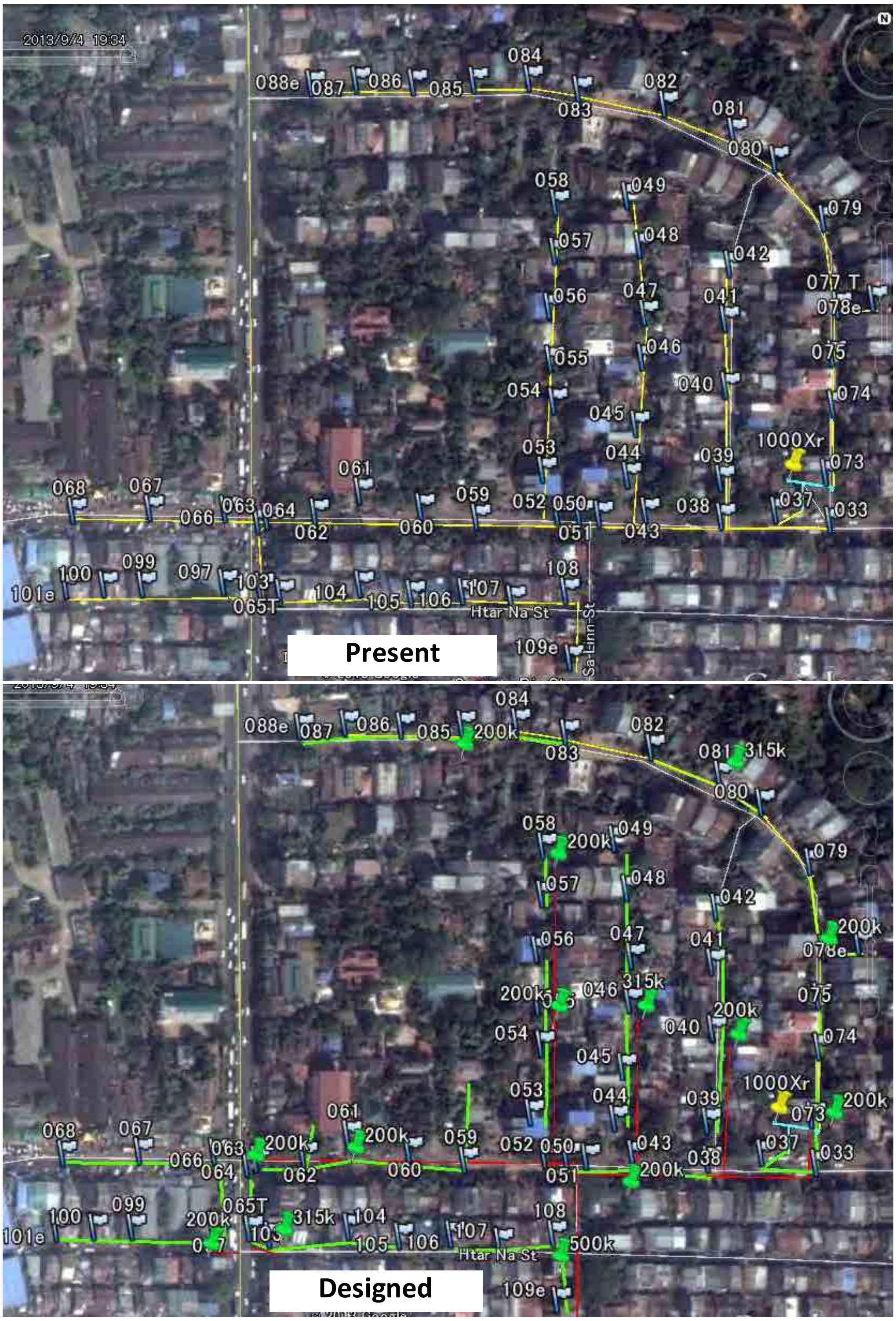


Figure 5-4: Drawings before and after the design of multi-transformer system in an overcrowded residential area.

Flagstaffs with 3 digit numbers, pins and colored lines represent electric poles, transformers and distribution lines respectively. Yellow and green for existing and desigined facilities, and red lines for extended MV (medium voltage of 11 or 6.6 kV) lines for multi-transformer system.

Table 5-6: Calculated voltage drop and loss in an overcrowded residential area

| | Present | Designed (3 times demand) |
|---|---|---|
| Number and capacity of transformer | 1 unit of 1000 kVA | 10 units of 200 kVA<br>2 units of 315 kVA<br>1 unit of 500 kVA |
| Voltage at LV line ends | Minimum 126 V (48% drop) | Minimum 230 V (4% drop) |
| Loss ratio in LV lines | Total 277 kW (25% loss) | Total 26 kW (1.0% loss) |

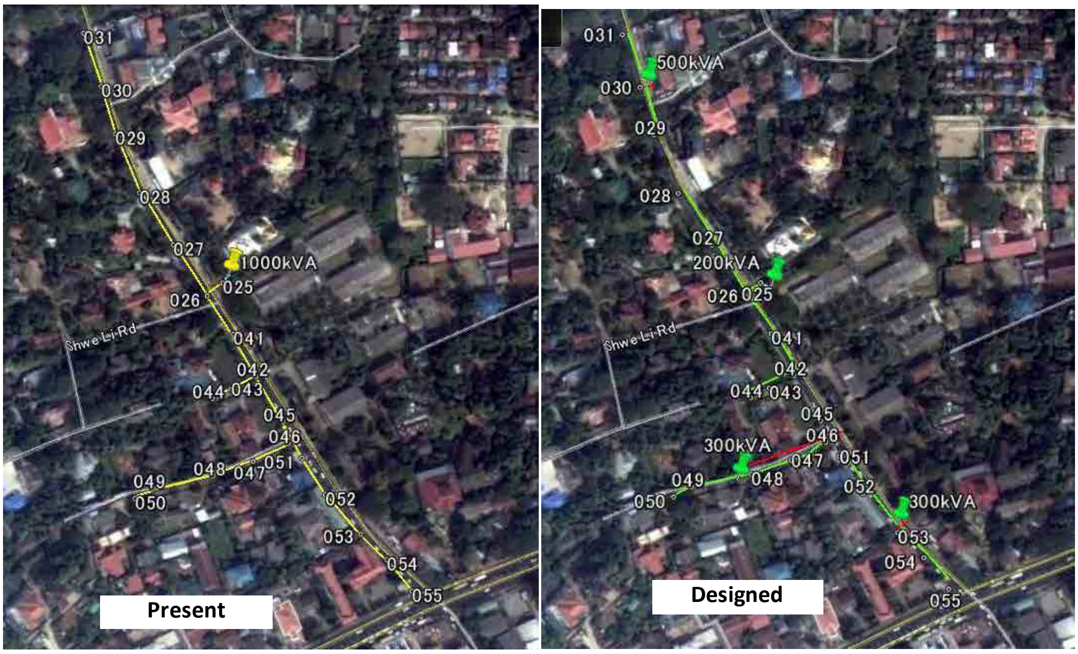



Figure 5-5: Drawings before and after the design in an upper-class residential area.

Circles with 3 digit numbers, pins and colored lines represent electric poles, transformers and distribution lines respectively. Yellow and green for existing and desigined facilities, and red lines for extended MV lines for multi-transformer system.

Table 5-7 :Calculated voltage drop and loss in an upper-class residential area

| | Present | Designed (3 times demand) |
|---|---|---|
| Number and capacity of transformer | 1 unit of 1000 kVA | 1 unit of 200 kVA<br>2 units of 300 kVA<br>1 unit of 500 kVA |
| Voltage at LV line ends | Minimum 198 V (18% drop) | Minimum 226 V (6% drop) |
| Loss ratio in LV lines | Total 60 kW (12% loss) | Total 34 kW (2.2% loss) |

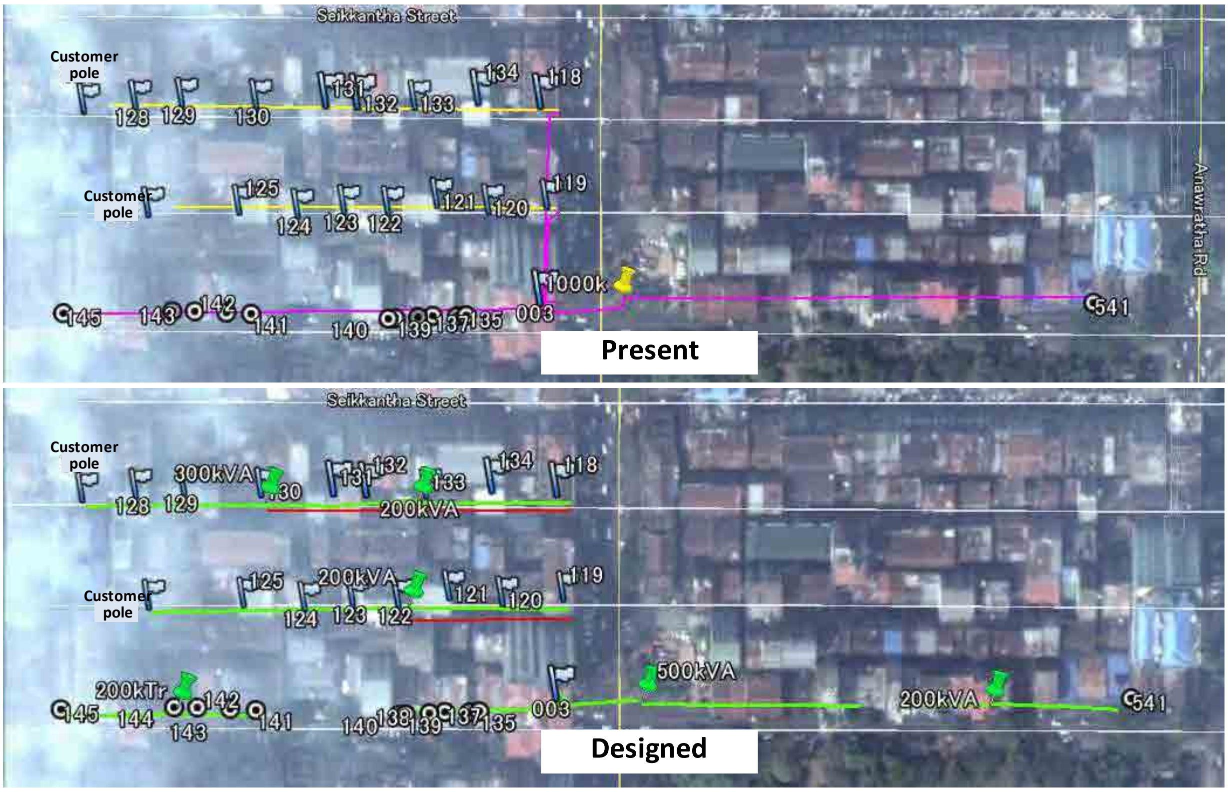



Figure 5-6: Drawings before and after the design in an underground downtown area.

Flagstaffs and circles with 3 digit numbers, pins and colored lines represent electric poles, service wire joint points, transformers and distribution lines respectively. Yellow and purple for existing facilities, and green for designed facilities, and red lines for extended MV lines for multi-transformer system.

Table 5-8: Calculated voltage drop and loss in an underground downtown area

| | Present | Designed (3 times demand) |
|---|---|---|
| Number and capacity of transformer | 1 unit of 1000 kVA | 4 units of 200 kVA<br>1 unit of 300 kVA<br>1 unit of 500 kVA |
| Voltage at LV line ends | Minimum 217 V (9.6% drop) | Minimum 232 V (3.3% drop) |
| Loss ratio in LV lines | Total 33 kW (5.3% loss) | Total 22 kW (1.5% loss) |

In the basic design, on the assumption that the electricity demand will increase three times in 10 years in a single uniform way compared with the current level, it is estimated that the effects of the reduction of LV distribution line loss and improvement of voltage drop. The results of the estimate show that large improvement effects are confirmed and the investment costs of the multi-transformers can be recovered in several years due to the effects of electric power purchase reduction resulting from the reduction of LV line loss.

According to the estimation results of the effects in the whole townships where the multi-transformer system will be introduced, it is expected that the distribution line loss will be reduced by 364GWh/year as a whole. The reduced loss of 364 GWh/year is worth the power of a plant of 46 MW.
The effects that are expected from the introduction of the multi-transformer system and the distribution line rehabilitation that is planned for simultaneous implementation are as follows.

- Reduction of distribution line loss
- Improvement of the low-voltage distribution line end voltage drop
- Reduction of power failure areas by the installation of distribution line section switches
- Early detection and early restoration of faulty parts by the introduction of the time sequence system to the distribution lines
- Reduction of distribution line failure by the introduction of not only insulated wires but also insulated primary cut out fuses

When the multi-transformer system project is implemented, the materials and equipment will be internationally procured, and the construction will be executed by YESB itself under the consultant guidance that is designed to foster YESB's execution engineers and improve its distribution line quality control capability.

### 5.2.3 Replacement of distribution line

This component is about the replacement of YESB's existing distribution lines. Namely, in this component, the costs for YESB to purchase equipments such as conductor wires and cables of 11kV and 0.4kV to replace the existing distribution lines will be subsidized. The projects in which YESB will purchase equipments and install them are selected accordingly with the priority investment plan. In order to reduce faulty trips due to contacting trees, insulation-coating wires will be introduced as the conducting wires to be purchased for distribution lines in this project. However, individual projects should be put into shape, be carefully selected taking substation projects into consideration and must be implemented each year.

### 5.2.4 Rehabilitation of training center and introduction of utility vehicles

Although YESB considers holding training on both engineers and workers as necessary, YESB’s training program is not yet sufficient in the volume, quality or the budget, and it has to be reconsidered. Therefore, renovation of the circumstances surrounding training system is truly needed; for example, improvement in training materials, equipments and practical facilities. For this reason, it is desired to be achieved as the candidate for Japanese ODA loan project. Meanwhile YESB already possesses training facilities adjacent to the 230kV Hlaing Tharyar substation, those training facilities are insufficient to provide practical trainings.

Thus, as a part of ODA loan project, it is desired to renovate current facilities and to equip various study materials so that trainees could have practical experience and learn effectively. In particular, 66kV substation devices and 11kV distribution facilities would have to be installed. Additionally, with a view to make the training program more effective and efficient, reforming training program by Japanese consulting service is also considered. Moreover, the study team would like to propose that YESB would apply pole construction trucks for installation of power distribution poles, small excavators, transport truck for small excavators and mobile substation which is equipped with 33/11-6.6kV 10MVA power transformers, 11kV switchgear cubicles and XLPE power cables. The training about how to handle these special-purpose vehicles to be introduced will be supported by the consultants to be employed at the project implementation.

The image of the layout of the training institute is shown in

Figure 5-7. Moreover, the examples of special-purpose vehicles are shown in Figure 5-8.

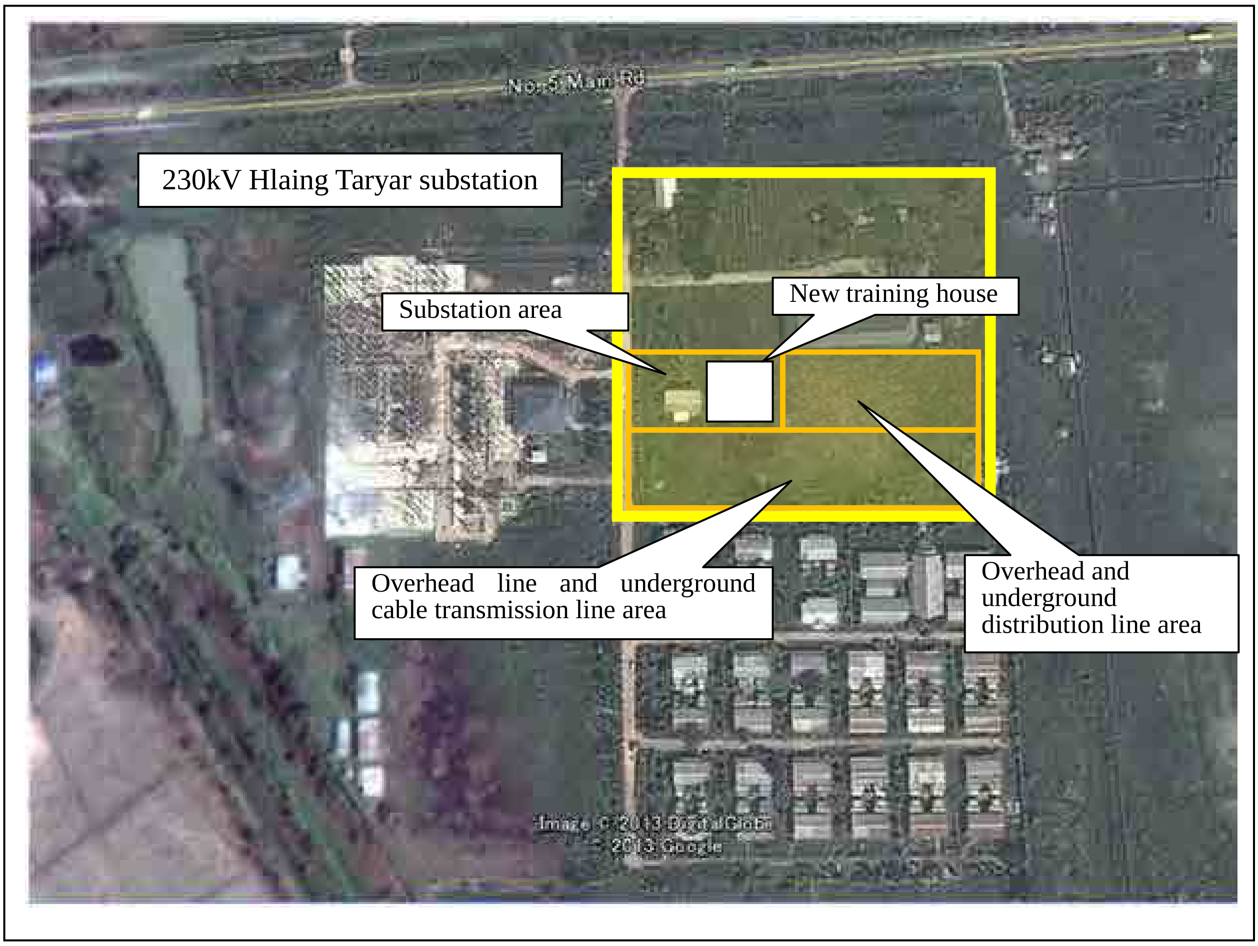



Figure 5-7: Outline of renovation plan of training center

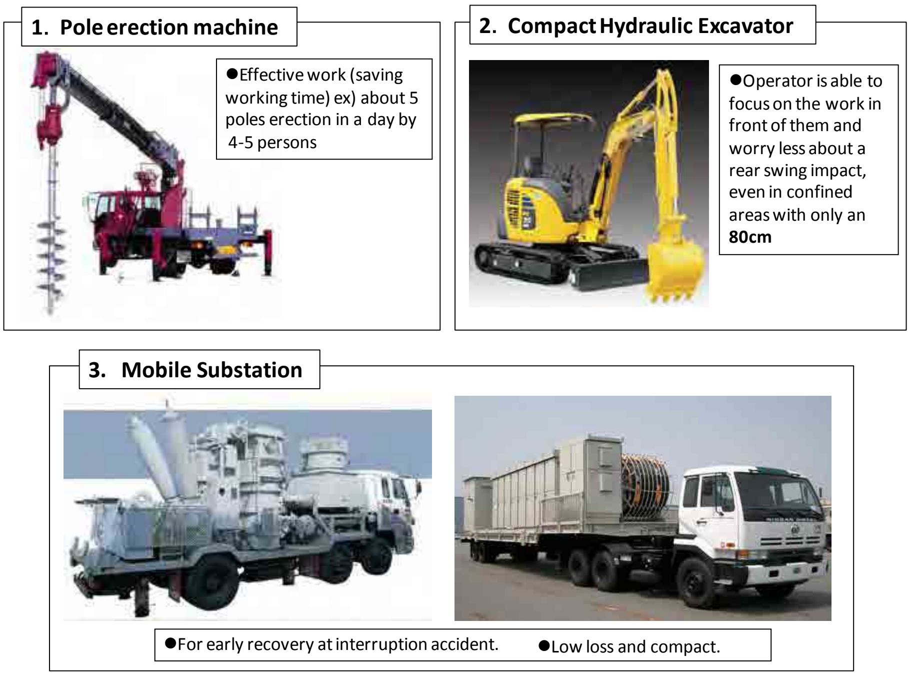



Figure 5-8: Example of utility vehicles

## 5.3 Suggestions on organization for construction, operation and maintenance

### 5.3.1 Organization for construction

Since the work volume of YESB is expected to increase with the implementation of this project, in order to execute the project smoothly, it is necessary to enhance engineers' execution technologies and secure workers under direct management and contractors. As described in the organizational structure of YESB in "2.3 Current State of Power Distribution Sectors", YESB engineers have many opportunities for dealing with facility renewal and restoration of failure, but little experience in new construction work. Therefore, for the engineers, it is necessary to support the enhancement of their technological capabilities such as those for construction plan, design, execution control, and inspection concerning the projects subject to Japanese ODA loan. The technicians are currently in charge of initial response when failure occurs, patrol, temporary restoration of distribution facilities, and so forth, but, since they have little experience in new construction work, it is necessary to strengthen their technologies through the participation in new construction work.

