The Republic of the Union of Myanmar
Ministry of Electric Power

THE PROJECT FOR FORMULATION
OF
THE NATIONAL ELECTRICITY MASTER PLAN
IN
THE REPUBLIC OF THE UNION OF MYANMAR

FINAL REPORT

December 2014

Japan International Cooperation Agency

NEWJEC Inc.
The Kansai Electric Power Co., Inc.

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The Project for Formulation of the National Electricity Master Plan
in the Republic of the Union of Myanmar

FINAL REPORT

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Abbreviations

Symbol	English
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BOO	Build Own and Operate
BOT	Build Operate and Transfer
BS	Balance Sheet
C/P	Counterpart
CCT	Clean Coal Technology
CF	Cash Flow
CIC	Central International Corporation
CIF	Cost, Insurance and Freight
COD	Commercial Operation Date
CSA	Coal Sales Agreement
D/D	Detailed Design
DAC	Development Assistance Committee
DEP	Department of Electric Power
DGSE	Department of Geological Survey & Mineral Exploration
DHPI	Department of Hydropower Implementation
DHPP	Department of Hydropower Planning
DOM	Department of Mines
DRD	Department of Rural Development
DSM	Demand Side Management
DZGD	Dry Zone Greening Department
ECC	Environmental Compliance Certificate
EDC	Energy Development Committee
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EMP	Environmental Management Plan
EP	Electrostatic Precipitator
EPC	Engineering, Procurement , Construction
EPD	Energy Planning Department
ESE	Electricity Supply Enterprise
EVN	Electricity of Vietnam
F/S	Feasibility Study
FD	Forest Department
FERD	Foreign Economic Relation Department
FESR	Framework of Economical and Social Reform
FGD	Flue Gas Desulfurization
FOB	Free on Board
FSRU	Floating Storage Regasification Units
FSU	Floating Storage Unit
GCC	Generation Control Center
GCV	Gross Caloric Value

Symbol	English
GDC	Gas Distribution Center
GDP	Gross Domestic Product
GE	Gas Engine
GECC	Gas Engine Combined Cycle
GOI	Government of Indonesia
GoM	Government of Myanmar
GOT	Government of Thiland
GOV	Government of Vietnam
GPSA	Gas Purchase Sales Agreement
GSA	Gas Sales Agreement
GT	Gas Turbine
GTA	Gas Transportation Agreement
GTCC	Gas Turbine Combined Cycle
GTW	Gas Turbine World
HGI	Hard Grove Index
HHV	Higher Heating Value
HPGE	Hydropower Generation Enterprise
HPP	Hydropower Plant
HSD	High Speed Diesel Oil
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IMF	International Monetary Fund
INGO	International Non-Governmental Organization
IPP	Independent Power Producer
IRD	Internal Revenue Department
ISO	International Organization for Standardization
JBIC	Japan Bank for International Cooperation
JCOAL	Japan Coal Energy Center
JEPIC	Japan Electric Power Information Center
JETRO	Japan External Trade Organization
JFPR	Japan Fund for Porverty Reduction Program
JICA	Japan International Cooperation Agency
JOGMEC	Japan Oil, Gas and Metal National Corporation
JV	Joint Venture
LDC	Load Dispatch Center
LESCO	Lahore Electricity Supply Company
LFS	Landfall Station
LNG	Liquid Natural Gas
LRMC	Long Run Marginal Cost
MEPE	Myanma Electric Power Enterprise
MES	Myanmar Engineering Society
METI	Ministry of Economy, Trade and Industry
MIC	Myanmar Investment Committee

Symbol	English
MOA	Memorandum of Agreement
MOAI	Ministry of Agriculture and Irrigation
MOBA	Ministry of Border Affairs
MOBM	Meteorological Observation Bureau of Myanmar
MOC	Ministry of Cooperation, Ministry of Construction
MOE	Ministry of Energy
MOECF	Ministry of Environmental Conservation and Forestry
MOEP	Ministry of Electric Power
MOF	Ministry of Finance
MOGE	Myanma Oil and Gas Enterprise
MOHA	Ministry of Home Affaris
MOI	Ministry of Industry
MOLFRD	Ministry of Livestock, Fisheries and Rural Development
MOM	Ministry of Mines
MOST	Ministry of Science and Technology
MOT	Ministry of Transportation
MOU	Memorandum of Understanding
MPE	Myanmar Petrochemical Enterprise
MPPE	Myanmar Petroleum Products Enterprise
MPTA	Myanmar Petroleum Trade Association
MREA	Myanmar Renewable Energy Association
MTE	Myanmar Timber Enterprise
NCC	National Control Center
NCDP	National Comprehensive Development Plan
NCV	Net Calorific Value
NEDO	New Energy and Industrial Technology Development Organization
NEMC	National Energy Management Committee
NEP	National Electrification Plan
NGO	Non-Governmental Organizations
NOx	Nitrogen Oxide
NPED	Ministry of National Planning and Economic Development
NWC	Net Working Capital
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
OGP	Oil, Gas, Petrochemicals
OPGW	Optical fiber Ground Wire
P/P/P	policies, plans & programs
PAD	Planning and Statistics Department
PDP	Power Development Plan
PGDP	Power Generation Development Plan
PL	Profit and Loss statement
PLC	Power Line Carrier
PLN	Perusahaan Listrik Negara
PPA	Power Purchase Agreement