It is effective to strengthen technological capabilities of engineers and technicians through on-job-training (OJT) while being engaged in actual operation. In this project, it is planned to formulate the training program of engineers and support the provision of training through consulting service of the project.

### 5.3.2 Suggestions on organization for operation and maintenance

The operation and management unit should be performed as the followings.

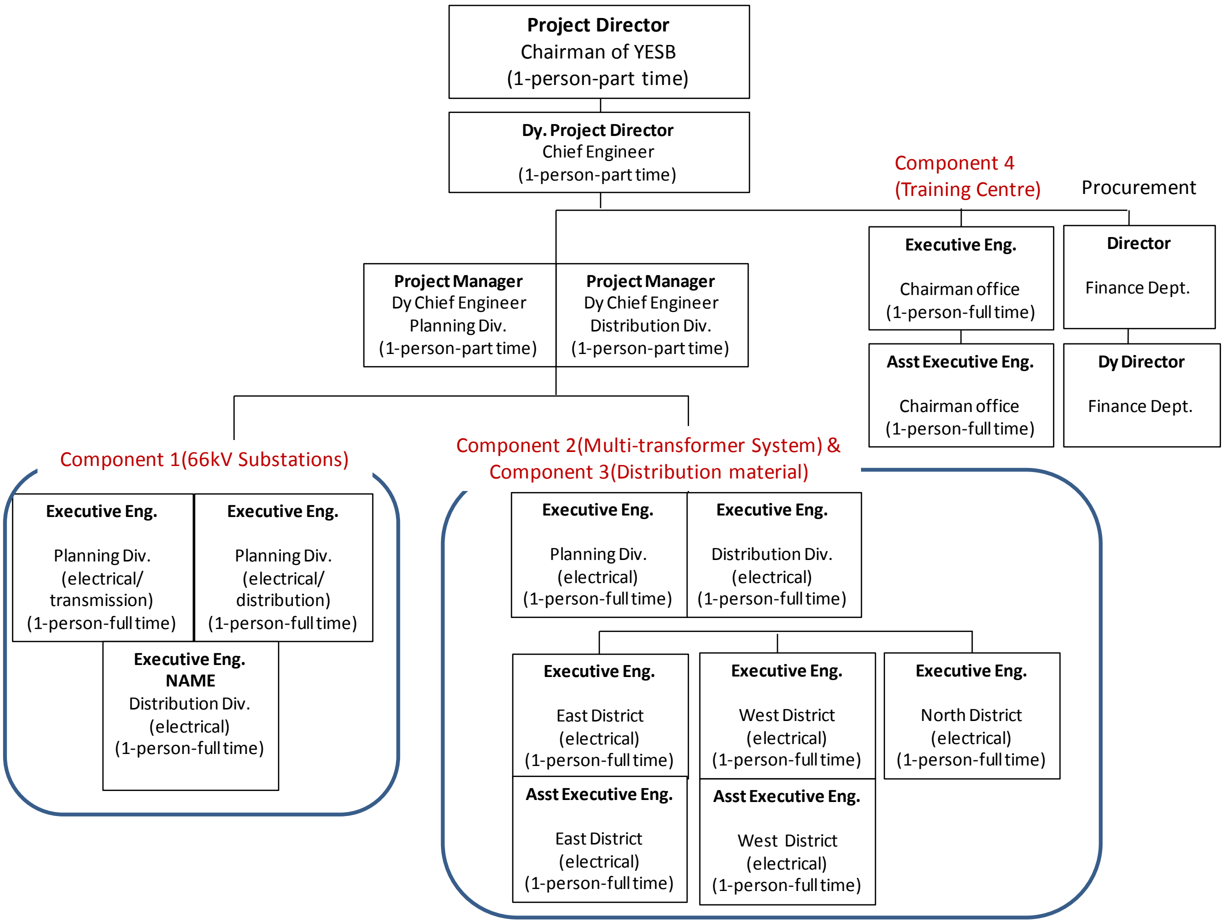



Figure 5-9: Project management unit

## 5.4 Training to engineers in YESB

### 5.4.1 Technological training provided by YESB

JICA Survey team conducted hearing investigations about technical trainings on engineers and workers which are organized by YESB.

As a result, survey team have learned that YESB holds group trainings on engineers and workers, but they learn a lot more through On-the-Job Training at site. Group trainings on engineers and workers in some particular level shown below are held two to three times a year, and the durations are about two weeks each time. Examples of the training programs are shown in Table 5-9. In addition, an example of the time table of a training program "Post-Electrical Proficiency Course for General Learner" for engineer is shown in Table 5-10.

Other than the trainings mentioned above, YESB nowadays has some opportunities to learn from foreign agencies such as JICA through seminars such as 'Technical Transfer Workshop".

Table 5-9: Training Courses opened by Engineering Department of YESB

| Sr No | Course Title | Term | Place | Number of Trainee |
|---|---|---|---|---|
| FY2008 | | | | |
| 1 | On-the-Job Proficiency Training Course for Engineers | 1 month | Hlaing Thayar Training Center (Head) | 50 |
| FY2010 | | | | |
| 1 | Proficiency Foundation Course for Sub-Assistant Engineer(2) | 4 weeks | Hlaing Thayar Training Center (Head) | 182 |
| 2 | Pre-Job Training Foundation Course for Electrical Reserve Learner Grade (3/4) | 2 weeks | Conference Room Ground Floor YESB Office | 56 |
| 3 | Proficiency Course for General Worker | 2 weeks | Hlaing Thayar Training Center (Head) | 114 |
| FY2011 | | | | |
| 1 | Pre-Job Training Foundation Course for Electrical Reserve Learner Grade (3/4) | 4 weeks | Conference Room Ground Floor YESB Office | 27 |
| 2 | Proficiency Foundation Course for Sub-Assistant Engineer(2) | 2 weeks | Hlaing Thayar Training Center (Head) | 215 |
| 3 | Proficiency Foundation Course for Electrical Reserve Learner Grade (3) | 2 weeks | Conference Room Ground Floor YESB Office | 204 |
| 4 | Pre-Job Training Course for Electrical Reserve Learner Grade (3) | 2 weeks | Conference Room Ground Floor YESB Office | 65 |
| 5 | Pre-Job Foundation Course for General Learner | 2 weeks | Conference Room Ground Floor YESB Office | 63 |
| FY2012 | | | | |
| 1 | Pre-Job Foundation Course for General Learner | 2 weeks | Conference Room Ground Floor YESB Office | 126 |
| FY2013(plan) | | | | |
| 1 | Post-Electrical Proficiency Course for General Learner | 2 weeks | Hlaing Thayar Training Center | 162 |

Table 5-10: Practical Training Course's time table

| | | | | | |
|---|---|---|---|---|---|
| 1st week LECTURE | Mon. | Opening Ceremony | Chief Engineer's speech | Distribution system of Yangon | Constructing of the lines |
| | Tue. | Precautionary measures | Overhead lines | Transformers and accessories | Erecting the poles and energizing |
| | Wed. | Equipment of substation | Substation construction | 400V electric line construction | 24 hours repair and maintenance |
| | Thu. | Safety measures | | Installation of 400 VCT, 3 phase 4 wire wattmeter | |
| | Fri. | Streetlights construction, maintenance and repair | line faults | distribution system | voltage losses and voltage drops |
| 2nd week PRACTICE | Mon. | Practical demonstration of overhead line construction | | | |
| | Tue. | Practical demonstration of overhead line demonstration | | | |
| | Wed. | Demonstration of steps of constructing and maintaining the substation Substation construction department | | | |
| | Thu. | Practical demonstration of underground termination and jointing Underground line department | | | |
| | Fri. | Refresher course's closing ceremony | | | |

### 5.4.2 Current facilities at Training Center

There are training facilities adjacent to the 230 kV Hlaing Thayar substation in the Yangon City. And the area is nearly the size of 140m x 150m.The facilities have one-storied training center built several years ago, which has lecture rooms and exhibition rooms for some electric gears. In addition, they have some practical training facilities such as distribution overhead lines, poles and substation facilities. Moreover, there are accommodation facilities for trainees, which can accommodate 80 trainees in total. However, these facilities are not frequency used nor effectively. In addition, current training facilities there such as substation equipments are of no use because some of these have already been broken-down. In order for the trainees to have real experience, YESB needs practical training facilities which are identical to real ones in addition to enhance and make effective use of them.

Figure 5-10 and Figure 5-11 show field training facilities such as distribution line and 33kV switch gears which are set up in FY2013. At this moment of December 2013, there are no 66kV facilities for training at the Training Center.


Figure 5-10: Practical training facilities (Distribution overhead lines and poles)


Figure 5-11: Practical training facilities (Substation facilities)

### 5.4.3 The necessity of the reorganization of the training programs on engineers and workers

In moving forward with the projects, YESB would have to enhance employees' performance capability and to increase the number of engineers and workers. In doing so, younger workers would have to have training programs intensely in addition to work with skilled workers to tackle the project, learning skills through on-the-job training.

With regard to the reinforcement of substations and transmission lines, the engineers need to have the know-how to formulate power transmission and substation reinforcement plans in consideration of the efficient operations of substations and transmission lines and to minimize the effects of faults and power transmission loss. Meanwhile, since distribution line construction works will be simultaneously executed in various areas, service interruption of electricity for such construction work will be required. Therefore, distribution engineers are required to create systematic construction plans which would minimize the frequency and duration of service interruptions due to construction works. Moreover, after the completion of construction works, engineers have to properly store the data and make the best of use for the better facility operation and maintenance. Thus, engineers and workers would have to learn various stuff and training programs which would provide these kinds of know-how would be desired.

### 5.4.4 The classification between engineers and workers

In arguing the training program to be reconsidered, the classification between Engineers and Workers must be noted. They are clearly separated from the beginning of their career at YESB. One must possess a collage degree of electrical engineering to be an engineer. Most of Engineers would work mainly at the head office and some of them work at township offices as administrators. Meanwhile, Workers would work mostly at township offices. Worker would be the one who has a degree of middle school or high school but has not learned basic electrical engineering at all. YESB recognizes that different topics, practical trainings on Engineers and basic lectures such as safety issues on Workers, would have to be prepared for them due to the different job roles for Engineers and Workers.

### 5.4.5 Proposal on the training for engineers in YESB

In accordance with the classification and the materials necessary for each class's training, the survey team would like to propose that YESB provide the education and training on engineers as follows. These education and training will be supported through consulting service of the project.

- Store and enhance the know-how of administration work necessary as an administrator of substation maintenance works or construction works, learning those through practical trainings.
- Enhance the engineer's skills, such as planning, designing, administrating construction works, and inspections, necessary when implementing distribution related projects.
- Strengthen the engineer's capability of planning works so that one can cope with the large amount of distribution line works.
- Strengthen the engineer's ability to educate Workers through on-the-job training taking advantage of construction works.

- Acquire abilities to grasp the entire description of work of the projects and create systematic construction plans to reduce the frequency and areas of service interruption resulting from substation and distribution line work
- Acquire in-machine control and learn how to use and store the data of equipments (transformers, low-voltage lines, meters, customers, etc.) of substations, transmission lines, and distribution facilities when the construction is completed, following the renewal of facilities

# Chapter 6 Environmental and Social Considerations

## 6.1 Agencies concerned for environmental and social considerations (ESC)

### (1) Project proponent: YESB

### (2) Regulatory agency of ESC (EIA Process):

Environmental Conservation Department (ECD), Ministry of Environmental Conservation and Forestry (MOECAF)

Note: Currently the EIA scheme is neither legally defined nor mandatory in Myanmar, yet. However, the Bylaw on EIA Procedure is being drafted under this administration, based on the Environmental Conservation Law 2012. Therefore, it is supposed that this agency should be in charge of the task in not distant future.

### (3) Project Appraisal (from the aspect of ESC): JICA

Note: JICA shall review the ESC of the project whether it is in accordance with JICA Guidelines for Environmental and Social Considerations (April 2010).

## 6.2 Legal scheme concerned with the project

### 6.2.1 Concerned legal scheme of Myanmar

#### 6.2.1.1 History

In 1994, *the National Environmental Policy* (NEP) was adopted by the Government, where it stated a policy that the preservation of natural resources was the responsibility of the nation and environmental protection should be put first in development activities for the sake of protecting the benefits of current and future generations.

In 1997, the National Commission for Environmental Affairs (NCEA) drew up *Myanmar Agenda 21* to provide the framework programs and action plans for the above Policy. The Agenda 21 put stress on sustainable development in four (4) primary sections that were 1) utilization of natural resources, 2) social development, 3) economic growth and 4) institutional development, where the concept of 'Environmental Impact Assessment' was prescribed to fulfill environmental considerations and an effective environmental management scheme in future national development plan.

In 2009, *the National Sustainable Development Strategy* (NSDS) was issued to set three (3) objectives for sustainability of 1) natural resources management, 2) integrated economic development and 3) social development. Each objective has respectively contained strategic areas (natural resources management 11, economic development 9 and social development 6) to tackle with. Here, the preparation and enforcement of Environmental Conservation Law was necessitated in the strategic areas of natural resources management. NSDS was officially approved by Ministry of National Planning and Economic Development (MOPD).

On the efforts above, in 30 March 2012 *the Environmental Conservation Law* was enacted and enforced from April, for which English version was publicized in July 2012. It comprehensively prescribes environmental administration in Myanmar and set framework on environmental conservation.

#### 6.2.1.2 Environmental Conservation Law

The Environmental Conservation Law (Law No.9/2012, 30 March 2012) discusses about physical and biological environment; environmental quality for the benefit of sustainability of nature and human beings; environmental quality standard; environmental audit; pollution of land, water, and atmosphere; beneficial use of environment for public health, safety and welfare; and so forth.

It consists of 14 chapters, respectively ChapI_Definition/ ChapII_Objectives/ ChapIII_Formation of Environmental Conservation Committee/ ChapIV_Duties and Powers of the Union Ministry charged with environmental conservation/ ChapV_Environmental Emergency/ ChapVI_Environmental Quality Standards/ ChapVII_Environmental Conservation/ ChapVIII_Management of Urban Environment/ ChapIX_Conservation of Natural Resources and Cultural Heritages/ ChapX_Prior Permission/ ChapXI_Insurance/ ChapXII_Prohibitions/ ChapXIII_Offences and Penalties/ ChapXIV_Miscellaneous.

In respect of environmental impact assessment (EIA), Chapter IV, VI to X and XIV should be noted though detailed regulations and requirements to correspond to the Law are not formulated so far.

Section 7 (m) of the Law in Chapter IV gives duties and powers to the Ministry[11], where in the Law it is defined as the Union Ministry assigned by the Union Government to perform the matters of environment, ‘causing to lay down and carry out a system of environmental impact assessment and social impact assessment as to whether or not a project or activity to be undertaken by any Government department, organization or person may cause a significant impact on the environment’.

In addition, there is neither a comprehensive law on pollution control nor rules of regulation on resettlement action plan (RAP) and compensation standard in Myanmar. However, Section 10 of the Law give the MOECAF the authority[12] to prescribe on environmental quality standards of water (surface, coastal sea and underground), atmosphere, noise and vibration, emission and effluent, solid waste and others stipulated by the Union Government, and Section 21 the authority to stipulates the categories of business, work-site or factory, work-shop which may cause impact on the environmental quality that requires to obtain the prior permission. In such regard, it is expected that more concrete bylaws and regulations on EIA, environmental standards and environmental permission will be formulated in not distant future.

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[11] The Ministry is interpreted as the Ministry of Environment Conservation and Forestry (MOECAF) in the context.
[12] Which with the approval of the Union Government

#### 6.2.1.3 Draft of bylaws

**(1) Environmental Conservation Rules**

*Environmental Conservation Rules* (ECR) are under preparation, based on the Environmental Conservation Law (ECL). The Rules are being prepared and will be enforced under the management of the Environmental Conservation Department (ECD), which is a newly created organization of MOECAF in October 2012. However, the Rules are still on the draft and their enactment is not completed yet.

**(2) Environmental Impact Assessment Procedure (Draft as of 13 May 2013)**

The *Draft EIA Procedure* is being prepared by MOECAF to exercise the power conferred by sub-section (b) of Section 42 of the ECL, which consists of the following chapters, annexes and appendix.

ChapI_Definitions/ ChapII_Establishment of EIA Process/ ChapIII_Screening/ ChapIV_IEE/ ChapV_EIA/ ChapVI_Environmental Consideration in Project Approval/ ChapVII_Monioring/ ChapVIII_Penalties/ Annex I_Project Categorization for Assessment Purposes (- currently empty -) / Annex II_Environmental Assessment Procedure Flowchart (Screening, IEE Preparation and Review, IEE Approval, Scoping, EIA Preparation and Review, EIA Approval, Appeal)/ Appendix I_Prescribed Penalties under EIA Procedure (- currently empty -).

Though it is yet finalized, the following draft sections should be noted. Section 3 states that all projects undertaken in Myanmar having the potential to cause significant Adverse Impacts are required to undertake EIA and to obtain an Environmental Compliance Certificate (ECC) in accordance with this Procedure. Then, Section 5 says that MOECAF shall, under the guidance of the Environmental Conservation Committee, form the EIA Report Review Body as a standing body to review the EIA of any project in request of MOECAF. Section 7 states 'This Procedure does not address specific matters in relation to resettlement and in relation to Projects that may have an Adverse Impact on Indigenous People. Projects involving resettlement or potentially affecting Indigenous People shall additionally comply with separate procedures issued by responsible ministries, and in absence of such procedures all such projects shall adhere to international best practice on Involuntary Resettlement and Indigenous People.'

#### 6.2.1.4 Other laws and regulations relevant to environmental and social considerations

Other key laws and regulations relevant to environmental and social considerations are summarized in as Table 6-1 below.

Table 6-1: Primary laws relevant to environmental conservation and management

| Title of the law | Law ID / Enacted Year | Key objectives of the law |
|---|---|---|
| Forest Law | Law No. 8/1992 (SLORC Law) | Aims at proper management of forests as national resources, balancing development and conservation, sustainable utilization of forests and forest products. Protected forests and protected public forests designated and regulated by the former MOF (predecessor of MOECAF) are prescribed. |
| Protection of Wildlife and Conservation of Natural Areas Law | Law No. 6/1994 (SLORC Law) | Aims at determination of natural areas and establishment of zoological garden, botanical gardens and the protected wildlife. Also provisions on such as hunting, registration and penalties are prescribed. |

| | | |
|---|---|---|
| Protection and Preservation of Cultural Heritage Regions Law | Law No. 9/1998 (SPDC Law) | Aims at protection and preservation of cultural heritages. Ministry of Culture (MOC) may set ancient monumental zone, ancient site zone and protected and preserved zone as cultural heritage regions. Prohibited activities in cultural heritage regions and heritages are prescribed. |
| Conservation of Water Resources and Rivers Law | Law No. 8/2006 (SPDC Law) | Aims at the conservation and management of water resources and rivers (including waterways). Prohibited activities regarding water resources; the disposal of oil, chemical, poisonous material and other materials; and the mining activities in the specific places of sea or its surrounding areas are regulated. Penalties are also prescribed. |
| YCDC Order No.10/99 | 1999 | It regulates the pollution control measures of a factory operating in industrial parks/estates; requires any business proponent the submission of pollution control and management plan to YCDC prior to the commencement of business; and prohibits discharging of wastewater into common properties of drainage, creeks and rivers without necessary treatment. |
| Land Acquisition Act (Burma Land Acquisition Manual) | 1894 (1947) | Promulgated in the British colonial era and redone by the Burma Gov. after World War II, still being the core principle for land acquisition in Myanmar. Many laws adopted complicated land classifications. Eleven (11) types of lands can be identified such as Freehold Land, Grant Land, Agricultural land, Grazing land, Forest Land, Town or Village Land, Cantonments and Monastery, though the types of lands were poorly defined in the legal framework. |

Source: Prepared by JICA Study Team, based on the information from copies of original laws, JICA (Feb.2013a)[13] and METI (Nov.2012)[14], et.al.

#### 6.2.1.5 Legal system on land acquisition and involuntary resettlement

The information in this section are generally based on 'JICA, *Profile on Environmental and Social Considerations in Myanmar, Chapter 7*, February 2013'.