Symbol	English
PPP	Public Private Partnership
PSC	Product Shearing Contract
PSD	Power System Department
RAP	Resettlement Action Plan
RCC	Regional Control Center
SC	Super Critical
SCADA	Supervisory Control And Data Acquisition
SCR	Selective Catalytic Reduction
SD	Survey Department
SEA	Strategic Environmental Assessment
SEE	State Economic Enterprise
SEZ	Special Economic Zone
SHS	Solar Home System
SIA	Social Impact Assessment
SLRD	Settlement and Land Records Department
SOE	State Owned Enterprise
SOx	Sulfur Oxide
SPC	Special Purpose Company
SPM	Suspended Particle Matter
ST	Steam Turbine
T/Ls	Transmission Lines
TA	Technical Assistance
TCF	trillion cubic feet
TNB	Tenaga Nasional Berhad
TPD	Thermal Power Department
TPDC	Township Peace and Development Council
TPP	Thermal Power Plant
UAGO	Union Attorney General Office
UNDP	United Nations Development Programme
UNHSR	The UN Refugee Agency
UNICEF	United Nations Children's Fund
USC	Ultra Super Critical
VPDC	Village Tract Peace and Development Council
WASP	Wien Automatic System Planning
WB	World Bank
WCR	World Coal Report
WHP	Well Head Platform
WIP	Work In Progress
YESB	Yangon City Electricity Supply Board

Units

bbl	Barrel (1 bbl = 159 liter)
bbtud	billion British thermal units per day
BTU	British Thermal Unit
GW	Gigawatt (=1,000 MW = 1,000,000 kW)
GWh	Gigawatt – hour (=1,000 MWh = 1,000,000 kWh)
hPa	Hectopascal (1 hPa = 1 milibar)
Hz	Hertz
km	Kilometer
km^2	square kilometer
kV	Kilo Volt
kVA	Kilo Volt Ampere
kW	kilowatt
kWh	Kilowatt - hour
m	meter
m^3	cubic meter
mm	millimeter
Mbtu	one thousand British thermal units
MMbbl	million barrels
MMbtu	= 1,000,000 btu
mmcfd	million cubic feet per day
mmld	million litter per day
MMscf	Million Standard Cubic Feet
MMscfd	Million Standard Cubic Feet per day
MMscm	Million Standard Cubic Meter
MPa	Mega Pascal (= 10.197 kgf/cm^2)
Mtoe	million tons of oil equivalent
MW	Megawatt (= 1,000 kW)
MWh	Megawatt – hour (= 1,000 kWh)
s	second
USD	United States Dollar
V	Volt

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The Republic of the Union of Myanmar (Myanmar) has proceeded with power generation development concentrating on hydroelectric power assisted mainly by the People's Republic of China, even after the economic sanctions imposed by the United States in 2003.

As a result, hydroelectric generation accounts for over 70% of total electric power generation, with output dropping widely in dry season. Moreover, actual power supply capacity cannot keep up with the demand for power due to the deterioration of existing facilities and the rapid increase in demand in recent years.

Under such circumstances, MOEP (Ministry of Electric Power) is conducting load adjustments by electricity outage rotation, which leads to large losses of social and economic activities. In addition, transmission and distribution facilities have up to a 25% transmission and distribution loss rate due to capacity and deterioration issues. Moreover, electricity outages are frequent due to animals, birds and trees accidently touching transmission lines and lightning. Therefore, measures for loss reduction and improvement of reliability are urgently required.

In view of the above situation, the GoM (Government of Myanmar) has highlighted the elimination of planned electric outages in the short term and the resolution of electric power shortages in the middle and long term as a major national priority.

In addition, President U Thein Sein ordered by decree in June 2012 a reform for national development, outlining the need for a mid and long term comprehensive plan for energy and electric power and the establishment of the NEMC (National Energy Management Committee) to formulate and implement long term electricity development plans based on a national energy policy.

While MOEP, MEPE (Myanma Electric Power Enterprise), YESB (Yangon City Electricity Supply Board) and ESE (Electricity Supply Enterprise) each have electricity development plans, they are not in conformity with each other and not based on long term power demand and supply forecasts. Therefore, a long term national electricity plan is essential to Myanmar.

1.2 PURPOSE OF THE STUDY

This study aims to demonstrate a harmonized middle/long term National Electricity Master Plan of power sources and transmission systems while sharing information closely with relevant organizations in Myanmar and other development organizations under the necessary technical transfer to the C/Ps (Counterpart(s)) of Myanmar.

1.3 OUTLINE OF THE STUDY

As the GoM is expediting the establishment of comprehensive energy and power development master plans under the initiative of the President, JICA (Japan International Cooperation Agency)'s support of the National Electricity Master Plan has been established in response to a request from the GoM. This is the first time Myanmar has worked to establish a comprehensive Power Sector Master Plan and thus there were significant constraints of available data. JICA

Study Team took various approaches to find alternative ways forward given the constraints of limited data.

In developing this study, while paying careful attention to the ownership of the Myanmar side and eventual technical transfer to them, many workshops and discussions were held with MOEP and other related authorities through eight field visits since 2013.

The fundamental purpose of this study is to provide inputs for the GoM to consider the current overall situation of the power sector in Myanmar and discuss its future direction.

In the course of the study, JICA Study Team frequently reviewed drafts of the National Electricity Master Plan with their Myanmar C/Ps. The following points were emphasized in the process of formulating the National Electricity Master Plan:

- Major findings (domestic energy source availability and constraints);
- Directions for the time being (three scenarios, with Myanmar carefully considering the optimal power source mix while taking into account the environment, cost and risk);
- What the GoM should do next (capacity-building for planning, establishing roadmaps (hydro, gas and coal, etc.) based on more detailed data and financial issues (IPP (Independent Power Producer) regulation, etc.).

Based on this initial National Electricity Master Plan, Myanmar should update it regularly and elaborate concrete development roadmaps. The capacity building is primary for staffs in charge.

Basic concepts of this study are summarized below:

Item	Description
Objectives	1) Formulation of the National Electricity Master Plan up to 2030 2) Technical transfer to the C/Ps of Myanmar
Target Facility	Electric power generation facilities and power system facilities of not less than 66kV transmission and substation system owned by MEPE
Implementation Agency	MOEP
Scope of Work	1) Formulation of the middle/long term optimum National Electricity Master Plan to realize the strategic power generation and transmission system 2) Analysis and recommendation on organization, policy and legal legislation in electric power sector

1.4 IMPLEMENTATION STRUCTURE FOR THE STUDY

DEP (Department of Electric Power) of MOEP is in charge of the implementation of this study as C/P and officers from each department of MOEP are assigned for this study. Member list of focal C/Ps is shown in Table 1.4-1. Implementation structure of JICA Study Team is shown in Fig. 1.4-1.

Table 1.4-1 Member List of Focal C/Ps

Organization	Name	Position
DEP	U Khin Maung Win	Director General
	Daw Mi Mi Khaing	Deputy Director General
	U Aung Myo Win	Assistant Director
	Daw Phyu Phyu Khin	Assistant Director
	Daw Chaw Thandar Soe	Staff Officer
DHPP (Department of Hydropower Planning)	Daw Thidar Aye	Deputy Director
DHPI (Department of Hydropower Implementation)	U Aung Lwin	Deputy Director
MEPE	U Aung Kyaw Oo	Deputy Chief Engineer
ESE	U Myo Min Thein	Executive Engineer
	U Kyi San Lin	Executive Engineer
	U Zaw Ye Myint	Deputy Chief Engineer
HPGE (Hydropower Generation Enterprise)	U Zayar Myint	Assistant Engineer
YESB	Daw Yee Mon Mon	Executive Engineer