**(1) Procedure for Land Acquisition**

The procedure for land acquisition should follow the five steps stated in the Land Acquisition Act in principle; namely 1) Preliminary investigation, 2) Hearing of Objections, 3) Declaration of intended acquisition, 4) Enquiry into measurements, value and claims, and award by the collector, 5) Taking Possession. Before starting that procedure, however, permission from the administrative agency with jurisdiction over the concerned land should be obtained.

**(2) Responsible Agencies**

Agencies responsible for management of land acquisition differ by the type of land as listed below. The General Administration Department (GAD) is also involved in items (a) and (b).

(a) In Yangon, Nay Pyi Taw and Mandalay cities, the City Development Committee (CDC) manages land acquisition activities.
(b) For any farmland, vacant, fallow and virgin lands, the MOAI manages land acquisition activities.
(c) For forest lands, the Forestry Department under the MOECAF manages land acquisition activities.
(d) For other town and village lands, the General Administration Department (GAD) under the MOHA

13 JICA (Feb.2013a), *Profile on Environmental and Social Considerations Myanmar,*
14 METI, JAPAN (Nov.2012), *Feasibility Study for Promotion of International Infrastructure Projects in FY2011, Study on the Substation Rehabilitation Project in Yangon, the Republic of the Union of Myanmar*

manages land acquisition activities.

### (3) Roles of Major Actors of Land Acquisition

The roles of actors are summarized below, particularly for land acquisition of non-agricultural and agricultural lands.

Table 6-2: Role of Major Actors of Land Acquisition

| Major Actor | Role |
|---|---|
| City Planning and Land Administration Department (CPLAD) | For non-agricultural lands, the City Planning and Land Administration Department (CPLAD) at township level investigates land use, area size, land ownership and tenant, and prepare necessary documents and maps for land acquisition. The CPLAD routinely handles transfer of land titles or subdivisions of plots, etc., and prepares land lease certificates. |
| Settlement and Land Record Department (SLRD) | For agricultural lands, the Settlement and Land Record Department (SLRD) under the MOAI at township level investigates area size and land ownership, and prepares necessary documents and maps for land acquisition. The SLRD surveys market prices of lands, buildings, crops and trees for compensation. |
| Award Committee | The Award Committee chaired by the respective Township Administrators is established to examine the award (entitlement, amount of compensation). |
| District Administrator | The District Administrator issues land lease grant for land not exceeding one acre. (The Lower Burma Town And Village Lands Manual, 1899) |
| Region/State Administrator | The Region or State Administrator issues land lease grant for land not exceeding five acres. (The Lower Burma Town And Village Lands Manual 1899) |
| GAD | The GAD issues land lease grant for land exceeding five acres.<br>(The Lower Burma Town And Village Lands Manual 1899) |

Source: JICA (Feb.2013), Chapter 7

### 6.2.2 JICA Guidelines for Environmental and Social Considerations (April 2010)

The Guidelines[15] requires project proponents (YESB in here) ESC for the concerned project as follows.

> 1. Project proponents etc. are required to incorporate the output of environmental and social considerations studies into project planning and decision-making processes.
>
> 2. When JICA provides support for and examinations of environmental and social considerations, JICA examines the requirements that must be met, as mentioned in Appendix 1. …

**(1) Category: The project is being assumed as Category B, according to JICA ESC Guidelines.**

**(2) ESC Procedures of JICA:**

It follows *3.1.2 Project Formation, 3.1 Preparatory Survey, 3 Procedures of Environmental and Social Considerations* in JICA ESC Guidelines.

## 6.3 Project Description

Refer to the Chapter 5 for Project Description of this project

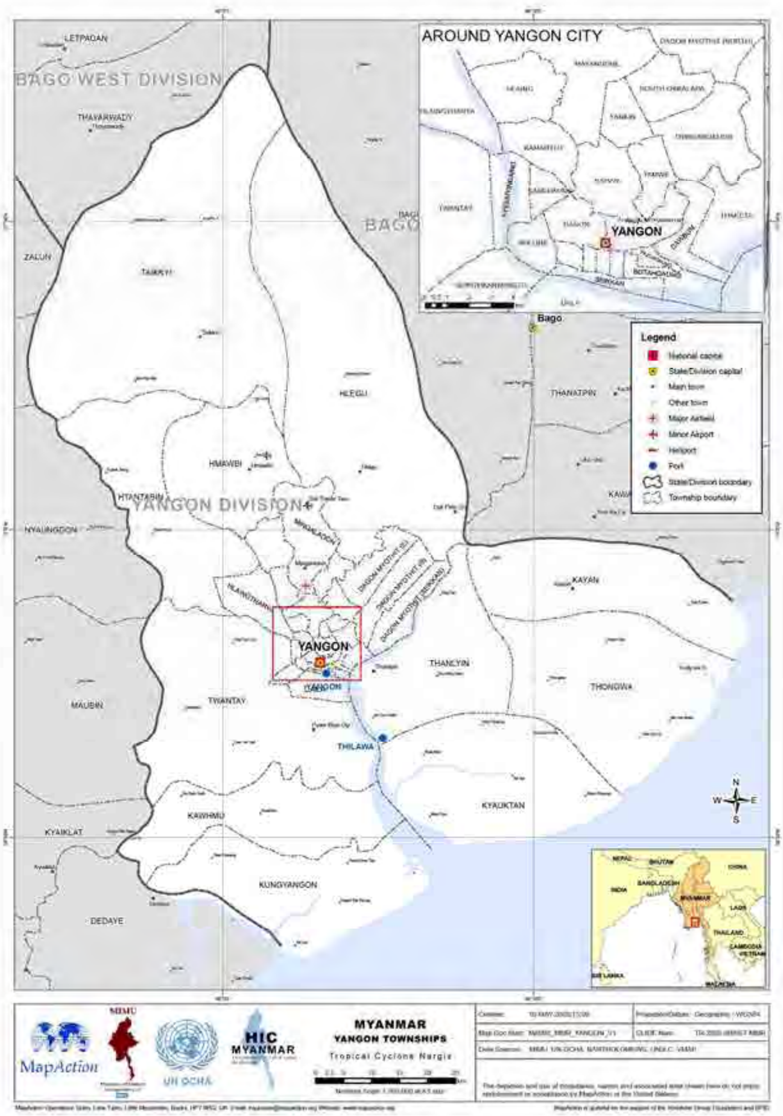
15 For the Guidelines, see URL: http://www.jica.go.jp/english/our_work/social_environmental/guideline/index.html

## 6.4 Site Description

### 6.4.1 Natural Environment

#### 6.4.1.1 Location and topographic conditions

Yangon is located in Lower Burma (Myanmar) at the convergence of the Yangon and Bago Rivers about 34 km upstream from the Gulf of Martaban at 16°48'N latitude, 96°09' E longitude. The Greater Yangon Area is between 16°35'N and 17°06' N latitude and between 95°58'E and 96°24'E longitude, east of the lower Ayeyarwaddy delta. A small hilly terrain runs through the center of Yangon from north to south, which from highest elevation point of about 30m gently slopes down to both eastern and western low-lying lands.

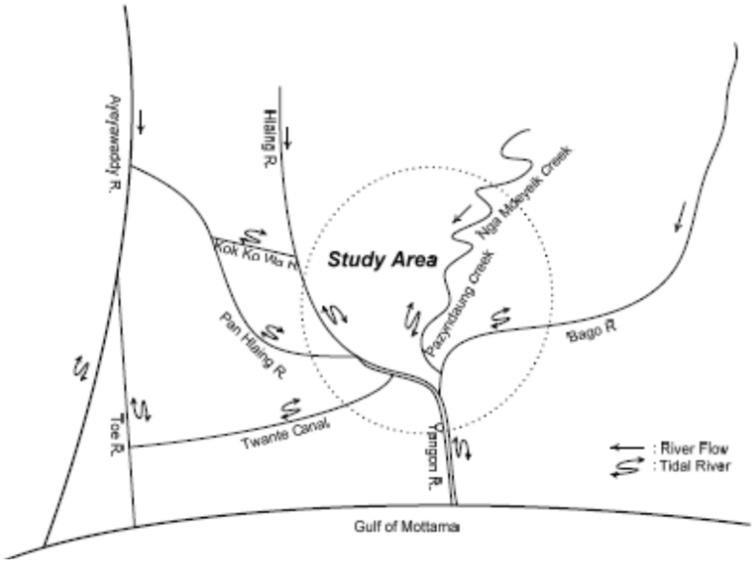



Source: Map Action (2008), MA008_MMR_YANGON_V1, YESB

Figure 6-1: Location of Project Site in Myanmar

### 6.4.1.2 Hydrological conditions

The central Yangon is surrounded in the south by Yangon River and Bago River. Flowing between Yangon River from northwest and Bago River from northeast, Nga Moeyeik Creek runs into the city center from north, where it changes its name to Pazyundaung Creek and has a confluence with Bago. In the west, Hlaing River, coming from north, changes its name to Yangon River at a confluence with Pan Hlaing River from the west and later with Twantay Canal.




Source: JICA (Feb. 2013b)[16], p2-2

Figure 6-2: River system around the Greater Yangon

The largest water body in the Greater Yangon Area is Yangon River under the jurisdiction of Myanmar Port Authority, with a share of 27.8 % of total water body. The second largest is Bago River, occupying 13.8 % of the body. The Rivers of Yangon and Bago are both brackish waters. Mingalardon Township contain 8.2 % of inland water body, with Hlawga Lake and other small water bodies, while only 1.2 ha of water bodies exist in Botahtaung, Dagon and Pazundaung Townships respectively. Supposedly partly due to this small water bodies, Botahtaung and Pazundaung Townships face the problem of poor drainage.

### 6.4.1.3 Climate

Yangon has a tropical monsoon climate under the Köppen climate classification system. The city features a long rainy season from May through October where a substantial amount of rainfall is received; and a dry season from November through April, where little rainfall is seen. During the course of the year, average temperatures show little variance, with average highs ranging from 29 to 37 °C and average lows ranging from 18 to 25 °C.

[16] JICA (Feb. 2013b), The Project for the Strategic Urban Development Plan of the Greater Yangon, Final Report

Table 6-3: Climate Statistics of Yangon Meteorological Station between 2000 through 2009

| Station | Annual Rainfall (mm) | Temperature (°C) | | Mean Relative Humidity (%) |
|---|---|---|---|---|
| | | Mean Max. | Mean Min. | |
| Yangon | 2,876 | 33.3 | 20.5 | 79.0 |

Source : Tabulated by the Study Team based on the data from Department of Meteorology and Hydrology

Table 6-4**:** Cimated Data for Yangon (1961-1990)

| **Unit** / **Month** | | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Annual** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Highest recorded** | °C | 37.8 | 38.3 | 39.4 | 41.1 | 40.6 | 36.7 | 33.9 | 33.9 | 34.4 | 35.0 | 35.0 | 35.6 | 41.1 |
| **Average high** | °C | 32.2 | 34.5 | 36.0 | 37.0 | 33.4 | 30.2 | 29.7 | 29.6 | 30.4 | 31.5 | 32.0 | 31.5 | 32.3 |
| **Daily mean** | °C | 25.1 | 26.9 | 28.8 | 30.7 | 29.2 | 27.4 | 26.9 | 26.9 | 27.3 | 27.9 | 27.2 | 25.3 | 27.5 |
| **Average low** | °C | 17.9 | 19.3 | 21.6 | 24.3 | 25.0 | 24.5 | 24.1 | 24.1 | 24.2 | 24.2 | 22.4 | 19.0 | 22.6 |
| **Lowest recorded** | °C | 12.8 | 13.3 | 16.1 | 20.0 | 20.6 | 21.7 | 21.1 | 20.0 | 22.2 | 21.7 | 16.1 | 12.8 | 12.8 |
| **Rainfall** | mm | 5 | 2 | 7 | 15 | 303 | 547 | 559 | 602 | 368 | 206 | 60 | 7 | 2,681 |
| **Average rainy days** | days | 0.2 | 0.2 | 0.4 | 1.6 | 12.6 | 25.3 | 26.2 | 26.1 | 19.5 | 12.2 | 4.8 | 0.2 | 129.3 |
| **Relative Humidity** | % | 62 | 66 | 69 | 66 | 73 | 85 | 86 | 87 | 85 | 78 | 71 | 65 | 74 |
| **Mean monthly sunshine hours** | hrs | 300 | 272 | 290 | 292 | 181 | 80 | 77 | 92 | 97 | 203 | 280 | 288 | 2,452 |

Source: Tabulated by the Study Team with Data of World Meteorological Organization and Danish Meteorological Institute

### 6.4.1.4 Ecological conditions

#### (1) Protected Area

There are 40 protected areas in Myanmar currently, including wildlife and bird sanctuaries, national parks and nature reserves, based on the Protection of Wildlife and Conservation of Natural Areas Law (Law No. 6/1994) of Myanmar. In Yangon Region, Hlawga Park is designated as a wildlife park under management of the Nature and Wildlife Conservation Division, MOECAF, with the status of strict watershed protection forest (see the profile of the Park at Table 6-5). No one is allowed to enter the Park without permission. Teaks and other trees are planted in the Park area every year. The Park' objectives are to protect the vegetation cover of the catchment area for Hlawga Lake, and to provide educational facilities of the nature. It locates in Mingalardon Township of Yangon. Hlawga Forest Reserve on the southern part of the Park preserves three types of tree habitat; evergreen forest, mixed deciduous forest and swamp forest, with the total of 108 tree species identified. Barking deers, hog deers and wild boars are the most common among total 12 mammal species.

Table 6-5**:** Protected Area in Yangon Region

| Name | Established Year | Area | | Location | Key Species Protected | Management Status | Note |
|---|---|---|---|---|---|---|---|
| | | $km^2$ | $mile^2$ | | | | |
| Hlawga Park | 1989 | 6.24 | 2.41 | Yangon Region | Sambar, Barking deer, Hog deer, Eld's deer, Macaque (Mythun), Migratory birds | Managed under Nature and Wildlife Conservation Division | Enclosed wildlife park (1-6-1989) |

Source: FD of MOECAF (2011)[17] and Instituto Oikos and BANKA (2011)[18] and ADB, et.al. (2008, 2012Rev)[19]

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[17] FD of MOECAF (2011), *General Information of established and proposed protected areas in Myanmar up to 2011*

## (2) Ecosystem

Myanmar has a diverse flora and fauna. Among them, 153 species are threatened as of IUCN Red List 2011. In the Greater Yangon, three (3) fauna species and two (2) flora species are recorded as threatened (See Table 6-6). All these threatened species are also protected by the Forest Law (Law No.8/1992) of Myanmar.

Table 6-6**:** Threatened Fauna and Flora Species recorded in Yangon as of November 2012

| No. | Scientific name | Common name | Family | IUCN, 2011 |
|---|---|---|---|---|
| 1 | Lissemys punctata  | Indian flap shell turtle | Trionychidae | Endangered |
| 2 | Indotestudo elongate  | Yellow tortoise | Testudinidae | Endangered |
| 3 | Python molurus bivittatus  | Burmese Python | Boidae | Endangered |
| 4 | Dipterocarpus alatus  | Kanyin-phyu | Dipterocarpaceae | Endangered |
| 5 | Hopea odorata  | Thin-gan | Dipterocarpaceae | Vulnerable |

Source: JICA (Feb. 2013b), p2-14

### 6.4.2 Social Environment

The Greater Yangon, with the population of around 7 million at the end of 2010-2011[20], occupies 12 % of national population and 22 % of GDP of Myanmar.

#### 6.4.2.1 Demographic Conditions

The average growth rate of population in Yangon City between 1998 and 2011 is 2.58% annually. Referring to JICA (Feb. 2013b), p2-20, there are 33 townships in Yangon City, which can be categorized into seven (7) township groups, e.g., Central Business District (CBD), Inner Urban Ring, South of CBD, Older Suburbs Zone, Outer Ring Zone, Northern Suburbs and New Suburbs Zone (See Figure 6-3). Looking by township group, the population of CBD and Outer Ring as city center decreased slightly between 1998 and 2011 while that of New Suburbs (to the north from city center) and South of CBD (to the south from city center) increased by 6 to 7 % during the same period.

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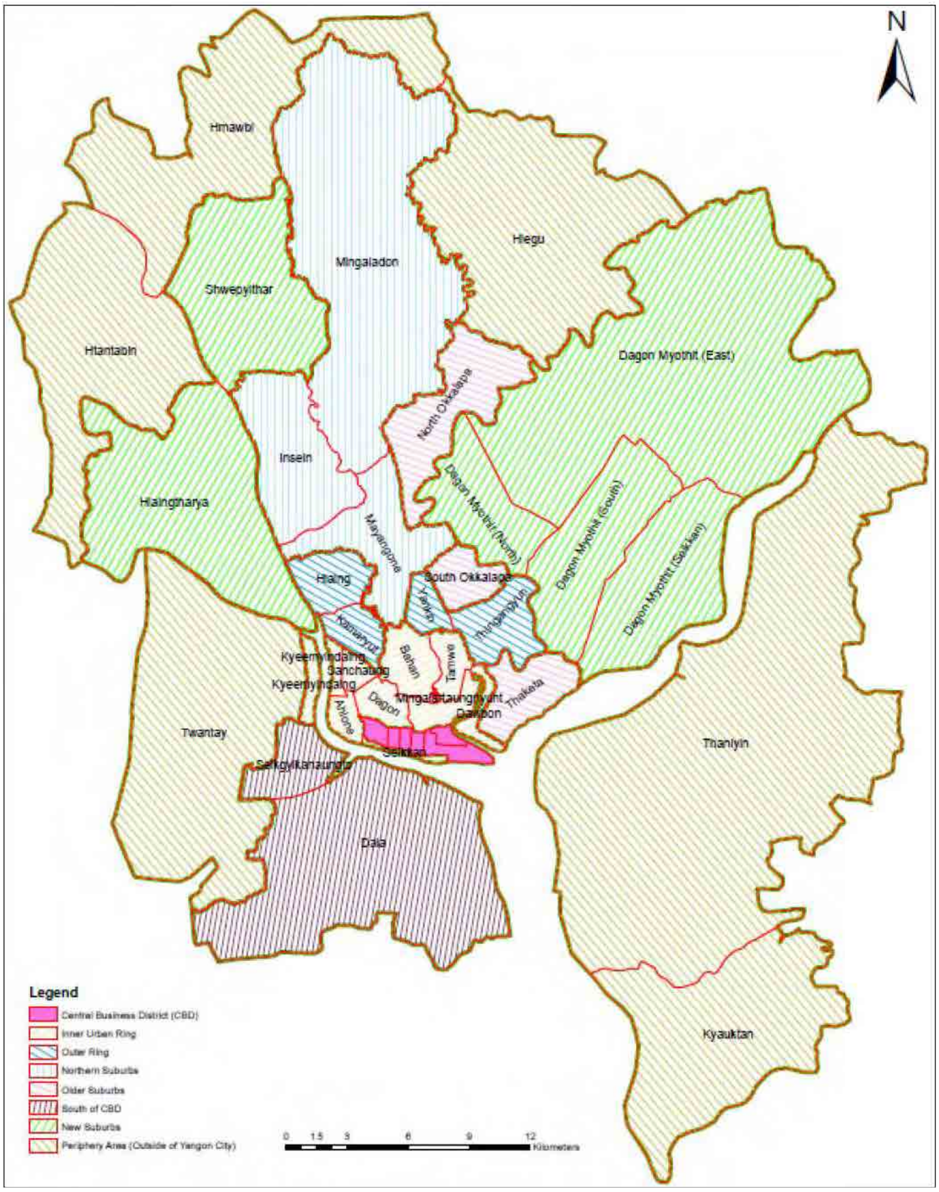
[18] Instituto Oikos and BANKA (2011), *Myanmar Protected Areas- Context, Current Status and Challenges*, pp30-31
[19] ADB, et al. (2008, 2012Rev), NCEA, MOF, Myanmar, and UNEP Regional Resources Center for Asia and the Pacific Myanmar National Environmental Performance Assessment (EPA) Report, pp145 and 147.
[20] On statistics (2010-2011) of the Planning Department, Ministry of National Planning and Economic Development (MOPD)

### 6.4.2.2 Industrial Composition

As to the industrial composition in Myanmar on Net-Production-Value (NPV), the agriculture, livestock, fishery and forestry sector has a share by 36%; the trade sector by 20%; the processing and manufacturing sector by 20%; and the services sector by 18%, according to 2010-11 statistics of MOPD. (JICA (Feb. 2013b), p2-22) In Yangon Region, the process and manufacturing sector by 37%, the trade sector by 25% and the services sector by 24% while the agriculture, livestock, fishery and forestry sector accounts for only 8% of the total NPV. The processing and manufacturing industry as the leading industry, the economic structure of Yangon Region largely lean toward commercial and industrial sectors.