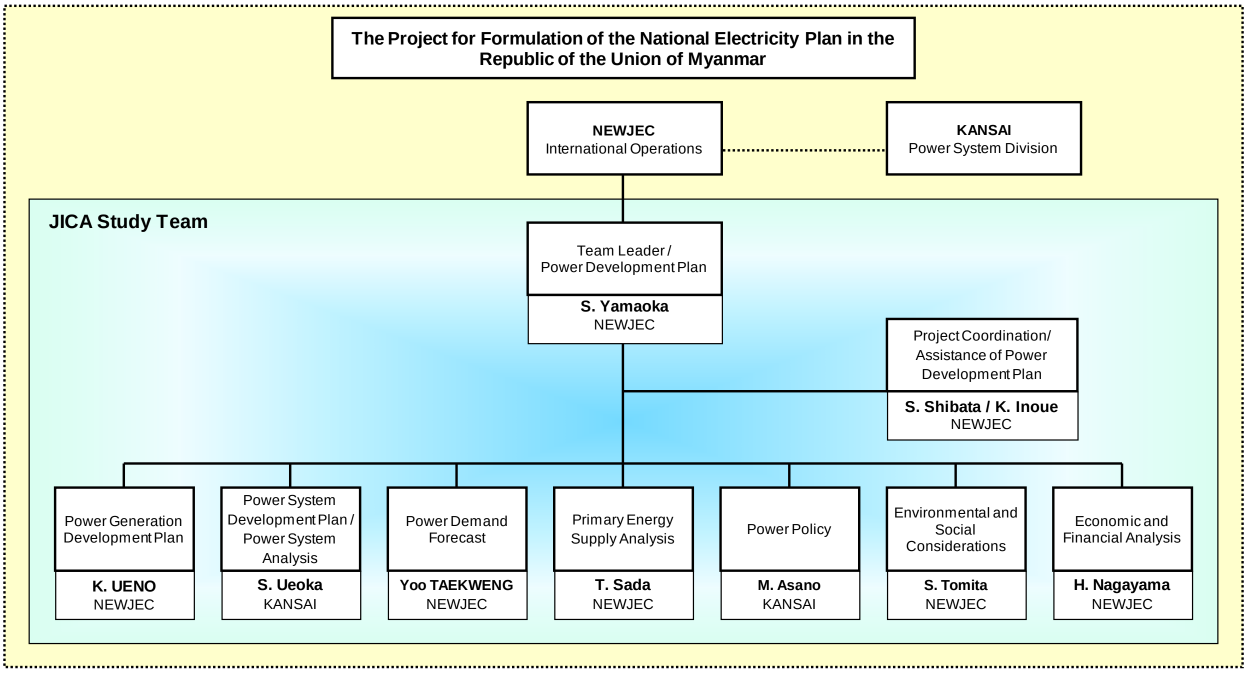


Fig. 1.4-1 Implementation Structure of JICA Study Team

1.5 OVERALL WORK SCHEDULE OF THE STUDY

Components of the study shall be classified into following three phases;

1) Data collection and analysis on electric power sector (June 2013 to October 2013)
2) Planning of alternative scenario for the National Electricity Master Plan (November 2013 to March 2014)
3) Formulation of optimized National Electricity Master Plan (April 2014 to December 2014)

Main study components in each phase and schedule are shown in Fig. 1.5-1 and Schedule of Site Investigation is shown in Fig. 1.5-2.

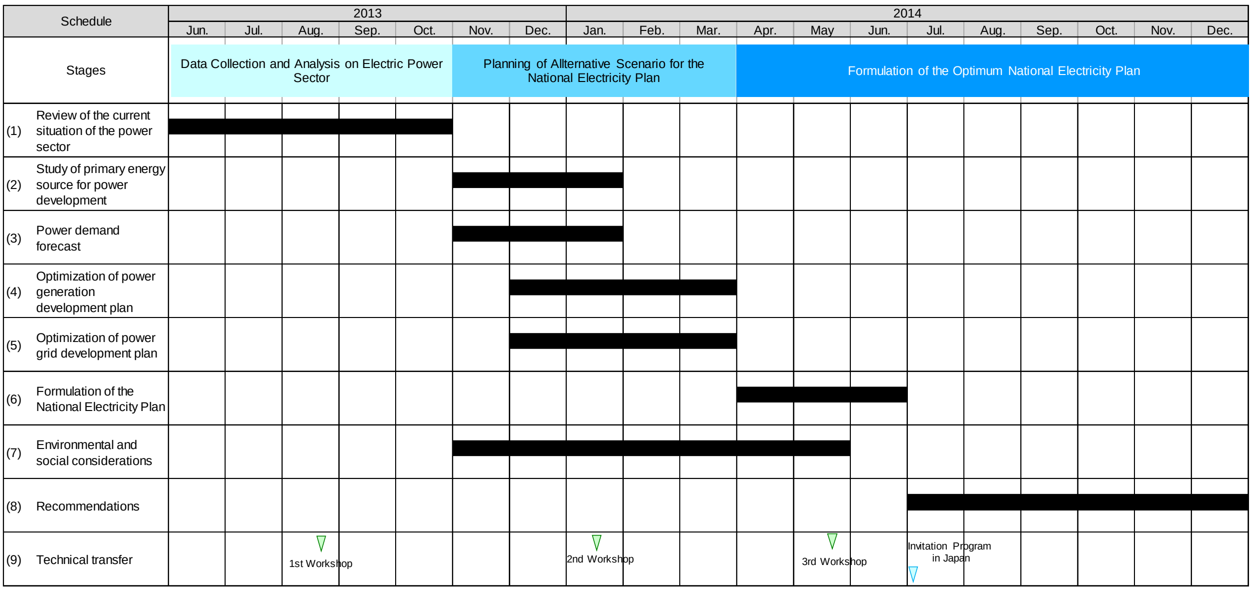


Fig. 1.5-1 Main Study Components and Schedule

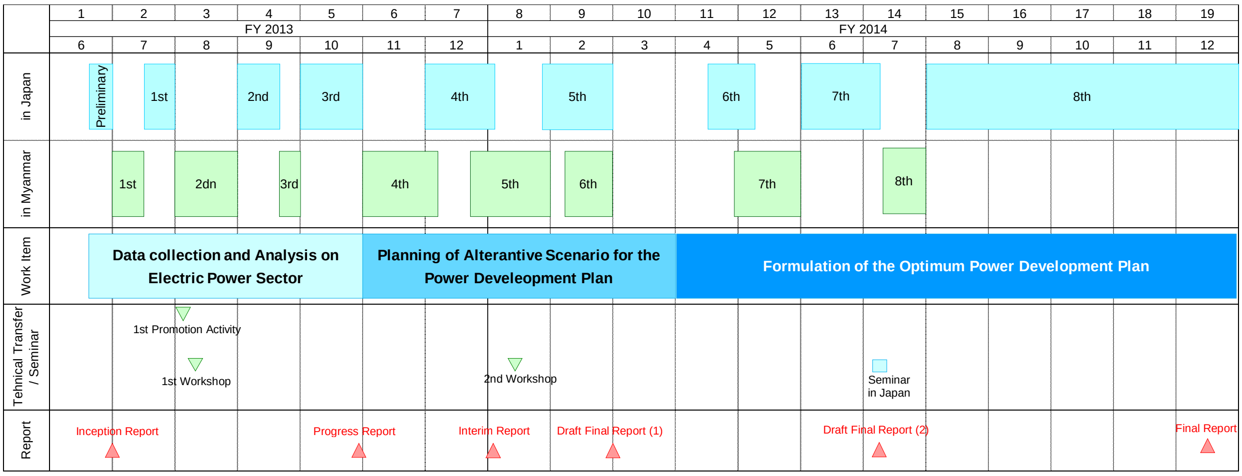


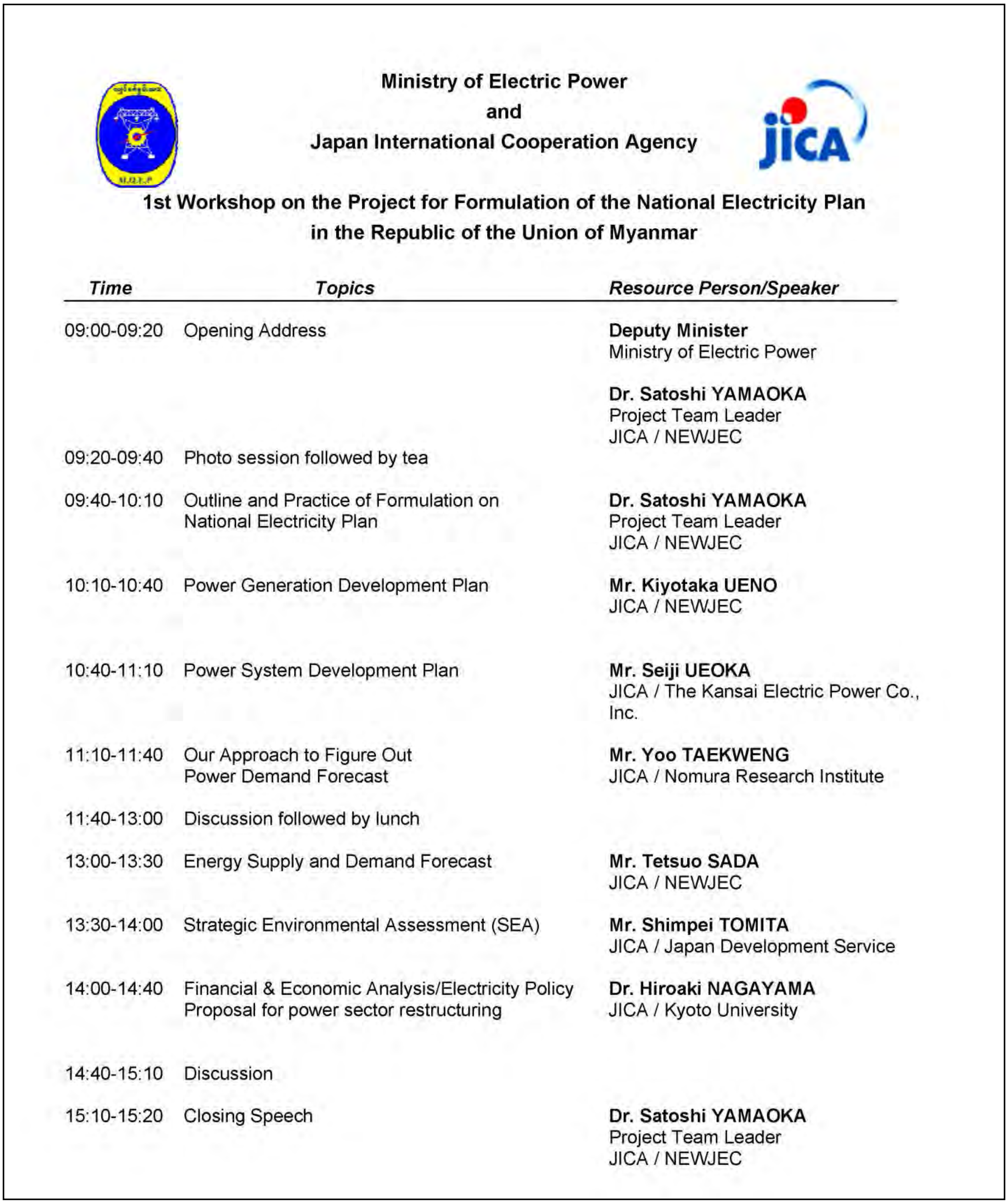
Fig. 1.5-2 Schedule of Site Investigation

1.6 TECHNICAL TRANSFER PROGRAM

Three workshops in Myanmar and a seminar in Japan had been held in this study as the technical transfer program for C/Ps.

(1) 1st Workshop

1st workshop was held on 30th August, 2013 at the main conference room of MOEP. JICA Study Team conducted presentations and discussions concerning case studies and methodologies on formulation of the National Electricity Master Plan against approximately 100 officers from MOEP, MOE (Ministry of Energy), FERD (Foreign Economic Relation Department) of NPED (Ministry of National Planning and Economic Development). Photographs and workshop program are shown in Fig. 1.6-1 and Fig. 1.6-2.