Source: JICA (Feb. 2013b), pXXiX

Figure 6-3: Township Group Categories of Yangon Region (Greater Yangon)

#### 6.4.2.3 Social Services

**(1) Education**

In Yangon Region, the number of enrollment students in primary school is 463,664 while that of middle (junior-high) school is 292158, on 2012-13 statistics of Department of Basic Education. (JICA (Feb. 2013b), p2-51) Only 63% of students proceeded to the middle school. Monastic schools, registered at Ministry of Religious Affairs, give education services to the poorest of the poor, who have no opportunity from government services, filling out the gap of the social services. The number of monastic school has grown since 2000.

**(2) Health Service**

Private hospitals have been permitted of operation by Law of Private Health Care Service (2007) since 2010. (JICA (Feb. 2013b), p2-56 - 71) However, only 5 health facilities were founded during 2005 to 2010 in Yangon Region. There are no hospitals with more than 25 beds in 11 townships. In 8 among 12 specialist hospitals, the occupancy rate of beds reached below 50%. No private clinic saw the occupancy rate more than 50%.

#### 6.4.2.4 Distribution of Poor Communities

The households below poverty line tend to aggregate in the periphery or south of CBD of Yangon, where the access to public service of the City is very limited. Most of the poor migrants end up with temporary houses in those quarters of the City, sometimes at places along railway and river bank. UN-Habitat has identified at least 65 poor urban areas in Yangon Region. The level of livelihood quality is low, with a typical house having the area of 200ft$^2$ (4-5 m$^2$) and made of wood, bamboo or galvanized iron roof. Especially, large poor populations live in Hlegu (northeast periphery) and Twantay (southwest periphery) and the largest community of the poor is in Hlaing Tharyar Township (west of the City).

## 6.5 Alternatives

### 6.5.1 Alternative Plans

Alternatives are YESB Original Plan and JICA Proposed Plan from 2016 to 2019 FY. All substations' subprojects for both plans are reinforcement or upgrading work of existing ones for the period concerned. However, JICA proposed plan enables those related subprojects without any site extension while YESB original plan has required site extension and land acquisition for some subprojects located in crowded area.

### 6.5.2 Comparison of Alternatives

Related substations subprojects: JICA plan have advantages both technically and environmentally. Technically it enables more power supply stability, compactness and efficiency. Environmentally and socially, in most aspects both plans are not significantly different, but JICA plans enable all subprojects without any site extension, not to cause additional social impacts.

Related T/L and D/L subprojects: Generally, both plans are similar from environmental and social aspects since in crowded area, underground cables option, with less social impacts, are planned to install. JICA plan proposes T/L from Thaketa Power Plant to Kyaikkasan SS, with the distance of around 4 miles, as key trunk line, which requires additional social considerations. However considering all T/L and D/L network concerned with the project, this proposed plan enables more efficiency and simple network, which will result in less total length of lines though it is difficult to present a clear numerical advantage in the current design stage.

## 6.6 Scoping for Environmental and Social Considerations Study

The scoping is based on Proposed Plan of this study from 2016 to 2019.

### 6.6.1 Scoping

Scoping item is referred to '*JICA Environmental Checklist 6 on Power Transmission & Distribution Lines*' and JICA internal manual for ESC report writing. The evaluation for environmental scoping is based on '*JICA Guidelines for Environmental and Social Considerations, April 2010*', and conducted for the category of pollution control, natural environment, social environment, global issues and others, with A to D grading system. Scoping result is as below.

Table 6-7: Scoping Matrix

| Category of Impacts | Items of Impacts | Degree of possible adverse impacts | | Check for | Reason of the assessment |
|---|---|---|---|---|---|
| | | before/during Construction | during Operation | | |
| Pollution Control | 1 Air Quality | B-/ D | D | SS<br>TL<br>DL | **During Construction (DC): -** There will be some but very limited impacts of work on dust and exhaust gases due to small scale of heavy machine and vehicles operation for construction works concerned. |
| | 2 Water Quality | C | B- | SS | **DC: -** For most subproject, **s**ignificant earthmoving activities are not expected. Whether any significant earthmoving activities are included in the project need to be confirmed.<br>**During Operation (DO): -** With aging degradation of Electric Transformer and Oil-Circuit Breaker, contained insulation oil could leak out. |
| | 3 Wastes | B- | B- | SS<br>TL<br>DL | **DC: -** Equipment such as power transformers, distribution transformers, oil circuit breaker and capacitor will be replaced with upgrade of substations and reformation of D/L concrete pole. Very old ones among them might contain PCB in insulation oil. Those should be strictly managed under the clear rule how to cope with them.<br>- Limited but some construction wastes are expected. Those should be properly treated.<br>**DO: -** The replaced equipment that might possibly contain PCBs need continuous strict management (safe storage) to avoid escape or leak into ambient environment. |

| Category of Impacts | Items of Impacts | Degree of possible adverse impacts: before/during Construction | Degree of possible adverse impacts: during Operation | Check for | Reason of the assessment |
|---|---|---|---|---|---|
| Pollution Control | 4 Soil Contamination | D | B- | SS TL DL | **DO: -** Due to the same cause as in '2 Water Quality' above, with aging degradation of Electric Transformer and Oil-Circuit Breaker, contained insulation oil could leak out. |
| | 5 Noise and Vibration | B-/D | C | | **DC: -** There will be some but very limited impacts of work on noise and vibration due to small scale of heavy machine and vehicles operation.<br>**DO: -** Due to the same cause as in '14 Living and Livelihood' below, Electric Transformer installed inside but aside the border of a substaion in a condensed residential area (like downtown) might cause a noize problem to neighbors. Careful check of layout and noise reduction measures will be required in such case. |
| | 6 Subsidence | D | D | SS | - Subsidence is not expected since there will be no activities concerned with the project that may induce subsidence, such as a large scale of cut and fill works or groundwater use. |
| | 7 Odor | D | D | SS TL DL | - No source of malodor or offensive odor will be existent in the project. |
| | 8 Sediment | D | D | | - No activities are expected to result in sediment degradation or pollution. |
| Natural Environment | 9 Protected Areas | D | D | SS TL | - Two largest and scenic lakes in Yangon are Hlawga Lake and Inya Lake. Those are either in Mingalardon Township or in Mayangone Township. Only naturally protected area in Yangon is Hlawga Wildlife Park, adjacent north of Hlawga lake, in Mingalardon Township. Both townships are out of scope of this project since those ones are covered with the YESB projects assisted by ADB. So, this project scope does not include any protected area. |
| | 10 Ecosystem | C | D | | - The project is located in urbanized or suburban areas of Yangon, where naturally and ecologically important habitats and systems are not identified in general. However, any possibility for clearance or fragmentation of a ecosystem community in suburban grass land or around surface water need to be checked. |
| | 11 Hydrology | D | D | SS TL DL | - No impacts are expected on hydrology since no construction works inside surface waters and significant cut and fill works will be conducted. |
| | 12 Topography and Geology | C | C | | - Project scope is under examination.<br>- Possibility of significant cutting and filling, work on soft ground or slope need to be checked. |
| Social Environment | 13 Resettlement and Land Acquisition | C | C | SS TL DL | - SS/ If the project includes new substations, the necessity of resettlement for site preparation will be checked. However, even in such a case, new substation sites will be chosen from the locations that do not require resettlement.<br>- TL/ The nessessity of land acquisition will be checked. The resettlement can be avoided with regrad to T/L. |
| | 14 Living and Livelihood | C | C | | **DC: -** Utility poles and aerial power transmission lines on and over the land of residents may require public consultation and mitigation measures for land use, safety, and blocking of pedetrian traffic. However, in urban area T/L and D/L are installed underground or along road side under YCDC public space in principle. So, impacts will be minor.<br>- It may be necessary during T/L and D/L installment work to have 'temporary roadside vendor and shop' set back or set aside temporarily during work. The proper procedure for it needs to be clarified.<br>**DO: -** Electric Transformer installed inside but aside the border of a substaion in a condensed residential area (like downtown) might cause a noize problem to neighbors. Careful check of layout and noise reduction measures will be required in such case. |
| | 15 People in poverty | D | D | SS TL | - No significant and specific effects on people in poor are expected while the project is generally expected to stabilize power supply in low-income quarters of Yangon. |
| | 16 Ethnic Minorities and Indigenous Peoples | C | C | | - Candidate sites are not living quarters of ethnic minorities and indigenous peoples.<br>- The project impacts on low income population need to be considered. |

| Category of Impacts | No. | Items of Impacts | Degree of possible adverse impacts: before/during Construction | Degree of possible adverse impacts: during Operation | Check for | Reason of the assessment |
|---|---|---|---|---|---|---|
| Social Environment | 17 | Local economies, such as employment and livelihood | B+/D | A+ | SS TL DL | **DC:** - Local economy will be stimulated to some extent due to temporary employment of workers and purchase of goods during construction works.<br>**DO:** - Local economy will be enhanced with more stable and efficient supply of electricity. |
| | 18 | Land use and utilization of local resources | C | C | | - As in '13 Resettlement and Land Acquisition' above, necessity of land use and its impacts for T/L and D/L needs to be studied. |
| | 19 | Water usage | D | D | | - No water usage is expected in the project. No activities that might affect water use of fisheries and agriculture are not existent in the project, too. |
| | 20 | Existing social infrastructure and services | D | D | | - No adverse impacts are expected on this aspect. |
| | 21 | Social structure and local decision-making institutions | D | D | | - No adverse impacts are expected on this aspect. |
| | 22 | Uneven distribution of benefits and damages | D | D | SS TL | - It is planned that target townships will include evenly both wealthier and low-income areas and also both downtown and suburban areas of Yangon, according to the needs and analysis of systematic development of power supply. Therefore, no negative impact is assumed on this aspect. |
| | 23 | Local conflicts of interest | D | D | | - With the same reason as '22 Uneven distribution of benefits and damages' above, no negative impact is assumed on this aspect. |
| | 24 | Heritage | C | D | | -Basically, the project facilities of substations, T/L and D/L can be planned to avoid any heritage sites. As the project scope become more clarified, avoidance of heritage sites will be confirmed. |
| | 25 | Landscape | C | C | SS TL DL | -In case new substations and aerial power transmission lines (T/L and D/L) are constructed or pass along the landscape of local scenic value, the landscape might be affected. In such case, mitigation measures need to be taken. |
| | 26 | Gender | D | D | | - No negative impacts are expected on gender aspect with the project. |
| | 27 | Children's rights | D | D | | - No negative impacts are expected on children's rights with the project. |
| | 28 | Infectious diseases such as HIV/AIDS | D | D | | - No large influx of construction workers from other regions and countries are expected for the project, considering the scale of construction works. Therefore, no significant impact is assumed on this aspect. |
| | 29 | Working environment | B- | D | | - Safety caution of heavy machine and vehicle movement and equipment installation work for construction workers will be required during construction |
| | 30 | Accident | B- | D | | -Safety caution of heavy machine and vehicle movement for the communities at project sites will be required during construction<br>-Works of underground incoming and outgoing power transmission lines and distribution lines have a risk to damage underground utility cables and pipes. |
| Global Issues | 31 | Climate Change/ Global Warming | D | B- | SS | **DO:**<br>-With aging degradation of Gas Circuit Breaker, contained gas could leak out, emitting SF6 gas which is a strong greenhouse gas (GHG). |

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

### 6.6.2 TOR for the Environmental and Social Considerations Study

Regarding the items having been evaluated as A, B or C in the scoping, Terms of Reference (TOR) for the pertinent environmental and social considerations study are prepared as follows.

Table 6-8: TOR for Environmental and Social Considerations (ESC) Study

| Environmental Category | Study Item | Method of the Study |
|---|---|---|
| Air Quality | (1) Type and size of construction works required<br>(2) Study of possible impacts of those works on dust and exhaust gases of construction work | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites |
| Water Quality | (1) Confirmation that no significant earthmoving activities are conducted in subprojects and soil erosion risk will not be raised.<br>(2) Current maintenance and monitoring conditions on Electric Transformer and Oil-Circuit Breaker in existing substations<br>(3) Oil outflow prevention equipment (1. around Electric Transformer and Oil-Circuit Breaker, 2. along site border of substations) | (1) Site survey of candidate sites<br>(2) Site survey and interview survey with substations staff at existing substations<br>(3) Ditto |
| Wastes | (1) Type and size of construction works required<br>(2) Study of possible impacts of those works on wastes of construction work<br>(3) Current situation and past records in YESB on storage, reuse or disposal of old replaced equipment such as power transformers, distribution transformers, oil circuit breaker and capacitor | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites<br>(3) Interview with YESB staff and inspection survey of the storage place |
| Soil Contamination | Same as (2) and (3) of Study for 'Water Quality',<br>(1) Current maintenance and monitoring conditions on Electric Transformer and Oil-Circuit Breaker in existing substations<br>(2) Oil outflow prevention equipment (1. around Electric Transformer and Oil-Circuit Breaker, 2. along site border of substations) | Same as (2) and (3) of Mthod of the Study for 'Water Quality',<br>(1) Site survey and interview survey with substations staff at existing substations<br>(2) Ditto |
| Noise and Vibration | (1) Type and size of construction works required<br>(2) Study of possible impacts of those works on inhabitants safety, noise and vibration, dust and exhaust gases, wastes of construction work<br>(3) Same as 'Living and Livelihood (2)' below, current situation on noize issues in existing substations, such as noize reduction measures and neighbors' complaint on noize and current situation especially in downtown. | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites<br>(3) Site survey and interview survey with substations staff at existing substations |
| Ecosystem | (1) Any possibility for clearance or fragmentation of a ecosystem community in suburban grass land or around surface water will be checked. | (1) Subproject profiling (location and type of construction work) of substations<br>(2) Map analysis of natural conditions along T/Ls |
| Topography and Geology | (1) Confirmation of project scope<br>(2) Possibility and scale, if any, of cut and fill works<br>(3) Any soft ground or slope on site preparation area fo substations and along the route of T/L and D/L | (1) Confirmation of project profile with project planning team<br>(2) Site survey of candidate sites |
| Resettlement and Land Acquisition | (1) SS/ The necessity of resettlement<br>(2)TL/ The nessessity of land acquisition | (1) Subproject profiling (location and type of construction work) of substations and T/Ls<br>(2) Site survey of candidate sites and map analysis along T/Ls |
| Living and Livelihood | (1) Land use and land status along assumed aerial power transmission lines with steel towers and utility poles.<br>(2) Standard procedure for temporary replacement of road side vendors and street traders<br>(3) Current situation on noize issues in existing substations, such as noize reduction measures and neighbors' complaint on noize and current situation especially in downtown. | (1) Site survey of candidate sites<br>(2) Questionnaire and interview survey with YESB management and staff at related division<br>(3) Site survey and interview survey with substations staff at existing substations |
| Ethnic Minorities and Indigenous Peoples | (1) Surrounding environment of candidate site<br>(2) Existence of low income population around candidate sites | (1) Subproject profiling (location and type of construction work) of substations<br>(2) Literature survey on demographic conditions, site survey and interview survey with local staff at candidate sites |
| Land use and utilization of local resources | (1) Same as 'Resettlement and Land Acquisition (2)' above | (1) Same as 'Resettlement and Land Acquisition (2)' above |
| Heritage | (1) Surrounding environment of candidate site<br>(2) Existence of any cultural and religeous heritage sites around candidate sites | (1) Subproject profiling (location and type of construction work) of substations and T/Ls<br>(2) Site survey of candidate sites |
| Landscape | (1) Surrounding environment of candidate site<br>(2) Existence of any landscape of local scenic value around candidate sites | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites |
| Working environment | (1) Type and size of construction works required<br>(2) Study of possible impacts of those works on safety of construction workers | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites |

| Environmental Category | Study Item | Method of the Study |
|---|---|---|
| Accident | (1) Type and size of construction works required<br>(2) Study of possible impacts of those works on inhabitants safety<br>(3) Type of existing utility cables and pipes | (1) Subproject profiling (location and type of construction work) of substations, T/Ls and D/Ls<br>(2) Site survey of candidate sites<br>(3) Interview survey with YESB staff at related division |
| Climate Change/ Global Warming | (1) Current maintenance conditions of gas circuit breaker in existing substations | (1) Site survey of existing substations |

## 6.7 Initial Environmental Examination (IEE)

Based on the TOR for the ESC study, an initial environmental examination (IEE) has been conducted on A, B and C items identified in the scoping.

### 6.7.1 Examination of Potential Impacts

Potential impacts are examined as follows.

Table 6-9: Initial Impact Examination（IEE）

| Category of Impacts | Items of Impacts | Check for | Reason of the assessment |
|---|---|---|---|
| Pollution Control | (1) Air Quality | SS<br>TL<br>DL | **During Construction:**<br>- There will be some but very limited impacts of work on dust and exhaust gases due to small scale of heavy machine and vehicles operation for construction works concerned. |
| | (2) Water Quality | SS | **During Construction:**<br>- Significant earthmoving activities are not expected. All subprojects for candidate substations are capacity increase of existing substations, which do not require earthmoving activities, such as cutting and filling.<br>**During Operation:**<br>- In several existing substations, oil spill is traced and left untreated around the ground where Electric Transformer and Oil-Circuit Breaker has been placed.<br>- Oil outflow prevention equipment has not been installed in existing substations. Especially, since a project site at MyntawtharS/S tends to be inundated, oil outflow prevention equipment is highly needed there. |
| | (3) Wastes | SS<br>TL<br>DL | **DC: -** Equipment such as power transformers, distribution transformers, oil circuit breaker and capacitor will be replaced with upgrade of substations and reformation of D/L concrete pole. Very old ones among them might contain **PCBs** in insulating oil. Those should be strictly managed under the clear rule how to cope with them.<br>- Limited but some construction wastes are expected. Those should be properly treated.<br>**DO: -** The replaced equipment that might possibly contain **PCBs** need continuous strict management (safe storage) to avoid escape or leak into ambient environment.<br>**On the management of PCB:**<br>The detailed survey results on PCBs are summarized in the Appended Table-1 below. |
| | (4) Soil Contamination | | Same as '(2) Water Quality' above.<br>**DO:**<br>- In several existing substations, oil spill is traced and left untreated around the ground where Electric Transformer and Oil-Circuit Breaker has been placed.<br>- Oil outflow prevention equipment has not been installed in existing substations. |
| | (5) Noise and Vibration | | **DC:**<br>- There will be some but very limited impacts of work on noise and vibrations due to small scale of heavy machine and vehicles operation for construction works concerned.<br>**DO:**<br>- Appropriate noise reduction measures for Electric Transformer will not cause noise problems. Standard distance to be taken to site border is indicated on the equipment concerned. |
| Natural Environment | (1) Ecosystem | SS<br>TL | **DC:**<br>- All substation subprojects are upgrade of existing SS inside the existing site space without extension of land space.<br>- Along asumed T/Ls, there are no naturally important ecological systems and habitats. No fragmentation of such systems are assumed in regard of T/L construction. |
| | (2) Topography and Geology | SS<br>TL<br>DL | - All substations are reinforcement of existing stations without extension. Therefore, there will be no significant cut and fill works in the project.<br>- Yangon area stands on a generally plain land. However, Yangon has sometimes heavy rains. So, slope protection measures along T/L will need careful measures. Especially, along T/L to Kyaikkasan SS, steel towers at river crossing will need proper slope protection measure against soil run-off. |

| Category of Impacts | Items of Impacts | Check for | Reason of the assessment |
|---|---|---|---|
| Social Environment | (1) Resettlement and Land Acquisition | SS TL DL | -Regarding resettlement, there will be no resettlement in this project.<br>- As for land acquisition, two steel towers are planned on both sides of a river at one river crossing point near Thaketa power generation plant along the planned T/L from kyaikkasan SS. YESB made a decision to construct the new towers on the land space where existing steel towers are currently standing, by replacing them. Therefore, land acquisition is not necessary for the new towers.<br>- For all other land spaces for T/L and D/L in the project, the road sides will be used either for underground or concrete poles. The ROW at road sides shall be applied to YCDC, which is the public organizations in charge. Therefore, there is no need for land acquisition. The ROW application to YCDC usually requires 2 to 3 months. |
| | (2) Living and Livelihood | | **DC:**<br>-In urban area T/L and D/L are installed underground in principle.<br>-Temporary replacement of road side vendors and street traders for construction works shall be requested by YCDC, the administrating public authority of the ROW for road and roadside in Yangon, if necessary. When YESB applies to YCDC for the work permit and schedule on the roads of Yangon area prior to the work, such request of temporary replacement of road side vendors and street traders are also made to YCDC. The duration of required replacement, if necessary, will be atmost a few days at each site concerned.<br>**DO:**<br>-Same as 'Pollution Control (5) Noise and Vibration' above, appropriate noise reduction measures for Electric Transformer will not cause noise problems. Standard distance to be taken to site border is indicated on the equipment concerned. |
| | (3) Ethnic Minorities and Indigenous Peoples | SS TL | -The project sites are not living quarters of ethnic minorities and indigenous peoples.<br>- The project will not affect low income population badly, too. |
| | (4) Land use and utilization of local resources | SS TL DL | **DC:**<br>-For project sites at Waizayantar S/S and Kokkaine S/S, site spaces are very limited. Therefore, temporary use of the backyard of SS (YCDC property) and the neighbor parking lot (the Housing Board, MOC, property) will be necessary during construction.<br>**DO:**<br>Same as the third condition of '(1) Resettlement and Land Acquisition' above.<br>-For land spaces for T/L and D/L in the project, the road sides will be used either for underground or concrete poles. The ROW at road sides shall be applied to YCDC, which is the public organizations in charge. |
| | (5) Heritage | SS TL | -No cultural and religious heritage sites are located adjacent to the project sites. |
| | (6) Landscape | SS TL DL | -No important local landscape are identified around the project sites. |
| | (7) Working environment | | **DC:**<br>-Safety caution of heavy machine and vehicle movement for construction workers will be required during construction for construction workers. Especially, project sites at 35th Street S/S and 41st Street S/S are located in narrow buildings of condenced downtown streets. Therefore, special cares on safety of workers need to be taken in construction works. |
| | (8) Accident | | **DC:**<br>-Works of underground incoming and outgoing power transmission lines and distribution lines have a risk to damage underground utility cables and pipes.<br>-Safety caution of heavy machine and vehicle movement for the community people along the streets facing the project sites will be required during construction. The operation of heavy machine and vehicle at Container (1)S/S requires special cares to other traffic in port area during construction. |
| Global Issues | (1) Climate Change/ Global Warming | SS | **DO:**<br>- With aging degradation of Gas Circuit Breaker, contained gas could leak out, emitting SF6 gas which is a strong greenhouse gas (GHG). |

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Appended Table-1: Management of PCB-used equipment and PCB-contained

(1) Current PCB management conditions in YESB

YESB demands no use of PCB in the specifications when it newly procures insulating oil-used equipment. Thus, YESB recognizes harmful effects of PCB, however, it has neither managed equipment in which PCB may be used or contained (hereinafter referred to as "PCB-contained equipment") in existing facilities, nor set the operation procedure on the assumption that PCB is contained when the equipment is repaired or removed.