Ministry of Electric Power
and
Japan International Cooperation Agency

1st Workshop on the Project for Formulation of the National Electricity Plan in the Republic of the Union of Myanmar

Time	*Topics*	*Resource Person/Speaker*
09:00-09:20	Opening Address	**Deputy Minister** Ministry of Electric Power **Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC
09:20-09:40	Photo session followed by tea	
09:40-10:10	Outline and Practice of Formulation on National Electricity Plan	**Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC
10:10-10:40	Power Generation Development Plan	**Mr. Kiyotaka UENO** JICA / NEWJEC
10:40-11:10	Power System Development Plan	**Mr. Seiji UEOKA** JICA / The Kansai Electric Power Co., Inc.
11:10-11:40	Our Approach to Figure Out Power Demand Forecast	**Mr. Yoo TAEKWENG** JICA / Nomura Research Institute
11:40-13:00	Discussion followed by lunch	
13:00-13:30	Energy Supply and Demand Forecast	**Mr. Tetsuo SADA** JICA / NEWJEC
13:30-14:00	Strategic Environmental Assessment (SEA)	**Mr. Shimpei TOMITA** JICA / Japan Development Service
14:00-14:40	Financial & Economic Analysis/Electricity Policy Proposal for power sector restructuring	**Dr. Hiroaki NAGAYAMA** JICA / Kyoto University
14:40-15:10	Discussion	
15:10-15:20	Closing Speech	**Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC

Fig. 1.6-1 Program of 1st Workshop in Myanmar

Opening Address

Presentation by JICA Study Team

Fig. 1.6-2 Photographs of 1st Workshop in Myanmar

(2) 2nd Workshop

2nd workshop was held on 19th February, 2013 at the main conference room of MOEP. JICA Study Team conducted presentations and discussions concerning case studies and methodologies on formulation of the National Electricity Master Plan against approximately 80 participants from MOEP, MOE, FERD of NPED, MOECAF (Ministry of Environmental Conservation and Forestry) and JICA headquarters and Myanmar Office. Workshop program is shown in Fig. 1.6-3.

Ministry of Electric Power
and
Japan International Cooperation Agency

2nd Workshop on the Project for Formulation of the National Electricity Master Plan in Myanmar

Time	*Topics*	*Resource Person/Speaker*
09:00-09:10	Opening Address	**Deputy Minister** Ministry of Electric Power
09:10-09:15	Opening Address	**Mr. Kyosuke INADA** Deputy Chief Representative Japan International Cooperation Agency Myanmar Office
09:15-09:55	Outline of Formulation of National Electricity Master Plan	**Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC
09:55-10:10	Discussion	
10:10-10:25	Break Time	
10:25-10:45	Power System Development Plan	**Mr. Seiji UEOKA** JICA / The Kansai Electric Power Co., Inc.
10:45-11:00	Environmental and Social Considerations	**Mr. Shimpei TOMITA** JICA / NEWJEC
11:00-11:30	Economic and Financial Analysis	**Dr. Hiroaki NAGAYAMA** JICA / Kyoto University
11:30-11:50	Discussion	
11:50-12:00	Closing Speech	**Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC

Fig. 1.6-3 Program of 2nd Workshop in Myanmar

(3) 3rd Workshop

3rd workshop was held on 27th May, 2014 at the main conference room of MOEP. JICA Study Team conducted presentations and discussions concerning progress of the study, issues for NEMC presentation, power system development, environmental and social considerations and power policy against approximately 70 participants from MOEP, MOE, FERD of NPED, MOECAF and JICA headquarters and Myanmar Office. Workshop program is shown in Fig. 1.6-4.

Ministry of Electric Power
and
Japan International Cooperation Agency

3rd Workshop on the Project for Formulation of the National Electricity Master Plan in Myanmar

Time	***Topics***	***Resource Person/Speaker***
09:00-09:05	Opening Address	**Deputy Minister** Ministry of Electric Power
09:05-09:10	Opening Address	**Mr. Akira MATSUNAGA** Director Energy and Mining Division 1 Industrial Development and Public Policy Department Japan International Cooperation Agency
09:10-09:40	Updates on Draft Final Report No.1 National Electricity Master Plan	**Dr. Satoshi YAMAOKA** Project Team Leader JICA / NEWJEC
09:40-10:00	Discussion	
10:00-10:15	Break Time	
10:15-10:35	Power System Development Plan	**Mr. Seiji UEOKA** JICA / The Kansai Electric Power Co., Inc.
10:35-10:55	Environmental and Social Considerations	**Mr. Shimpei TOMITA** JICA / NEWJEC
10:55-11:15	Power Policy	**Mr. Makoto ASANO** JICA / The Kansai Electric Power Co., Inc.
11:15-11:35	Discussion	

Fig. 1.6-4 Program of 3rd Workshop in Myanmar

(4) Seminar in Japan

1) Outline

C/Ps concerned with this study (10 persons from MOEP, MOE and NPED) had been invited to Japan from 5th July 2014 to 12th July 2014 in order to implement site investigations of Japanese electric facilities and to hold a seminar to promote the National Electricity Master Plan and to exchange information and opinions with Japanese governmental organizations and private companies interested in business in Myanmar.

Table 1.6-1 Participant List

No	Affiliation			Name
	Ministry	Position	Department	
1	Ministry of Electric Power	Director General	Department of Electric Power	U Khin Maung Win
2		Deputy Chief Engineer	Myanma Electric Power Enterprise	U Zaw Ye Myint
3		Deputy Director (Civil)	Department of Hydropower Planning	Daw Thida Aye
4		Deputy Director	Department of Electric Power	Daw Myint Myint Kyi Swe
5		Assistant Director	Department of Electric Power	Daw Phyu Phyu Khin
6		Executive Engineer	Myanma Electric Power Enterprise	U Kyi San Lin
7	Ministry of National Planning and Economic Development	Deputy Director	Planning Department	Daw Khin Moe Moe
8		Deputy Director	Project Appraisal & Progress Reporting Department	U Aye Cho
9	Ministry of Energy	Executive Engineer	Myanma Oil and Gas Enterprise	Mr. Than Sein
10		Staff Officer	Energy Planning Department	Mr. Sei Thu Kyaw Kyaw

Table 1.6-2 Schedule

Date		Program	Accommodation
5/7/2014	Sat	Move to Bangkok	-
6/7/2014	Sun	Move to Osaka	Osaka
7/7/2014	Mon	AM :Courtesy call to The Kansai Electric Power Co., Inc. and preparation for the seminar presentation PM : Takatsuki Substation	Osaka
8/7/2014	Tue	AM :Sakai PV and Gas Station PM : Move to Tokyo	Tokyo
9/7/2014	Wed	AM :Courtesy call to JICA PM : Discussion on the formulation of the national electricity master plan	Tokyo
10/7/2014	Thu	Preparation for the seminar presentation	Tokyo
11/7/2014	Fri	Seminar	Tokyo
12/7/2014	Sat	Return to Myanmar	-

Preparation for Seminar Prepatation

Takatsuki Substation

Sakai Photovoltaic and Gas Power Station

Courtesy Call to JICA

Fig. 1.6-5 Photos in Japan

2) Seminar in Japan

Seminar of “Strategy on the Development of Electric Power Sector in Myanmar” was held at Tokyo on 11th July 2014. Approximately 240 persons from private companies and organizations concerned with business in electric power sector participated in this seminar.

Purposes of this seminar are to introduce the strategy of the National Electricity Master Plan, future viewpoints and business opportunities in electric power sector in Myanmar by JICA Study Team and Myanmar personnel from MOEP, MOE and NPED.

ミャンマー・日本外交関係樹立 60 周年記念事業

『ミャンマーの電力セクター開発と今後の方向性』
～ミャンマー初の電力マスタープランの取り組み～
Strategy on the Development of Electric Power Sector in Myanmar
-Progress of First National Electricity Master Plan-

主　催　：独立行政法人国際協力機構（JICA）、株式会社ニュージェック
日　時　：2014 年 7 月 11 日（金）13：30～17：10（13：00 開場）
会　場　：TKP ガーデンシティ品川 1 階　グリーンウインド

プログラム（予定）

時間	発表内容	発表者
13:30 – 13:40	開会挨拶 **Opening Address**	JICA 理事　市川　雅一
13:40 – 13:50		電力省電力局 局長　U Khin Maung Win
13:50 – 14:05	『ミャンマー国電力セクターにおける JICA の協力』 **JICA's Assistance to the Power Sector of Myanmar**	JICA 東南アジア・大洋州部 東南アジア第 4 課 企画役　金　哲太郎
14:05 – 14:30	『ミャンマー国の最新電力事情の紹介』 **Country Report for Power Sector**	ミャンマー国電力省電力公社 技術主任 U Kyi San Lin
14:30 – 15:15	『電力開発マスタープランの概要　~2030 年までの展望~』 **Outline of National Electricity Master Plan　－Vision as of 2030　－**	㈱ニュージェック国際事業本部 技術グループ統括　山岡　暁 ミャンマー国電力省　電力局 局長　U Khin Maung Win
15:15 - 15:40	休　憩　　　**Coffee Break**	
15:40 – 16:05	『ミャンマー国電力セクターへの投資』 **Investment for Power Sector in Myanmar**	ミャンマー国電力省電力局 副課長　Daw Myint Myint Kyi Swe
16:05 – 16:30	『ミャンマー国における持続的な発電のための国内ガス供給の確保』 **Ensuring Domestic Supply of Natural Gas for Sustainable Power Generation in Myanmar**	ミャンマー国エネルギー省 天然ガス石油公社 技術主任　U Than Sein
16:30 – 16:50	『ミャンマー国におけるプロジェクト承認の流れ』 **Procedure of Project Appraisal in FERD**	ミャンマー国国家計画経済開発省 副課長　U Aye Cho
16:50 – 17:05	全体質疑応答　　**Overall Q&A**	
17:05 – 17:15	閉会挨拶 **Closing Remarks**	JICA 産業開発・公共政策部 部長　植嶋　卓巳

*1 発表プログラムは当日に変更する可能性がある旨、御留意下さい
*2 当日のプレゼンテーション発表は日英同時通訳の導入を予定しております。

Fig. 1.6-6　　Seminar Program

Opening Address

Seminar Presentation (1)

Seminar Presentation (2)

Fig. 1.6-7　Photos in the Seminar

(5) Technical Transfer for Concerned Personnel

Explanation and provision of the data and analysis related to this study had been implemented by JICA Study Team as the technical transfer for MOEP staffs concerned. Seminar on the economic and financial analysis was held on 3rd August 2014. In addition, lectures such as power demand forecast, power generation development, power system development planning, environmental assessment and economic and financial analysis had been implemented for MOEP staffs in concerned organizations from 4th August to 7th August 2014.