YESB repairs distribution transformers of not more than 500 kVA in capacity and stores removed such transformers at the repair plant and storage warehouse (about 20 m x 60 m) owned by the 24-hour maintenance section of YESB Distribution Department. Since the warehouse is covered with a roof and walls and has a concrete floor, there is little possibility of insulating oil leaking to outside. The insulating oil used for repaired and removed equipment is all reused after being passed through purification filters. Removed equipment is disassembled after insulating oil is extracted and iron-processed products are sold to steel factories. When transformers of more than 500 kVA have broken down, YESB outsources their repair to local transformer manufacturers and stores equipment that cannot be repaired in its substations.

The results of a hearing investigation into one of the main transformer manufacturers in Myanmar show that the manufacture is fully aware of the need of PCB management and makes it a rule to receive a certificate that PCB is not contained in insulating oil when it is purchased. Regarding transformers that have been outsourced to repair, however, the manufacture has no method of checking if PCB is contained in their insulating oil, and exercises no specific PCB management although it has taken scattering and leak preventive measures. Recovered insulating oil is reused after being passed through purification filters. The oil that cannot be recycled due to deterioration of insulation property is sold to transformer manufacturers, where it is reused for miniature transformers with low insulation level.

As mentioned above, YESB and transformer manufacturers are fully aware of the need of PCB management. Moreover, since most insulating oil is reused, there is little possibility that PCB-contained insulating oil is scattered and leaked to outside due to inadvertent treatment.

Meanwhile, the disassembly of removed equipment and the sale of iron-processed products should be avoided if the relevant equipment is PCB-contained equipment.

(2) How to manage PCB-used equipment and PCB-contained insulating oil

Production of PCB-contained oil and PCB-used equipment was discontinued worldwide by 1980. Therefore, there is a possibility that PCB is contained in equipment that was manufactured before 1980. Moreover, since YESB reuses the insulating oil extracted from repaired and removed equipment after its purification using the sole purification system, it cannot be denied that PCB-contained recycled insulating oil is also refilled to the equipment that was manufactured after 1980 if the internal parts were repaired in house. Namely, it can be judged that PCB is not contained in the equipment only when it was manufactured after 1980 and has not been repaired.

To clearly determine if PCB is contained in insulating oil, an analysis on PCB containing can be performed. However, since there are currently no devices to detect and analyze PCB in YESB, it is not realistic to perform analysis on all equipment that will be removed in the future.

### 6.7.2 Impact Evaluation

Potential impacts are evaluated at IEE level and necessary mitigation measures are identified as follows.

Table 6-10: Impact Assessment at Scoping and after IEE

| Category of Impacts | Items of Impacts | Impact Assesment at Scoping: before/during Construction | Impact Assesment at Scoping: during Operation | Impact Assessment based on IEE: before/during Construction | Impact Assessment based on IEE: during Operation | Check for | Reason of the assessment | Mitigation Measures to be taken |
|---|---|---|---|---|---|---|---|---|
| Pollution Control | 1 Air Quality | B-/D | D | B-/D | N/A | SS TL DL | **During Construction (DC):**<br>- There will be some but very limited impacts of work on dust and exhaust gases due to small scale of heavy machine and vehicles operation for construction works concerned. | **During Construction (DC):**<br>For dust, to use dust-block-screen around work area and to inform adjacent building and houses on work schedule in advance. |
| | 2 Water Quality | C | B- | D | B- | SS | **DC:**<br>- Significant earthmoving activities are not expected. All subprojects for candidate substations are capacity increase of existing substations, which do not require earthmoving activities, such as cutting and filling.<br>**During Operation (DO):**<br>- In several existing substations, oil spill is traced and left untreated around the ground where Electric Transformer and Oil-Circuit Breaker has been placed.<br>- Oil outflow prevention equipment has not been installed in existing substations. Especially, since a project site at MyntawtharS/S tends to be inundated, oil outflow prevention equipment is highly needed there. | **At Design:**<br>Oil outflow prevention equipment along site border of substations are recommended to install.<br>**During Operation (DO):**<br>Regular and proper maintenance and monitoring of Electric Transformer and Oil-Circuit Breaker is required at substations during operation. |
| | 3 Wastes | B- | B- | B- | B- | SS TL DL | **DC:**<br>- Equipment such as power transformers, distribution transformers, oil circuit breaker and capacitor will be replaced with upgrade of substations and reformation of D/L concrete pole. Very old ones among them might contain **PCBs** in insulating oil. Those should be strictly managed under the clear rule how to cope with them.<br>- Limited but some construction wastes are expected. Those should be properly treated.<br>**DO:**<br>- The replaced equipment that might possibly contain **PCBs** need continuous strict management (safe storage) to avoid escape or leak into ambient environment. | **DC:**<br>For construction wastes, contractor to take proper procedure for disposal<br><br>**DC and DO:**<br>On the management of PCB:<br>The recommended measures on PCB management are summarized in the Appended Table-2. |
| | 4 Soil Contamination | D | B- | D | B- | | Same as '(2) Water Quality' above.<br>**DO:**<br>- In several existing substations, oil spill is traced and left untreated around the ground where Electric Transformer and Oil-Circuit Breaker has been placed.<br>- Oil outflow prevention equipment has not been installed in existing substations. | Same as '(2) Water Quality' above.<br>**DO:**<br>Regular and proper maintenance and monitoring of Electric Transformer and Oil-Circuit Breaker is required at substations during operation. |
| | 5 Noise and Vibration | B-/D | C | B-/D | D | | **DC:**<br>- There will be some but very limited impacts of work on noise and vibrations due to small scale of heavy machine and vehicles operation for construction works concerned.<br>**DO:**<br>- Appropriate noise reduction measures for Electric Transformer will not cause noise problems. Standard distance to be taken to site border is indicated on the equipment concerned. | **DC:**<br>For noise and vibration, work time constraint is recommendable. |
| | 6 Subsidence | D | D | N/A | N/A | SS | - Subsidence is not expected since there will be no activities concerned with the project that may induce subsidence, such as a large scale of cut and fill works or groundwater use. | N/A |
| | 7 Odor | D | D | N/A | N/A | SS TL DL | - No source of malodor or offensive odor will be existent in the project. | N/A |
| | 8 Sediment | D | D | N/A | N/A | | - No activities are expected to result in sediment degradation or pollution. | N/A |

| Category of Impacts | Items of Impacts | Impact Assesment at Scoping | | Impact Assessment based on IEE | | Check for | Reason of the assessment | Mitigation Measures to be taken |
|---|---|---|---|---|---|---|---|---|
| | | before/during Construction | during Operation | before/during Construction | during Operation | | | |
| Natural Environment | 9 Protected Areas | D | D | N/A | N/A | SS TL | - Two largest and scenic lakes in Yangon are Hlawga Lake and Inya Lake. Those are either in Mingalardon Township or in Mayangone Township. Only naturally protected area in Yangon is Hlawga Wildlife Park, adjacent north of Hlawga lake, in Mingalardon Township. Both townships are out of scope of this project since those ones are covered with the YESB projects assisted by ADB. So, this project scope does not include any protected area. | N/A |
| | 10 Ecosystem | C | D | D | D | | **DC:** - All substation subprojects are upgrade of existing SS inside the existing site space without extension of land space.<br>- Along asumed T/Ls, there are no naturally important ecological systems and habitats. No fragmentation of such systems are assumed in regard of T/L construction. | N/A |
| | 11 Hydrology | D | D | N/A | N/A | SS TL DL | - No impacts are expected on hydrology since no construction works inside surface waters and significant cut and fill works will be conducted. | N/A |
| | 12 Topography and Geology | C | C | B- | B- | | - All substations are reinforcement of existing stations without extension. Therefore, there will be no significant cut and fill works in the project.<br>- Yangon area stands on a generally plain land. However, Yangon has sometimes heavy rains. So, slope protection measures along T/L will need careful measures. Especially, along T/L to Kyaikkasan SS, steel towers at river crossing will need proper slope protection measure against soil run-off. | **At Design, DC and DO:**<br>Slope protection measures against soil run-off along T/L, especially at river crossing. |
| Social Environment | 13 Resettlement and Land Acquisition | C | C | D | D | SS TL DL | **Before Construction:**<br>-Regarding resettlement, there will be no resettlement in this project.<br>- As for land acquisition, two steel towers are planned on both sides of a river at one river crossing point near Thaketa power generation plant along the planned T/L from kyaikkasan SS. YESB made a decision to construct the new towers on the land space where existing steel towers are currently standing, by replacing them. Therefore, land acquisition is not necessary for the new towers.<br>- For all other land spaces for T/L and D/L in the project, the road sides will be used either for underground or concrete poles. The ROW at road sides are applied to YCDC, which is the public organizations in charge. Therefore, there is no need for land acquisition. The ROW application to YCDC usually requires 2 to 3 months. This types of application has been made appropriately as confirmed by YESB executives and engineers. | N/A |
| | 14 Living and Livelihood | C | C | B- | D | | **DC:**<br>-In urban area T/L and D/L are installed underground in principle.<br>-Same as 'Pollution Control (5) Noise and Vibration' above, appropriate noise reduction measures for Electric Transformer will not cause noise problems. Standard distance to be taken to site border is indicated on the equipment concerned.<br>-Temporary replacement of road side vendors and street traders for construction works shall be requested by YCDC, the administrating public authority of the ROW for road and roadside in Yangon, if necessary. When YESB applies to YCDC for the work permit and schedule on the roads of Yangon area prior to the work, such request of temporary replacement of road side vendors and street traders are also made to YCDC. The duration of required replacement, if necessary, will be atmost a few days at each site concerned. | **At Design:**<br>- In condenced residential areas like downtown, underground cables are used for T/L and D/L in principle.<br>**At Design and DC:**<br>- For noise reduction of Electric Transformer, standard noise attenuation distance indicated on equipment to be kept from site border at installation, or installed in the building in case of llimited site space of downtown substations.<br>**Before Construction:**<br>- Request of temporary replacement of road side vendors and street traders shall made properly through YCDC. |
| | 15 People in poverty | D | D | N/A | N/A | SS TL | - No significant and specific effects on people in poor are expected while the project is generally expected to stabilize power supply in low-income quarters of Yangon. | N/A |
| | 16 Ethnic Minorities and Indigenous Peoples | C | C | D | D | | -The project sites are not living quarters of ethnic minorities and indigenous peoples.<br>- The project will not affect low income population badly, too. | N/A |
| | 17 Local economies, such as employment and livelihood | B+/ D | A+ | B+/ D | A+ | SS TL DL | **DC:** - Local economy will be stimulated to some extent due to temporary employment of workers and purchase of goods during construction works.<br>**DO:** - Local economy will be enhanced with more stable and efficient supply of electricity. | N/A |

| Category of Impacts | Items of Impacts | Impact Assesment at Scoping | | Impact Assessment based on IEE | | Check for | Reason of the assessment | Mitigation Measures to be taken |
|---|---|---|---|---|---|---|---|---|
| | | before/during Construction | during Operation | before/during Construction | during Operation | | | |
| Social Environment | 18 Land use and utilization of local resources | C | C | B-/D | B-/D | SS TL DL | **DC:**<br>- For project sites at Waizayantar S/S and Kokkaine S/S, site spaces are very limited. Therefore, temporary use of the backyard of SS (YCDC property) and the neighbor parking lot (the Housing Board, MOC, property) will be necessary during construction.<br>**DO:**<br>- Related to the third condtion of 'Resettlement and Land Acquisition', there will be cases where the new or reformed concrete poles of T/L and D/L will limit the road side space for pedestrian. | **Before Construction:**<br>- Application of temoporary land use to the pertinent organizations such as YCDC or the Housing Board of MOC, to be made sufficiently (two or three months) prior to the construction schedule date.<br>**DO:**<br>Where the concrete poles become an obstacle to the flow of pedestrian due to a limited road side, the installment of safety sign boards for traffic and pedestrian will be recomendable. |
| | 19 Water usage | D | D | N/A | N/A | | - No water usage is expected in the project. No activities that might affect water use of fisheries and agriculture are not existent in the project, too. | N/A |
| | 20 Existing social infrastructure and services | D | D | N/A | N/A | | - No adverse impacts are expected on this aspect. | N/A |
| | 21 Social structure and local decision-making institutions | D | D | N/A | N/A | | - No adverse impacts are expected on this aspect. | N/A |
| | 22 Uneven distribution of benefits and damages | D | D | N/A | N/A | SS TL | - It is planned that target townships will include evenly both wealthier and low-income areas and also both downtown and suburban areas of Yangon, acoording to the needs and analysis of systematic development of power supply. Therefore, no negative impact is assumed on this aspect. | N/A |
| | 23 Local conflicts of interest | D | D | N/A | N/A | | - With the same reason as '22 Uneven distribution of benefits and damages' above, no negative impact is assumed on this aspect. | N/A |
| | 24 Heritage | C | D | D | D | | -No cultural and religious heritage sites are located adjacent to the project sites. | N/A |
| | 25 Landscape | C | C | D | D | SS TL DL | -No important local landscape are identified around the project sites. | N/A |
| | 26 Gender | D | D | N/A | N/A | | - No negative impacts are expected on gender aspect with the project. | N/A |
| | 27 Children’s rights | D | D | N/A | N/A | | - No negative impacts are expected on children's rights with the project. | N/A |
| | 28 Infectious diseases such as HIV/AIDS | D | D | N/A | N/A | | - No large influx of construction workers from other regions and countries are expected for the project, considering the scale of construction works. Therefore, no significant impact is assumed on this aspect. | N/A |
| | 29 Working environment | B- | D | B- | D | SS TL DL | **DC:**<br>-Safety caution of heavy machine and vehicle movement for construction workers will be required during construction for construction workers. Especially, project sites at 35th Street S/S and 41st Street S/S are located in narrow buildings of condenced downtown streets. Therefore, special cares on safety of workers need to be taken in construction works. | **DC:**<br>For safety measures for construction workers in regard of heavy machine and vehicle movement, to employ advance safety management plan and to use safety sign and measures during construction activities. |
| | 30 Accident | B- | D | B- | D | | **DC:**<br>-Works of underground incoming and outgoing power transmission lines and distribution lines have a risk to damage underground utility cables and pipes.<br>-Safety caution of heavy machine and vehicle movement for the community people along the streets facing the project sites will be required during construction. The operation of heavy machine and vehicle at Container (1)S/S requires special cares to other traffic in port area during construction. | **DC:**<br>- For installation of underground cables, to request utilities agencies to attend during work<br>**Before Construction and DC:**<br>- For safety measures for the community people in regard of heavy machine and vehicle movement, to inform adjacent community on work schedule and safety caution in advance. |
| Global Issues | 31 Climate Change/ Global Warming | D | B- | D | B- | SS | **DO:**<br>- With aging degradation of Gas Circuit Breaker, contained gas could leak out, emitting SF6 gas which is a strong greenhouse gas (GHG). | **DO:**<br>Proper maintenance and monitoring of Gas Circuit Breaker is required. |

A+/-: Significant positive/negative impact is expected. B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown.
(A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

## 6.8 Environmental Mitigation Required

Regarding potential impacts evaluated as A, B or C in IEE, necessary mitigation measures are identified with respect to the project stages during design, construction and operation stages, respectively. Required scheme and cost to implement the measures properly are also identified. Cost resources are indicated here since actual costs will be estimated in Detailed Design Study.

Table 6-11: Mitigation Measures (in Design and Construction)

| Category of Impacts | No. | Items of Impacts | Project Stage | Check for | Mitigation Measures to be taken | Implementing Agency | Responsible Agency | Undertaking Cost |
|---|---|---|---|---|---|---|---|---|
| Pollution Control | 1 | Air Quality | During Construction | SS<br>TL<br>DL | (1) For dust, to use dust-block-screen around work area and to inform adjacent building and houses on work schedule in advance. | Construction Contractor | YESB | Construction Contractor |
| | 2 | Water Quality | At Design<br>During Construction | SS | (1) To install oil outflow prevention equipment along site border of substations | YESB (Design)<br>Construction Contractor (DC) | YESB | YESB |
| | 3 | Wastes | During Construction | SS<br>TL<br>DL | (1) For construction wastes, contractor to take proper procedure for disposal<br>(2) On the management of PCB:<br>The recommended measures on PCB management are summarized in the Appended Table-2 below. | (1) Construction Contractor<br>(2) YESB | YESB | (1) Construction Contractor<br>(2) YESB |
| | 4 | Noise and Vibration | During Construction | SS<br>TL<br>DL | (1) For noise and vibration, work time constraint (tentatively) between 7:00 and 19:00 | Construction Contractor | YESB | Construction Contractor |
| Natural Environment | 5 | Topography and Geology | At Design<br>During Construction | SS<br>TL<br>DL | (1) To install slope protection measures against soil run-off along T/L, especially at river crossing | YESB (Design)<br>Construction Contractor (DC) | YESB | YESB (Design) |
| Social Environment | 6 | Living and Livelihood | At Design<br>Before Construction | SS<br>TL<br>DL | (1) In condenced residential areas like downtown, underground cables are used for T/L and D/L in principle.<br>(2) For noise reduction of Electric Transformer, standard noise attenuation distance indicated on equipment to be kept from site border at installation, or installed in the building in case of llimited site space of downtown substations.<br>(3) Request of temporary replacement of road side vendors and street traders shall be made properly through YCDC. | (1) YESB<br>(2) YESB<br>(3) YCDC | YESB | (1) YESB<br>(2) No cost<br>(3) YESB |
| | 7 | Land use and utilization of local resources | Before Construction | SS<br>TL<br>DL | (1) Application of temoporary land use to the pertinent organizations such as YCDC or the Housing Board of MOC, to be made sufficiently (two or three months) prior to the construction schedule date. | YESB | YESB | No cost |
| | 8 | Working environment | During Construction | SS<br>TL<br>DL | (1) For safety measures for construction workers in regard of heavy machine and vehicle movement, to employ advance safety management plan and to use safety sign and measures during construction activities. | Construction Contractor | YESB | Construction Contractor |
| | 9 | Accident | Before Construction<br>During Construction | SS<br>TL<br>DL | (1) For installation of underground cables, to request utilities agencies to attend during work<br>(2) For safety measures for the community people in regard of heavy machine and vehicle movement, to inform adjacent community on work schedule and safety caution in advance. | (1) YESB<br>(2) YESB/ Construction Contractor | YESB | (1) YESB<br>(2) Construction Contractor |

Appended Table-2: Recommendable measures on the management of PCB-used equipment and PCB-contained insulating oil

Based on the IEE study on 'Current PCB management conditions in YESB' and 'Management of PCB-used equipment and PCB-contained insulating oil', the following measures can be proposed.

(i) The manufacturing year and repair history of insulating oil-used equipment should be managed
(ii) The equipment whose manufacturing year is 1979 or before and the equipment whose manufacturing year is 1980 or after of which internal repair is performed after installation, should be all subject to PCB management.

For the equipment subject to PCB management, it is necessary to establish PCB decomposition facilities in Myanmar in the future. As the current measures, it is desired to secure a site of sufficient area and store equipment that may contain PCB in the site by clearing distinguishing it from other materials after taking measures for preventing the scattering and leak of insulating oil contained in the equipment. Moreover, in order not to contaminate the equipment in which no PCB is contained, with PCB, new oil should be used as insulating oil that will be refilled to repaired equipment. Also, it is desired that the insulating oil extracted from the equipment subject to PCB management is not reused (the use of old oil for oil purification devices is also prohibited) and stored and managed in the same way as the equipment subject to PCB management.

Moreover, when the repair of equipment is outsourced to transformer manufacturers, the equipment in which no PCB is contained may be contaminated with PCB if the manufacture uses recycled insulating oil. Therefore, it is desired that, in the ordering specifications that will be issued when the repair is outsourced to transformer manufacturers, YESB demands the use of insulating oil once used for the relevant equipment or new oil as the insulating oil that will be refilled after the repair.

In addition, since the repair plant and storage warehouse of YESB has little possibility of causing leak of insulating oil, it is possible to use the plant/warehouse as a storage place for the equipment subject to PCB management among all equipment that will be removed in this project. However, since the plant/warehouse has remarkably deteriorated and does not have a sufficient storage space as to the amount of PCB-contained equipment that is expected to be stored, it is necessary to separately secure a storage space. The necessity of securing a new storage space and to establish a monitoring scheme as above has been consulted with YESB. YESB understood it and agreed to take necessary steps.

Table 6-12: Mitigation Measures (during Operation)

| Category of Impacts | No. | Items of Impacts | Project Stage | Check for | Mitigation Measures to be taken | Implementing Agency | Responsible Agency | Undertaking Cost |
|---|---|---|---|---|---|---|---|---|
| Pollution Control | 1 | Water Quality<br>Soil Contamination | During Operation | SS | (1) Regular and proper maintenance and monitoring of Electric Transformer and Oil-Circuit Breaker is required at substations during operation. | YESB | YESB | YESB |
| | 2 | Wastes | During Operation | SS<br>TL<br>DL | (1) On the management of PCB:<br>The recommended measures on PCB management are summarized in the Appended Table-2. | YESB | YESB | YESB |

| Category of Impacts | No. | Items of Impacts | Project Stage | Check for | Mitigation Measures to be taken | Implementing Agency | Responsible Agency | Undertaking Cost |
|---|---|---|---|---|---|---|---|---|
| Natural Environment | 3 | Topography and Geology | During Operation | SS<br>TL<br>DL | (1) Slope protection measures against soil run-off along T/L, especially at river crossing. | YESB | YESB | YESB |
| Social Environment | 4 | Land use and utilization of local resources | During Operation | SS<br>TL<br>DL | (1) Where the concrete poles become an obstacle to the flow of pedestrian due to a limited road side, the installment of safety sign boards for traffic and pedestrian will be recomendable. | YESB/ YCDC | YCDC | YESB |
| Global Issues | 5 | Climate Change/ Global Warming | During Operation | SS | (1) Proper maintenance and monitoring of Gas Circuit Breaker is required. | YESB | YESB | YESB |

## 6.9 Environmental Monitoring Plan

To assure that the sound environmental management system is working on the project, the environmental monitoring plan for potential impacts and mitigation measures are recommended as below, including monitoring item, indicator for monitoring, monitoring location, method and reporting scheme.

Table 6-13: Environmental Monitoring Plan

| | Item | Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Monitoring Framework required | Reporting interval to JICA office |
|---|---|---|---|---|---|---|---|---|
| during construction | Air Quality (dust) | use of dust-block | substations in crowded residential or commercial area | Once in peak work period for each substation / to monitor relevant mitigation plan is properly implemented | N/A | YESB | A team of 3 Executive Engineers for SS and T/L and a team of 7 Executive Engineers for D/L that will be formed in PMU for the Project | once per 3 months |
| | | advance notice to adjacent building and houses on work schedule | houses / shops adjacent to substations in crowded area | Once per month / to monitor relevant mitigation plan is properly implemented | N/A | YESB | | |
| | Wastes (construction waste/ PCBs) | procedure of disposal | all construction sites of substations, T/L and D/L | at end of construction period for each site | N/A | YESB | | |
| | | PCB Management | storage spaces (temporary and designated by YESB) for concerned equipment (refer to the mitigation plan on the Appended Table-2) | After replacement at each site and once per month in the storage place / to keep traceability and monitor safe storage conditions of the concerned equipment | No concrete standards/ Stockholm Convention on Persistent Organic Pollutants | YESB | Assignment of a chief administrator for PCB mangement | |

| | Item | Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Monitoring Framework required | Reporting interval to JICA office |
|---|---|---|---|---|---|---|---|---|
| during construction | Noise and vibration | work time constraint | substations in crowded residential or commercial area | Once in peak work period for each substation / to monitor relevant mitigation plan is properly implemented | 10 hours between 7:00 and 19:00 Japan/ IFC | YESB | A team of 3 Executive Engineers for SS and T/L and a team of 7 Executive Engineers for D/L that will be formed in PMU for the Project | once per 3 months |
| | Accident (underground cable installation) | attendance of utility agent | along incoming and outgoing T/L of substations and D/L in crowded area | Prior to excavation at underground cables to be installed | N/A | YESB | | |
| | Working environment/ Accident (safety measures) | advance safety management plan | all construction sites of substations, T/L and D/L | Prior to work at every site | ILO Guidelines Safety and Health in Construction | YESB | | |
| | | use of safety sign and measures | around construction sites at substations in crowded area and along T/L | Prior to work at every site | | YESB | | |
| | | advance notice to adjacent community on work schedule and safety caution | community adjacent to substations in crowded area | Prior to work at every site | N/A | YESB | | |
| during operation | Water Quality / Soil Contamination (insulating oil) | leakage of insulation oil | under/around electric transformer and oil-circuit breaker | once per month | to be checked | YESB | A team of 3 Executive Engineers for SS and T/L | once per 6 months |
| | Wastes (PCBs) | PCB Management | the storage space designated by YESB for concerned equipment (refer to the mitigation plan on the Appended Table-2) | once per month in the storage place / to keep traceability and monitor safe storage conditions of the concerned equipment | No concrete standards/ Stockholm Convention on Persistent Organic Pollutants | YESB | Assignment of a chief administrator for PCB mangement | |
| | Topography and Geology (slope protection) | Slope protection measures | steel towers to be installed at a river crossing along T/L to Kyaikkasan SS | once per month in rainy season and once per 3 months in dry season / to monitor slope protection measures around the steel tower concerned | N/A | YESB | A team of 3 Executive Engineers for SS and T/L and a team of 7 Executive Engineers for D/L that will be formed in PMU for the Project | |
| | Land use and utilization of local resources | Safety sign boards for traffic and pedestrian | where the new or reformed concrete poles of T/L and D/L will limit the road side space for pedestrian | Once at the end of construction period and once per 6 months / to monitor the safety conditions of pedestrian and safety signboards | N/A | YESB/ YCDC | | |
| | GHG (climate change) | degradation of gas-circuit breaker (container of SF6 gas) | gas-circuit breaker | once every month | Kyoto Protocol and IPCC Guidelines | YESB | A team of 3 Executive Engineers for SS and T/L | |

Monitoring Format for the above monitoring plan is attached in Appendix 6-1.

## 6.10 Stakeholders Consultation

Regarding substations, all sub-projects are upgrade of existing SS inside the existing site space without extension of land space. When power capacity is increased, incoming and outgoing T/L will become underground or use existing overhead lines with little extension of those. Construction activities required for the related work for each substation is comparable to build a 3 to 4 story house. So, significant impacts will not happen. Therefore, local stakeholders' consultation for substation projects is not applicable in substation sub-projects.

Regarding transmission line, the road sides will be used either for underground cables or concrete poles in almost all places for transmission line (T/L) and distribution line (D/L) in the project. The ROW at road sides shall be applied to YCDC, which is the public organization in charge. Therefore, there is no need of land acquisition for these cases. Only one exception is the case where two steel towers are planned on both sides of a river at one river crossing point near Thaketa power generation plant along the planned T/L from Kyaikkasan SS. However, YESB made a decision to construct the new towers on the land space where existing steel towers are currently standing, by replacing them. Therefore, land acquisition is also not necessary for the case.

Summarizing the above, all major works for the project will be conducted in the existing sites of substations and two steel towers for a T/L, as replacement to existing facilities. Other works, such as underground cables and concrete poles installation, will be conducted along road sides under the authorization of YCDC, the public organization in charge, without any land acquisition.

Therefore, it is recommended for the project that YESB will ensure a steady implementation of advance notice and consultation to/with respective adjacent communities on construction work schedule and safety caution, prior to related construction works, which is planned in the mitigation measures and environmental monitoring plan. That is considered to be proper stakeholders' consultation for the project.

# Chapter 7 Project Evaluation

## 7.1 Effects assumed as a result of the Japanese ODA loan project

The implementation of the Japanese ODA loan project expects the following effects:

1) **Reducing transmission or distribution loss**

Power loss may be reduced by removing overload of the power transmission and distribution facilities and distributing load. Transmission loss may be reduced by selecting the appropriate electric line size depending on the tolerance of the transmission capacity.

Power loss of the power distribution facilities may be reduced with the shortened low-voltage lines by installing low loss transformers or installing transformers of smaller capacity in different locations.

Under the environment insufficient in power sources, the reduced power loss could improve the availability of power supply or save power generating fuel. This consequently contributes to the improved profitability of the YESB.

2) **Reducing the duration and number of times of power outage**

The new construction and rehabilitation of transmission and distribution lines could reduce the number of the faults of power transmission and distribution lines.

Taking into account the fact that the downtown area and its suburban areas are the possible candidates for this Japanese ODA loan, it is expected to improve power supply to the major facilities or office buildings of both national and international companies.

3) **Improving voltage drop or fluctuations**

In the power transmission systems, fluctuations in the system voltage could be reduced by decreasing load shedding associated with transmission faults after the extended 66kV power transmission lines and by installing power capacitors.

The power distribution lines extended by the low-voltage power distribution lines lead to greater voltage drop at the line end and disable the use of electrical appliances. Fluctuations in voltage may be reduced by installing smaller transformers for power distribution lines in different locations.

4) **Improving fluctuations in frequency**

Similarly, it is expected to reduce fluctuations in frequency of the electric power systems.

5) **Reducing $CO_2$ emissions**

The reduced power loss could save fuel used in thermal power plants. Also, the improved electric power supply can shorten the operating time of emergency generators, which expects to reduce the amount of fuel used for emergency generators. $CO_2$ emissions could consequently be reduced.

6) **Enhancement of work safety and efficiency**

Since the project is implemented with the support of consultants, the engineers can raise their awareness of safety and enhance their technology and can develop the efficient work executing method.

In addition, the introduction of construction machinery or vehicles for work at height can improve work safety and enable quick and efficient works so that the township engineers who are busy dealing with faults can enhance the tolerance of works.

7) **Capacity building of engineers and basic workers**

With the implementation of Japanese ODA loan projects, the YESB's engineers and workers can participate in the execution of projects to enhance their execution techniques.

8) **Strengthening of the capacity building for planning, operation and maintenance and project management**

With the implementation of Japanese ODA loan projects, YESB engineers can learn the system planning method, know-how of the operation maintenance, and execution control from the consultants. Thus, YESB engineers can enhance their capacity.

As abovementioned, the construction, addition and rehabilitation of power transmission and distribution lines in the Yangon City has improved the reliability of the electric power systems, which can expect to reduce the number of faults of power transmission and distribution lines. It is further expected that the advanced electric power development in Myanmar in addition to the improved reliability of power transmission and distribution systems improves electric power supply throughout the year and increases the attraction of the city for both the citizens of the Yangon City and national and international participating companies. Finally, it would be more effective to clarify the implementation policies and employ consultants for systematic promotion in relation to the system plans and the construction, addition and rehabilitation of power transmission and distribution facilities.

## 7.2 Suggestion of operation indicator and effect indicator

The base year of the operation and effect indicators should be April 2023 two years after the completion of the projects.

As the operation and effect indicators for the candidate projects under Japanese ODA loan, it is recommended to set the following six items

[Operation indicator]

(i) Substation transformer installation capacity

(ii)Transformer Availability Factor

(iii)Electricity Supply

(iv)System Average Interruption Frequency Index (SAIFI: Annual average number of power outage per customer)

(v)System Average Interruption Duration Index (SAIDI: Annual average outage time per customer)

[Effect indicator]

(vi) Power transmission and distribution loss rate

### 7.2.1 Substation transformer installation capacity

The indicator value for determining if the transformers of substations are installed as scheduled.
The following numeric values are set.

**Supply capacity at substations: 690MVA**

Regarding the total installation capacity of transformers in the substation reinforcement work subject to the project in Component 1.
The indicators, namely the installation capacity values, do not include the capacity of transformers that will be installed in the substations that are not included in Component 1.

### 7.2.2 Transformer Availability Factor

The capacity operation rates of the transformers of substations to be built under the projects are set as the indicator.

**Transformer Availability Factor: 76%**

The operating rates of the transformers as of April FY2023

$$= \frac{\text{Peak demand (MW) of the whole 23 candidate townships for the yen loan project}}{\text{Total capacity of transformers (MVA) for the whole 23 candidate townships for the yen loan project}}$$

$$= 1{,}154\text{MW} \; / \; (1{,}681\text{MVA} \times 0.9(\text{Power factor}))$$

$$= 76\%$$

Additionally, the survey team also assumes that YESB continues reinforcing substations even after the completion of the yen loan project during the period of FY2020 to 2023 in order to meet the demand increase.

### 7.2.3 Electricity Supply

The amount of power (GWh) transmitted from the transformers of substations to be built under the projects is set as the indicator.

**Electricity Supply: 1,641GWh**

The amount of power transmitted for one year in FY2022 is set as the indicator. The indicator above can be estimated based on the estimated peak demand value (MW) and the estimated load factor value (%) in FY2022 as follows.

Electricity Supply = peak demand(at FY2022) × load factor(at FY2022)

Electricity Supply = 543.1MW
(Total sum of max demands of 21 targeted substations as of 2022)

× ( 690/1,100)

(Capacity of targeted transformer / Total transformer capacity of 21 targeted substations as of 2022)

× 0.55(Annual load factor)× 8,760 (hour)

= 340.7 MW (Max power corresponds to the load of targeted transformers) × 0.55× 8760

= 1,641 (GWh)

Additionally, the survey team also assumes that YESB continues reinforcing substations even after the completion of the yen loan project during the period of FY2020 to 2023 in order to meet the demand increase.

### 7.2.4 System Average Interruption Frequency Index (SAIFI)

The indicator for checking if the transmission-transformation facilities that are installed in the projects are appropriately operated and maintained.

**Annual average number of power outage per customer: 0 (zero) / year-customer**

Only the number of power outages resulting from accidents that occurred to the transmission lines and substation facilities that are installed in the Component 1 is counted for the indicator, and the 0 (zero) case is set as the target value.

### 7.2.5 System Average Interruption Duration Index (SAIDI)

The indicator is used for checking the transmission-transformation facilities in the projects are appropriately operated and maintained.

**Annual average outage time per customer: 0 (zero) minutes / year-customer**

Only the outage time resulting from accidents that occurred to the transmission lines and substation facilities that are installed in Component 1 is counted for the indicator, and the 0 (zero) minute is set as the target value.

### 7.2.6 Power transmission and distribution loss rate

**Power transmission and distribution loss rate**

As the indicator for power transmission and distribution loss rate, the following numeric value is set.

**Power transmission and distribution loss rate: 15.2%**

**(1)Set basis**

**18.7%** (the results of power transmission and distribution loss rates in 2012)
**-1.5%** (Effects by the execution of transmission-transformation project)
**-2.0%** (Effects by the execution of power distribution project)

**(2)Calculation method**

The method of calculating the reductions in power transmission loss and distribution loss in the projects and their results are shown below.

**(3)Transmission-transformation loss rate**

The transmission loss reduction effects as of 2023 when the substation reinforcement plan in Component 1 are calculated. (The effects are calculated from the amount of annual transmission loss in FY2022) The procedures are as follows.

**1)** Calculate the "transmission loss when the project is not executed" and the "transmission loss after the execution of project" in FY2022.

The "transmission loss when the project is not executed" should be calculated on the assumption that the future demand of power is transmitted via the existing 33 kV system, while the "transmission loss after the execution of project" should be calculated on the assumption that the power from the transformers with the voltage raised to 66 kV is transmitted via the 66 kV system.

Based on the power flow value mentioned above and the following equation, the annual power loss is calculated.

$$\text{Power loss [MW]} = \Sigma\,(3 \times I[kA]^2 \times R[\Omega/km] \times L[km])$$

Here,

I: Current [kA], R: Resistance of transmission line per unit length [Ω/km],

L: Transmission line length [km]

Annual power loss [MWh] = Power loss in the maximum load [MW]
x Loss coefficient (p) x 8760[h]

**2)** Based on the difference of transmission losses mentioned above and annual power amount in the whole YESB areas, the "loss improvement rate by the execution of project" is calculated. On the assumption that the losses in the transmission-transformation projects will be improved at the same rate in the whole YESB areas, the "loss improvement rate in the whole YESB" is calculated based on the ratio between the demands in the townships subject to the projects this time and the total demand in the whole YESB areas.

The results of the calculation of loss improvement rate (%) in the whole YESB areas are as shown in Table 7-1. From the results above, the loss improvement rate (indicator) in the transmission -transformation project as of April 2023 becomes 1.5%.

Table 7-1: The results of the calculation of loss improvement rate (%) in the whole YESB areas

| Item | Assumed value in FY2022 |
|---|---|
| Power loss when the project is not executed | 106,040 MWh |
| Power loss after the project is executed | 49,668 MWh |
| Reduction by the execution of project | 56,372 MWh |
| Annual purchase | 17,792 GWh |
| Loss improvement rate by the execution of project | 0.3% |
| Demand in townships subject to project | 543 MW |
| YESB's total demand | 2,519 MW |
| Loss improvement rate (indicator) in the whole YESB areas | 1.5% |

**(4) Power distribution loss rate**

The power loss reduction effects when the multi-transformer system (regarding the transformers for low-voltage power distribution and low-voltage lines) in Component 2 is executed, is calculated. In the execution of the project, low-loss type transformers are used. Regarding the medium-voltage distribution lines, since the operation rates resulting from increase of demand will be appropriately maintained at the current level, the loss rate of the medium-voltage distribution lines should be considered at the current level and the loss reduction value should not be taken into consideration.

The comparative evaluation between the case where the multi-transformer system is used in April 2022 and the case where the current low-voltage distribution system is maintained is performed. The power loss is calculated by the following approximation.

Annual power loss [MWh] $= \Sigma\ (3 \times I[kA]^2 \times R[\Omega/km] \times L[km])$ x Loss coefficient (p) x 8760[h]

Here,

I: Low-voltage line current [kA],

R: Resistance of low-voltage 1 thread per unit length [Ω/km],

L: Low-voltage line length [km]

The results are shown in Table 7-2. The loss of transformers themselves normally increases due to the division to low-capacity transformers. With the introduction of amorphous transformers, however, the loss of transformers themselves is restrained to the normal level by offsetting the increase resulting from the division. The loss improvement rate (indicator) resulting from the introduction of the multi-transformer system is 2.0% as of 2022. In this component, the townships where the multi-transformer system is introduced on a priority basis are selected in consideration of the constraints such as work-related personnel and material input. Therefore, the calculation of the effects of loss rate reduction is limited to the transformers subject to the selection this time and is not applied to the whole YESB areas.

Table 7-2: The results of the calculation of loss improvement rate in the whole YESB areas

| Item | Assumed value in FY2022 |
|---|---|
| Power loss when the project is not executed | 405,242 MWh |
| Power loss after the execution of project | 41,366 MWh |
| Reduction by the execution of project | 363,876 MWh |
| Annual purchase | 17,792 GWh |
| Loss improvement rate by the execution of project | 2.0 % |

### 7.3 Monitoring indicator by the YESB

The items of the operation and effect indicator are monitored by the YESB as follows. The monitored values for each indicator are reported to the JICA every time the following measurement is performed.

**(1) Substation transformer installation capacity**

The transformer installation capacity (MVA) at the end of every fiscal year and the scheduled transformer installation capacity (MVA) at the end of the next fiscal year are measured from FY 2016 until the completion of the project.

**(2)Transformer operating rate**

At the substations subject to Japanese ODA loan, find the transformer operating rate when the maximum load, up until April FY2023, is seen.

**(3)Electricity Supply**

Find the annual sum of the power transmitted (MWh) in FY2022 in the substations subject to the projects under Japanese ODA loan. For the measurement in FY2022, the monthly electricity supply value (MWh) is measured.

**(4) System Average Interruption Frequency Index (SAIFI)**

The number of power outages caused by accidents in the substations subject to the projects under Japanese ODA loan and to their related transmission lines is measured every month after the operation of such substations starts.

#### (5) System Average Interruption Duration Index (SAIDI:Annual average outage time per customer)

The duration of power outages caused by accidents in the substations subject to the projects under Japanese ODA loan and to their related transmission lines is measured every month after the operation of such substations starts.

#### (6) Power transmission and distribution loss rate

As the monitoring method, the YESB calculates the power transmission and distribution loss rate based on the amount of annual power purchased from the MEPE and the amount of power sales by the YESB in FY2022.

**Power transmission and distribution loss rate (%)**

＝ (The annual power purchased from the MEPE (MWh) - the amount of power sales by the YESB(MWh)) / ( The amount of annual power purchased from the MEPE (MWh))

### 7.4 Estimate of the effects of reducing greenhouse gas emissions

Based on the power transmission and distribution loss reduction under the project for Japanese ODA loan project calculated in the preceding section, the amount of $CO_2$ emission limitation is calculated. As shown in the table below, against the amount of power transmission and distribution loss reduction under the projects for Japanese ODA loan, the amount of $CO_2$ emission limitation becomes 119,798 ($tCO_2$/year).

Table 7-3:Estimate of the effects of reducing greenhouse gas emissions

| | |
|---|---|
| $CO_2$ emission unit of purchased power* (i) | 0.262 (t $CO_2$/MWh) |
| Power transmission and distribution loss reduction under Japanese ODA loan project (GWh/ year) (ii) | 457,243MWh) |
| $CO_2$ emission limitation (i)×(ii) | 119,798($tCO_2$/year) |

* Source: IEA statistics 2012, CO2 emissions from fuel combustion

# Chapter 8 Current Issues and Suggestions for Distribution Sector in the Yangon Region

## 8.1 Power system planning

### (1)Current situation

YESB has not definitely determined the system plan policy. Under the current facilities renewal policy, YESB plans to reinforce facilities when the operation rates of facilities such as transformers exceed 80%.YESB has not yet used the N-1 reference as reliability reference at present.

Meanwhile, to control the demand results of substations, YESB records the current and voltage values every hour on papers at each substation. However, those data are not effectively used as the data for substation plans. As the efforts for loss reduction, YESB plans to increase the primary side voltage of substations from 33kV to 66kV and the distribution voltage from 6.6kV to 11kV and has already been implementing the plan.

### (2)Suggestions

(a) Substation planning based on the latest demand results and the regular review of 5-year plans

The local demand trends are always changing according to economic conditions and development plans in the surrounding areas. It is desirable that YESB creates the system that the head office's planning department grasps the demand results (maximum value) and regularly reviews the contents of 5-year plans based on such data.

(b) Introduction of the system analysis program

To study voltage and power flow in the transmission system and establish the facilities in consideration of the N-1 reference, the software such as the system analysis program PSS/E used in this survey should be introduced. It is desirable for YESB head office's planning department to unify the control of system data.

## 8.2 Power system operation

### (1)Current situation

The power system operations in YESB-controlled areas are conducted at the Mayangon substation located in the Mayangon township 24 hours a day. The Mayangon substation collects the power flow and voltage data of 66kV and 33kV substations and transmission lines hourly by telephone. Since the system conditions are grasped over the telephone, it takes some time to grasp the system conditions and get failures restored when system failures have occurred.

### (2)Suggestions

(a) Introduction of the SCADA system

It is desirable to introduce the Supervisory Control and Data Acquisition (SCDA) system for the purposes of remote monitoring, remote collection of various data, and remote control operation of equipment. With the introduction of the SCADA system, YESB can automatically collect and utilize on-site substation data and get failures restored early when failures have occurred and enhance the reliability of the electric power system.

## 8.3 Relay setting methodology

**(1)Current situation**

Transformers are protected by the current differential relay and Over Current (OC) relay. In order to protect the power distribution lines, the OC relay and Ground Over Current relay (GOC Ry) are used. The YESB currently performs relay setting so that the relays will be activated when the values such as current exceeds values, which are 80% of the rated current of transformers or distribution lines. And YESB does not perform relay setting based on the calculation of current when failures have occurred. Therefore, such relay setting may have led to the occurrence of unnecessary power outages. Moreover, since no calculations are performed based on fault current, it is possible that relay actions are not made against the minimum fault current caused by failures at the ends of distribution lines.

**(2)Suggestions**

(a) Proposal on protective relay setting method in consideration of fault current

It is desirable to perform the protective relay setting against fault current in consideration of system impedance instead of the setting of overload relays designed for overload protection of facilities. If the relay setting is performed based on fault current, appropriate relay actions can be made against the failures of facilities and the occurrence of unnecessary power outages can be reduced.

(b)Proposal on the concept of protection coordination

The concept of protection coordination of relays which localizes failure sections should be introduced. With the selection of optimal protective relays and the setting of time limit, the range of failure removal can be minimized and the range of power outages when the relays have tripped can be minimized.

It is expected that the technology proposed in (a) and (b) above will be transferred through capacity building to be achieved by consultants who will be employed in the projects.

## 8.4 Substation design and construction, operation and maintenance

### 8.4.1 Design and construction

**(1) Current situation**

The many substations at YESB have such a simple configuration of one transmission line and one power transformer because YESB does not possess N-1 policy. Therefore, the reliability of the substations is low.

YESB is moving forward with new installation and reinforcement projects of substations as the countermeasure against stagnating overload and increasing load accordingly with 5 year project plan. For the YESB system improvement, the capacity of transmission line and substation needs to be increased as well as expanding 66kV system. Therefore, uprating existing 33kV substation to 66kV and constructing additional two (2) transmission lines (incoming and outgoing) for one substation are studied.

Air insulated outdoor substation is the standard type of YESB 66kV and 33kV substation. The land space of existing 33kV substation is not enough for uprating to 66kV, and it is difficult to acquire the additional land space for a new substation installation because Yangon area is already urbanized. Therefore, all equipment to be installed must be efficiently packed in a limited land space of the substations.

**(2) Suggestions**

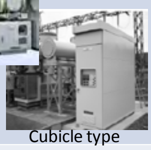
As described in 4.4.2, the configuration of two transmission lines and two transformers in a substation would be recommended to be adopted in the future. Desirable substation configuration (single line diagram) is shown in Figure 4-10.

However, the area of the existing substation is limited and it is difficult to acquire enough land space for newly installation and expansion of substations, especially in downtown area. Therefore, substation layout reformation to reduce occupied space is desirable. (AIS can be installed in case of enough land space.)

In order to reduce the occupied area of substation, the application of GIS for 66kV switchgears is recommended. The land space necessary for a GIS is smaller than that for AIS (Air insulated switchgears), and GIS substation is safer and has more harmonic appearance than AIS because there is no bare live part. (Though GIS is more costly than AIS.)

There are several types of GIS as described in 4.4.2 (3), and the type of GIS is determined by substation basic design considering the importance, incoming bays, land space, layout, maintainability, frequency of replacement, and so on. For 66kV switchgears, new compact type GIS and cubicle type GIS (C-GIS) are half size compared to the conventional type of GIS. Table 8-1 shows the comparison of the types of 66kVswitchgear.

Table 8-1: Comparison of 66kV switchgear

| | Switch gear | GIS | |
|---|---|---|---|
| Picture |  |  Conventional type |  New compact type  Cubicle type |
| Space | Wide | Small | Very small |
| Cost | Low | High | |
| Construction | Easy to carry each equipment | Installing bays orderly<br>Bus connection work necessary | |
| Maintenance | Routine maintenance<br>Easy to check | Periodical maintenance free for main contacts<br>(driving gear maintenance needed) | |
| At accident | Easy to check fault point<br>Easy to carry in / out | Need to gas check for finding fault compartment<br>Much time for carrying | |
| Use | Enough land space<br>Suburb area | Limited land space<br>City area | |

Source: JICA survey team

### 8.4.2 Facility management

**(1) Current situation**

For the maintenance management of power facilities, it is very important to manage the facility data, drawings, and documents.

As basic drawings, YESB creates and stores the single line diagrams and layout drawings of each substation. However, the layout drawings include those that have not been updated to the latest state and have incorrect positional dimensions. Moreover, YESB has not sufficiently controlled documents including construction work design drawings, operation manuals, and commissioning test reports and has no records of construction work and repairs.

Regarding the facility data, YESB has created the lists of main equipment such as transformers and circuit breakers but they lack the records of manufacturers and manufacturing years.

Regarding the failure and fault data, YESB records the occurrences of daily power outages, but the causes of outages and the fault location and point are not specified for many power outages.

**(2) Suggestions**

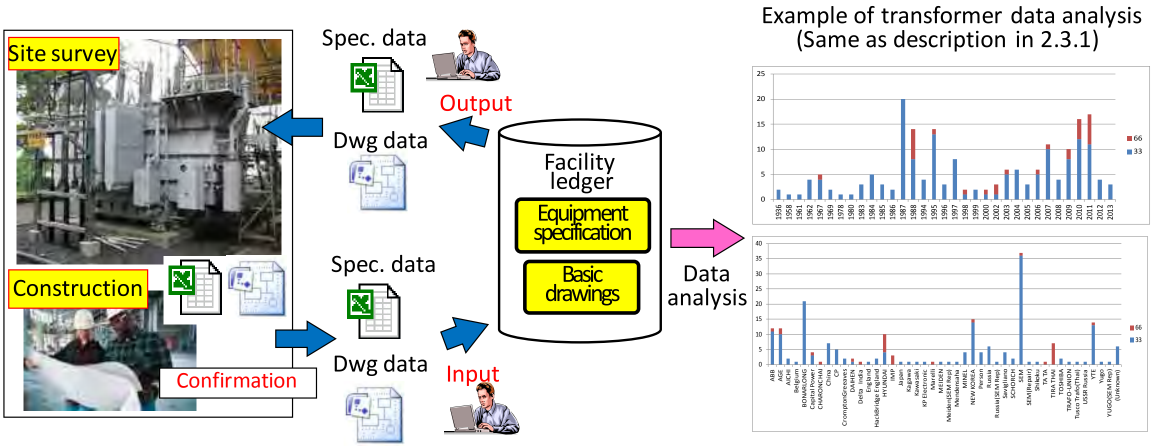
(a) Drawings and documents management

It is recommended to constantly store the single line diagrams and layout drawings in the latest state as the master drawings at the maintenance offices. The drawings and documents including single line diagrams, layout diagrams, history records, construction work design drawings, equipment operation manuals, and commissioning test reports can be used for the operations, maintenance, and construction work of substations. In addition, the detailed drawings and documents such as work design drawings, manuals, etc. would have to be stored in substations and/or maintenance offices.

(b) Facility data management

It is required to create the lists of equipment specifications as the facility data. In this survey, the list of transformer specifications data (including manufacturers and manufacturing years) was created through the cooperation with YESB. These specifications data can be used for coping with equipment failures and judging the timing of replacing the equipment. In addition to the list of transformer specifications, it is recommended to create the lists of substation major equipments (CB, DS, PT, etc.) specifications and control them as the latest information. Figure 8-1 shows the image of operation of facility data management. The facility ledger is a master data server, and the facility data can be shared with YESB employees through the Intranet.

Regarding the failure and fault data, it is desirable to arrange the power outage records and classify the power outage events. The power outage events classified as failure or fault can be used for estimating the locations and causes of the failure / fault and as the measures to prevent the recurrence of the failure / fault and the facility measures (replacement, repairs, etc.).Statistical analysis can be performed by data management, and the failure and fault data analysis results can be utilized for measures of reliability improvement.




Source: JICA survey team

Figure 8-1: Image of operation of facility data management

### 8.4.3 Maintenance improvement

**(1) Current situation**

Substation round check (visual inspection) is performed in YESB, however, shutdown maintenance is not implemented because of system outage (YESB system is not “N-1” system). YESB basically applies CM (Corrective Maintenance) and BM (Breakdown Maintenance) for substation equipment. Shutdown maintenance and abnormality check for TBM (Time Based Maintenance) and CBM (Condition Based Maintenance) are impossible for YESB present network. Considering YESB situation, following maintenance methods are suggested.

**(2) Suggestions**

(a) Continuous monitoring for abnormality

When abnormalities, defects, and suspicious things are found at round check of substation, their aspects should be recorded in detail in continuous monitoring sheet, and continuous monitoring should be implemented at the future round check.

(b) Open / close operational test at load shedding operation

Open / close operational test for each non-operated circuit breaker for one year is conducted every year for preventing their operation failures.

In YESB, load shedding is often carried out. YESB staff can check circuit breaker’s open / close operation at the system operation of load shedding.

(c) Dissolved gas analysis for power transformer

DGA (Dissolved Gas Analysis) is useful and common external diagnosis for checking transformer condition. There are two types of DGA methods: high precision type (fixed type in laboratory) and simple portable type. For YESB, it is easier to introduce portable type DGA instrument and check aged transformer condition by combustible dissolved gasses generation in insulating oil. Power transformer condition can be monitored by applying DGA in YESB transformer maintenance. It would enable YESB to grasp the internal condition of transformers such as overheating and discharging and to foresee transformer internal fault by analyzing generated dissolved gasses trend.

Source: www.gedigitalenergy.com/MD.htm

Figure 8-2: Portable type DGA instrument

Table 8-2:Ranges of 90% typical gas configuration values observed in power transformers discribed in IEC 60599

| H2 | CH4 | C2H6 | C2H2 | C2H4 | CO | CO2 |
|---|---|---|---|---|---|---|
| 50 – 150 | 30 - 130 | 20 - 90 | 2 - 20<br>(No OLTC) | 60 - 280 | 400 - 600 | 3800 -<br>14000 |

Source: IEC 60599 :1999+A1:2007

(d) Prevention of dust and moisture

There are openings on the substation building wall. Therefore, dust and moisture come into the building. The condition for equipment and relays is not good. Rust generation, insulation resistance increase, contact resistance increase might occur, and then, equipment and facilities might deteriorate, and fault and failure might occur. Countermeasures, such as air conditioner, electric fans with shutter and thermostat, are desired for preventing from dust and moisture coming.

### 8.4.4 SF6 gas control

**(1) Current situation**

YESB does not have SF6 gas recovery equipment. For internal fault of SF6 gas insulated equipment with small quantity of SF6 gas such as 33kV GIS, SF6 gas is recovered by using vacuum pump. The number of 66kV GIS and GCB will increase with 66kV system expansion in the near future.

**(2) Suggestions**

SF6 gas control is very important and severe because SF6 gas is the most potent greenhouse gas with a global warming potential of 23 900 times that of CO2. In IEC standard, SF6 gas handling is standardized in 2013, and the final SF6 gas pressure of recovery (residual pressure) is ruled to be less than 2kPa. (IEC 62271-4 Ed.1.0 (2013) High-voltage switchgear and controlgear - Part 4: Handling procedures for sulphur hexafluoride (SF6) and its mixtures)

In general, utilities purchase SF6 gas recovery equipment with GIS from manufacturer in the world.

In the proposed substation project, some 66kV GISs will be installed in several substations. One unit of SF6 gas recovery equipment is to be purchased from each GIS manufacturer and stored in one substation building or YESB warehouse.

Supervisors of GIS manufacturer come to site at open maintenance of GIS/GCB. SF6 gas handling work can be also controlled by supervisors. (It needs to be included in the maintenance contract.)

### 8.4.5 PCB control

PCB control is described in Appended Table-1 in 6.7.1 and Appended Table-2 in 6.8.

**(1) Current situation**

Production of PCB-contained oil and PCB-used equipment was discontinued worldwide by 1980. Therefore, there is a possibility that PCB is contained in equipment that was manufactured before 1980. Moreover, since YESB reuses the insulating oil extracted from repaired and removed equipment after its purification using the sole purification system, it cannot be denied that PCB-contained recycled insulating oil is also refilled to the equipment that was manufactured after 1980 if the internal parts were repaired in house. Namely, it can be judged that PCB is not contained in the equipment only when it was manufactured after 1980 and has not been repaired.

**(2) Suggestions**

The following measures can be proposed.

(i) The manufacturing year and repair history of insulating oil-used equipment should be managed

(ii) The equipment whose manufacturing year is 1979 or before and the equipment whose manufacturing year is 1980 or after of which internal repair is performed after installation, should be all subject to PCB management.

As the current measures until PCB contamination analysis is commonly performed in Myanmar and PCB detoxification treatment facilities is established in the future, it is desired to secure a site of sufficient area and store equipment that may contain PCB in the site by clearing distinguishing it from other materials after taking measures for preventing the scattering and leak of insulating oil contained in the equipment. Moreover, in order not to contaminate the equipment in which no PCB is contained, with PCB, new oil should be used as insulating oil that will be refilled to repaired equipment. Also, it is desired that the insulating oil extracted from the equipment subject to PCB management is not reused (the use of old oil for oil purification devices is also prohibited) and stored and managed in the same way as the equipment subject to PCB management.

## 8.5 Operation of distribution lines

**(1)Current situation**

YESB has been studying the measures to reduce power loss and trying some of them but not yet determined specific implementing methods as its standards. Meanwhile, supply voltage is not controlled in a proper range, since even the law doesn’t define it.

Moreover, when failures occur in the middle of voltage distribution lines, a lack of switches could cause larger scale power outages for longer hours which would otherwise have been prevented.

**(2)Suggestions and effects**

(a)Loss reduction, voltage drop improvement and public safety enhancement

The study team would like to propose the following measures simultaneously with installing the multi-transformer system in which amorphous transformers are applied aiming for a lower distribution loss. (For its detail, see 5.2.2 Introduction of multi-transformer system)

- Apply insulation coated wires to low-voltage lines when replacing existing bare wires in concurrence with the installation of the multi-transformer system in order to avoid grounding fault due to touching trees or the lines and to avoid electricity theft.
- Limit the number of models of LV lines and apply them as their standard models. Keep all the data, such as the model, size and length, together with the contract information of the customer when replacing LV lines in order to control voltage drops.
- Consider the connections of three-phase service wires when replacing LV lines and swap the connection of each phase if necessary in order to reduce unbalance currents in three phases.
- Check the existing service wires on site one by one in order to reduce electricity theft and see if they match to the information of customer contracts when reconnecting service lines from old wires to new one.
- Apply parallel joint connectors, which don't require any special technique, when reconnecting service wires to LV lines in order to improve the connection quality and to reduce contact resistance and errors caused by inadequate connections and to find electricity thefts easily. (If the parallel joint connectors with torque control are introduced, the connecting can be performed easily and the contact resistance can be improved uniformly.)

The measures mentioned above would reduce both technical and non-technical loss, securing public safety, reducing fault outage, and improving voltage drop. Furthermore, it is desirable to develop multi-transformer system and amorphous transformers together with performing these measures to all townships under the control of YESB. In addition, with the technology transfer from the consultants when the projects are implemented, YESB engineers can enhance their skills and the facilities can be efficiently developed.

(b)Outage time shortening

According to the importance and the failure frequency of middle voltage lines, YESB is recommended to introduce section switches such as time sequential re-closers and over-current indicators as fault detectors into the middle voltage lines. (See 4.4.1 Standardization of power distribution facilities (4)). With the introduction, it is expected that YESB can quickly identify the sections of failures, shorten the power outage time, and limit the power outage range.

## 8.6 Training programs and training center, and introducing special purpose vehicles

### (1)Current situation

YESB holds group trainings on engineers and workers, but they learn a lot more through On-the-Job Training at site. Group trainings on engineers and workers in some particular level are held two to three times a year, and the durations are about two weeks each time as described in 5.6 of this report.

There are training facilities adjacent to the 230 kV Hlaing Thayar substation in the Yangon City. There are one-storied training center, with lecture rooms and exhibition rooms for some electric gears. In addition, there are some practical training facilities such as distribution overhead lines / poles and substation facilities. However, these facilities are used only with low frequency. YESB needs practical training facilities which are identical to real ones. Therefore, it is necessary to enhance and make effective use of the practical training facilities.

### (2)Suggestions

In accordance with the classification and the necessary material for each class's training, it is proposed that YESB provide the education and training to engineers and workers as follows.

- Enhancing the know-how through practices of administration of substation construction work and operation maintenance after the start of operation
- Enhancing the technique for executing the plan, design, construction management, inspection, etc.
- Acquiring the know-how for formulating the order planning to cope with the increase of substation and distribution line work volume
- Executing the construction work through the on-the-job training of workers to strengthen the technical capabilities
- Acquiring the know-how for grasping the entire description of work in the projects and creating systematic construction plans

Moreover, as special-purpose vehicles, it is proposed that YESB introduce pole construction trucks for power distribution poles, small excavators, transport truck for small excavators and mobile substation which consist of vehicle equipped with 33/11-6.6kV 10MVA power transformers, truck mounted 11kV switchgear cubicles and XLPE power cables, in order to enhance the ability of construction.

The training for handling special-purpose vehicles to be introduced will be supported by the consultants to be employed at the project implementation.

## 8.7 Environmental Management

In Myanmar, as described in Section 6.2.1.2, a bylaw on Environmental Impact Assessment, *the EIA Procedure*, is being prepared in accordance with the Environmental Conservation Law by the Environmental Conservation Department of MOECAF. The ECD aims to finalize the draft EIA procedure by the end of 2014 and enact it as bylaw in 2015. After its enactment, an EIA will be required before

YESB implements any new projects and business operation, including large-scale refurbishment and upgrading projects for existing facilities. In addition to the national legislation, anytime YESB apply for assistance of international banks or assisting agencies to YESB's projects and business activities, it will also be one of preconditions for their assistance that YESB should implement an EIA, according to the environmental guidelines of concerned assisting agency.

Further, YESB's environmental management activities, such as disposal of insulating oil and waste materials and PCB management, also need to be strengthened in consideration of the formulation of national environmental conservation rules (ECR) or the assistance of international organizations. Such environmental management relates to YESB's overall business operation, as well as to environmental and social considerations for a new project; namely EIA and Environmental Management Plan in project planning, or environmental monitoring during and after project implementation.

In accord with the above situation, YESB will need to develop the organizational scheme and human resources that can correspond to such tasks in a few years to come. Since the EIA system has not existed in Myanmar Legislation up to now, YESB is not currently equipped with the specialized unit and manpower to implement environmental and social considerations, environmental management and EIA. Therefore, the Study recommends that YESB will take the necessary measures to build up organization and human resources as follows.

**(1) Specialized fields to be built up**

The capacity improvements are advisable in the fields listed in the below table, as to the specialized fields expected to be built up by a human resources development plan.

| Related fields | | Examples of concerned items |
|---|---|---|
| Environmental and social considerations (ESC) | Considerations on natural environment | water environment, ecological environment,<br>natural protected area |
| | Pollution control | insulating oil (water pollution, soil contamination, and solid waste), noise control |
| | Considerations on social environment | public consultation, safety management, considerations on local communities and the socially vulnerable |
| Environmental monitoring | | environmental standards |
| EIA system | | legislative scheme (domestic laws and regulations, and international standards and guidelines) |
| Environmental management | | PCB management and measures for controlling greenhouse gases (SF6/ sulfur hexafluoride) |

**(2) Necessary human resources and organizational unit**

There are two large fields in EIA; namely environmental considerations and social ones. Since the former field relates to natural environmental impacts and pollution control measures, it requires the capacity improvement of human resources who have broad knowledge and skills in ecological and chemical matters. On the other hand, since the latter does to the comprehension of social impacts and consensus building in stakeholders, it requires the personnel who have had special training in social science, social survey and expertise in public consultation. Those who have specialized knowledge in either environmental or social considerations can also contribute to the environmental management activities in respective fields. In addition to such personnel as above, it is also recommendable to develop the personnel who are trained specifically for the EIA system because what is required in implementation of an EIA process contains the complex process management consisting of relevant laws and regulations, comprehension of national and international standards, assessment of impacts and related permits and procedures.

With respect to environmental management, the appointment of personnel in charge for PCB management is strongly advised. In case of Japan, the related law stipulates that any business entity who generates wastes suspected to contain PCB shall appoint a 'chief administrator of industrial waste subject to special control'. The responsibility of the chief administrator consists in 1) comprehension of industrial wastes subject to special control; 2) planning the management plan of industrial wastes subject to special control; and 3) ensuring of proper management, comprised of confirming storage conditions and issuance of manifesto and storage. Since the personnel in charge for PCB management is required of a grave responsibility and authority for the sake of strict management of the material and suspected wastes, it is advisable to appoint a high official to the position from one of deputy-chief-engineers or directors at concerned departments in YESB.

Considering all the above, the Study recommends that YESB will develop a unit with 3 to 5 staffs specially trained for supervising EIA and environmental management activities concerning YESB business operation. It may be suggested for the unit to set in as 'environmental management unit' under the Administration Department, distinct from public relations duties, or under Planning and Engineering Divisions.

# Appendix

# Yangon City Electricity Supply Board

## Duties and Responsibilities of Distribution Department

**Deputy Chief Engineer**

- **Superintendent Engineer**
  - **Network Control Division**
    - **System Network and Control Section**
      1. Repairing and maintaining the power lines.
      2. Trying quickly to regain power in case of power break down.
      3. Checking and giving permission for those who apply for new transformers.
      3. Checking and giving permission for Power System Improvement works to improve power system.
      4. Organizing power break down list of state-owned factories, universities, universities, colleagues, schools, embassies, government servants' housings, CNG shops, river irrigation.
      5. Organizing reports of power break down for each township.
    - **Substation Section**
      1. Performing regular power distribution.
      2. Performing maintenance works to distribute power without interruption.
    - **Street Lighting Section**
      1. Checking and repairing street lights of main roads and streets. Also perform extension of street light in needed areas.
    - **Mobile (Emergency Generator) Section**
      1. Providing spare diesel generators for special occasions not to happen power break down.
- **Superintendent Engineer**
  - **Distribution Division**
    - **Construction Small Substation Section**
      1. Building new minor substations to improve power system of Yangon city.
    - **Substation Maintenance Section**
      1. Maintenance and repairing sub-stations on daily, weekly, monthly basis to enable to supply all of the consumers continuously.
    - **24 hrs Maintenance Section**
      1. Standby 24 hrs services for power lines, sub-stations of Yangon city if they break down.

# Yangon City Electricity Supply Board

## Duties and Responsibilities of Planning Department

**Deputy Chief Engineer**

### Superintendent Engineer — Network Planning and Networking Analysis Division

**Statistic Planning Section**

1. Organizing data and list of major sub-stations and transformers.
2. Record keeping of extended sub-stations, transformers and power lines.
3. Organizing and presenting of reports every three and four months regarding engineering aspects.
4. Organizing and presenting of list implementation on economic projects.
5. Organize and present needed equipments of sub-sections. Coordinated and request for those needs. Collect data and list of them.

**Network Analyzing Section**

1. Record electric shock and make analysis so that instructions come out.
2. Making record and analysis of daily power production and usage.
3. Record and analysis of voltage and load of sub-stations and transformers.

**Network Planning & Design Section**

1. Record and draw network of power supply for Yangon Division.
2. Analyzing, review and present about sub-stations and power lines which are necessary to extend construction.
3. Drawing layouts of those extended constructions.
4. Record keeping of main sub-stations and main power lines.
5. Submit report about sub-stations and power lines equipments to Specification Technical

**Engineer Budget Section**

1. Preparing budgets for engineering activities.
2. Allowance of expenditures according to budget through request.
3. Keeping account of financial facts and figures.
4. Checking the skills of estimating budget
5. Organizing P.O of engineering.

### Superintendent Engineer — Implementation Division

**Over Head Section**

1. Building new over head power lines
2. Maintenance and repairing over head lines.

**Underground Section**

1. Building new underground lines.
2. Maintenance and repairing underground cable.

**Major S/S Construction Section**

1. Conducting surveys, analyzing data and information and submission of project proposal to construct major sub-stations.

**Computer Section**

1. Organizing data regarding major sub-stations and transformers.
2. Keeping records the extended sub-stations, transformers and power lines.
3. Keeping records the data of daily power production and consumption.
4. Keeping records and organizing data of receiving units and selling units and calculate the losses.

**Training Section**

1. Providing training courses of engineering skills.
2. Providing training courses for other staff's skills.
3. Performing the task of management.

# Yangon City Electricity Supply Board

## Duties and Responsibilities of Testing and General Services Department

**Deputy Chief Engineer**

- **Superintendent Engineer**
  - **Testing and Commissioning Sub-Division**
    - **Testing and Commissioning Section**
      1. Checking both old and new meters.
      2. Checking the meters which stopped or not properly work.
      3. Field visiting for checking meters.
      4. Providing testing and supporting materials which are needed in each township offices.
    - **Communication Section**
      1. Performing the tasks of computerizing
      2. Carrying out communication works to be efficient.
    - **Unit Losses Control Section**
      1. Checking the power losses controlling work in every township.
      2. Sealing
      3. Changing the stopped/broken meters.
      4. Checking and carrying out installation of required meters to get receiving units properly in sub-stations.
      5. Checking illegal use of power.
      6. Calculation and Checking on power unit differences between check- meter and each lighting meter of condominium.
      7. Checking the Government servants' meter.
      8. Check on issues of no meter unit even using high load.
    - **Meter Section**
      1. Checking and giving permission applications for single phase two wires lighting meter (1p2w), three phases four wires commercial meters and industrial use.
      2. Checking and giving permission for installation of temporary meters.
      3. Checking and giving permission to change of temporary meter to permanent meter.
      4. Checking and giving permission for advertising signboards lighting.
- **Superintendent Engineer**
  - **General Services Sub-Division**
    - **Production Workshop Section**
      1. Production of accessories for sub-stations.
      2. Production of accessories for distribution lines.
      3. Production of accessories for meter.
    - **Main repairing Workshop Section**
      1. Major repairing of out of order or damaged equipments of sub-stations, transformers.
- **Superintendent Engineer**
  - **Civil Sub-Division**
    1. Construction, maintenance and repairing the new offices, government servants' housing.
    2. Building the foundation of sub-stations and also doing repairing and maintenance tasks.
    3. Preparing the meeting room.
    4. Arranging to get water supply for government servants' housing.

## Example of Monitoring Form for Construction Phase and Operation Phase

The latest results of the below monitoring items shall be submitted to JICA as part of Quarterly Progress Report throughout the construction phase

### 1. Monitoring of Construction Activities

#### 1.1 Overall Monitoring for Construction Activities

| Monitoring Item | Monitoring method | Measures to be taken | Frequency |
|---|---|---|---|
| General performance of mitigation plan and monitoring plan | Visiting project sites and monitoring activities of implementation agencies<br><br>Sample inquiries to the inhabitants living around the project sites<br><br>Listing unexpected issues to be taken measures that are not identified in the original mitigation and monitoring plans | | Once before construction<br><br>Monthly during construction<br><br>and Once after construction |

### 1.2 Air Quality (dust)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| use of dust-block | substations in crowded residential or commercial area | Once in peak work period for each substation | N/A | YESB | once every 3 months |

**Monitoring Form**

| Location (name of SS) | Date of work period | Contents of work in peak work day | Proper implementation of mitigation measures | Contractor name |
|---|---|---|---|---|
| | From (201*/ **/**)<br>To (201*/**/**) | Describe: | ▪ Describe what dust block was used<br>( ) | |
| | Peak work date | | ▪ Describe how dust block was used<br>( ) | |
| | 201*/ **/** | | | |

Note: Records of SS works in every 3 months should be summarized by YESB to report to JICA

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| advance notice to adjacent building and houses on work schedule | houses / shops adjacent to substations in crowded area | Once per month | N/A | YESB | once every 3 months |

**Monitoring Form**

| Location (name of SS) | Date of work period | Proper implementation of mitigation measures | Contractor name |
|---|---|---|---|
| | From (201*/ **/**)<br>To (201*/**/**) | Date of advance notice to the surrounding communities: 201*/ **/**<br>How was advance notice made:<br>✓ Used media (visit/ telephone/ announcement paper/ or other )<br>✓ Area of notified ( )<br>✓ What was informed (check item that applied√ )<br>▪ Work schedule ( )<br>▪ Contents of work ( )<br>▪ Safety caution ( )<br>▪ Other ( ) | <br>**Monitors**<br>YESB |

Note: Records of SS works in every 3 months should be summarized by YESB to report to JICA. Attach the information material used at work site to the report.

### 1.3 Wastes

#### (1) construction waste

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| procedure of disposal | all construction sites of substations, T/L and D/L | at end of construction period for each site | N/A | YESB | once every 3 months |

**Monitoring Form**

| Location (name of SS/TL/DL) | Date of work period | List up wastes that were generated in the work | Describe the way of disposal, for each type of waste respectively | Take photos of wastes before and after disposal And attach them here | Contractor name |
|---|---|---|---|---|---|
| | From (201*/ **/**) To (201*/**/**) | | | Photo | |

Note: Records of works in every 3 months should be summarized by YESB to report to JICA.



#### (2) PCBs

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| PCB Management | storage spaces (temporary and designated by YESB) for concerned equipment (refer to the mitigation plan on the Appended Table-2) | After replacement at each site and once per month in the storage place / to keep traceability and monitor safe storage conditions of the concerned equipment | No concrete standards/ Stockholm Convention on Persistent Organic Pollutants | YESB | once every 3 months |

**Monitoring Form**

| List of replaced equipment concerned | Location the equipment are replaced (name/site of SS/ TL/DL) | Storage place | Current conditions of the concerned equipment |
|---|---|---|---|
| Is the list properly updated after replacement each site?<br><br>Note: List should include type of equipment, manufacturing year and repair history of the equipment concerned | | Describe conditions of storage place | Conditions of stored equipment concerned at YESB storage<br><br>Record of outsourcing conditions to transformer manufacturers |

Note: Records of works in every 3 months should be summarized by YESB to report to JICA. Attach the list of relevant equipment and inspection records.

### 1.4 Noise and Vibration

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Country standard | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|---|
| work time constraint | substations in crowded residential or commercial area | Once in peak work period for each substation | N/A | 10 hours between 7:00 and 19:00 Japan/ IFC criteria referred | YESB | once every 3 months |

**Monitoring Form**

| Location (name of SS) | Date of work period | Contents of work in peak work day | Working hours on the peak day | Contractor name |
|---|---|---|---|---|
| | From (201*/ **/**)<br>To (201*/**/**)<br>Peak work date<br>201*/ **/** | Describe: | Between **:** and **:** | |

Note: Records of SS works in every 3 months should be summarized by YESB to report to JICA

### 1.5 Accident (underground cable installation)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| attendance of utility agent | along incoming and outgoing T/L of substations and D/L in crowded area | Prior to excavation at underground cables to be installed | N/A | YESB | once every 3 months |

**Monitoring Form**

| Location (cable installation) | Contents of Work | Utility agent who attended | Describe trouble, if any | YESB Division in charge |
|---|---|---|---|---|
| | | | | |

Note: Records of works in every 3 months should be summarized by YESB to report to JICA.

## 1.6 Working Environment / Accidents (Safety Measures)

**Monitoring Plan**

| Item | Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|---|
| safety measures | advance safety management plan | all construction sites of substations, T/L and D/L | Prior to work at every site | ILO Guidelines Safety and Health in Construction | YESB | once every 3 months |
| | use of safety sign and measures | around construction sites at substations in crowded area and along T/L | Prior to work at every site | | YESB | once every 3 months |
| | advance notice to adjacent community on work schedule and safety caution | community adjacent to substations in crowded area | Prior to work at every site | N/A | YESB | once every 3 months |

**Monitoring Form 1 for safety measures**

| Indicator | Location and date of construction work | Safety measures taken | Accidents case | Improvement measures taken after accidents | Contractor name |
|---|---|---|---|---|---|
| ▪ advance safety management plan<br>▪ use of safety sign and measures | Location:<br><br>From (201*/ **/**)<br>To (201*/**/**) | | ▪ No of incidents<br>▪ Type of incidents | | |

**Monitoring Form 2 for safety measures**

<table>
<tr><th>Location of work</th><th>Date of work period</th><th>Proper implementation of mitigation measures</th><th>Contractor name</th></tr>
<tr><td rowspan="3"></td><td>From (201*/ **/**)<br>To (201*/**/**)</td><td rowspan="3">Date of advance notice to the surrounding communities: 201*/ **/**<br>How was advance notice made:<br>(3) Used media (visit/ telephone/ announcement paper/ or other )<br>(4) Area of notified ( )<br>(5) What was informed (check item that applied√ )<br>▪ Work schedule ( )<br>▪ Contents of work ( )<br>▪ Safety caution ( )<br>▪ Other ( )</td><td></td></tr>
<tr><td>Type of construction work</td><td>Monitors</td></tr>
<tr><td></td><td>YESB</td></tr>
</table>

Note: Records of works in every 3 months should be summarized by YESB to report to JICA. Attach the information material used at work site to the report.

## 2. Monitoring during Operation Activities

### 2.1 Water Quality / Soil Contamination (Management of Insulating Oil)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| leakage of insulation oil | under/around electric transformer and oil-circuit breaker | once every month | to be checked | YESB | once every 6 months |

**Monitoring Form**

| List of Electric Transformer and Oil-Circuit Breakers<br><br><Corresponding list should be attached> | Record of round inspection with the listed equipment<br><br><Corresponding inspection record should be attached> | Trouble case | Remedial measures taken for the trouble | YESB Division in charge |
|---|---|---|---|---|
| | | | | |

Note: Records of works in every 6 months should be summarized by YESB to report to JICA. Attach the list of relevant equipment and inspection records.

### 2.2 Wastes (PCBs)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| PCB Management | the storage space designated by YESB for concerned equipment (refer to the mitigation plan on the Appended Table-2) | once per month in the storage place / to keep traceability and monitor safe storage conditions of the concerned equipment | No concrete standards/ Stockholm Convention on Persistent Organic Pollutants | YESB | once every 6 months |

**Monitoring Form**

| List of replaced equipment concerned | Storage place | Current conditions of the concerned equipment |
|---|---|---|
| Is the list properly updated monthly?<br><br>Note: List should include type of equipment, manufacturing year and repair history of the equipment concerned | Describe conditions of storage place | Conditions of stored equipment concerned at YESB storage<br><br>Record of outsourcing conditions to transformer manufacturers |

Note: Records of works in every 6 months should be summarized by YESB to report to JICA. Attach the list of relevant equipment and inspection records.

### 2.3 Topography and Geology (Slope Protection)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| Slope protection measures | steel towers to be installed at a river crossing along T/L to Kyaikkasan SS | once per month in rainy season and once per 3 months in dry season / to monitor slope protection measures around the steel tower concerned | N/A | YESB | once every 6 months |

**Monitoring Form**

| Location | Description of slope condition at the location | Measures to be taken (if any problems identified) |
|---|---|---|
| Steel towers having installed at a river crossing along T/L to Kyaikkasan SS | Describe the slope conditions around the steel towers concerned<br><br>Describe the basement conditions of the steel towers concerned | Describe measure to be taken:<br>- When it should be taken?<br>- How it should be taken?<br><br>(Describe measures taken, if already done) |

Note: Records of works in every 6 months should be summarized by YESB to report to JICA.

### 2.4 Land use and utilization of local resources (safety measures for traffic and pedestrian)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| Safety sign boards for traffic and pedestrian | where the new or reformed concrete poles of T/L and D/L will limit the road side space for pedestrian | Once at the end of construction period and once per 6 months / to monitor the safety conditions of pedestrian and safety signboards | N/A | YESB/ YCDC | once every 6 months |

**Monitoring Form**

| Locations | Safety measures taken for pedestrian and traffic | Current conditions of pedestrian and traffic safety | Photo at the sites |
|---|---|---|---|
| List identified locations of limited road side space due to installed concrete poles of T/L and D/L | Describe measures taken at each sites concerned such as safety signboards | Describe current conditions of traffic and pedestrian at the sites | |

Note: Records of works in every 6 months should be summarized by YESB to report to JICA. Attach the list of relevant locations and inspection records.

### 2.5 Management of SF6 (GHG)

**Monitoring Plan**

| Indicator | Location | Method / Frequency | Reference Standard | Responsible Agency | Reporting interval to JICA office |
|---|---|---|---|---|---|
| degradation of gas-circuit breaker (container of SF6 gas) | gas-circuit breaker | once every month | Kyoto Protocol and IPCC Guidelines | YESB | once every 6 months |

**Monitoring Form**

| List of Gas-Circuit Breakers | Record of round inspection with the listed equipment | Trouble case | Remedial measures taken for the trouble | YESB Division in charge |
|---|---|---|---|---|
| <Corresponding list should be attached> | <Corresponding inspection record should be attached> | | | |

Note: Records of works in every 6 months should be summarized by YESB to report to JICA. Attach the list of relevant equipment and inspection records.