Table 1.6-3 Participants of Lectures

Field	Participant
Power Demand Forecast Power Generation Development Environmental and Social Considerations	Daw Myint Myint Kwi Swe (Deputy Director, DEP) U Aung Myo Win (Assistant Director, DEP) Daw Phyu Phyu Khin (Assistant Director, DEP) U Kyaw Swar Soe Hlaing (Senior Engineer, MEPE)
Power System Development Planning	U Kyi San Lin (Executive Engineer, MEPE) U Win Kyaw (Executive Engineer, MEPE)
Economic and Financial Analysis	Daw Aye Aye Mon (Director, DEP) U Tun Min Soe (Staff Officer, DEP) Daw Nay Yi Lin (Staff Officer, DEP)


Seminar (1)


Seminar (2)


Power Demand Forecast
Power Generation Development


Power Generation Development
Environmental and Social Considerations


Power System Development Planning


Economic and Financial Analysis

Fig. 1.6-8 Pictures of Technical Transfer Activities

CHAPTER 2

PRESENT STATE AND ISSUES OF POWER SECTOR

CHAPTER 2 PRESENT STATE AND ISSUES OF POWER SECTOR

2.1 PRESENT STATE OF POWER POLICY IN MYANMAR

After transition to the democratic government in March 2011, electricity demand has rapidly increased by more than 10% annually according to economy growth. The GoM (Government of Myanmar) is now urgently required to ensure the short term electricity supply capacity and to formulate a medium & long term PDP (Power Development Plan).

The GoM will make a comprehensive energy policy combining energy and electric power fields in accordance with the Myanmar National Plan.

2.1.1 Myanmar National Plan

As of April 2014, there are the following three (3) Myanmar National Plans indicating the GoM policy:

- FESR (Framework of Economic and Social Reform): publicized in January 2013
- NCDP (National Comprehensive Development Plan): under preparation
- Five-Year Plan based on NCDP: under preparation

FESR is an essential policy tool of the GoM to realize both the short term and long term potential of Myanmar. Firstly, it provides a reform bridge linking the ongoing programs of the GoM to NCDP, a 20-year long term plan, which the GoM is drawing up in consultation with the Parliament for the country’s economy to grow on a part with the dynamic Asian economies. Secondly, FESR serves as a required reference for various entities of the GoM develop more detailed sectional and regional plans. Thirdly, it can serve as a guide for building lasting cooperation with development partners as well as international bodies to obtain mutual benefits. Lastly, but not least, it focuses on potential “quick wins” that the GoM will consider implementing to bring tangible and sustainable benefits to the nation.

Section 5.3 “Energy and Mining” of Chapter 5 “Sector Policies for Inclusive Growth and Poverty Reduction” of FESR shows a policy on energy and electric power.

President U Thein Sein, in his address on 9th August 2013, expressed importance of electricity, (1) to manage electrification at full capacity in Yangon and Mandalay where most of the industries are being run, (2) to raise number of households in all regions and states that consume electricity.

NCDP as long term national plan is now developing through broad consultations and bottom-up process, and has not been in public as of April 2014. The Five-Year Plan based on NCDP also has not been in public.

2.1.2 Energy Policy

President U Thein Sein, in his address on 19th June 2012, expressed the GoM would establish NEMC (National Energy Management Committee) at the Planning Commission for overall matters for energy sector of the State and implement the National Energy Plan for short and long term objectives in compliance with the National Energy Policy. The GoM would have to implement such energy projects as oil, natural gas and coal after drafting the National Energy Plan.

According to the presidential policy, NEMC and EDC (Energy Development Committee) were established on 9th January 2013.

NEMC consists of Vice-President (2), eight related Union Ministers of MOE (Ministry of Energy), MOEP (Ministry of Electric Power), MOAI (Ministry of Agriculture & Irrigation), MOECAF (Ministry of Environmental Conservation & Forestry), MOI (Ministry of Industry), MOM (Ministry of Mines), NPED (Ministry of the National Planning and Economic Development), MOST (Ministry of Science & Technology), and three experts.

There are twenty-two duties and functions of NEMC. Main substances are as follows:

- To formulate the National Energy Policy based on energy demand and production and fulfillment of energy requirement on energy matters of the State,
- To formulate energy regulations for ensuring implementation of energy development of the State in accordance with the National Energy Policy,
- For development of electrical sector, to fulfill the current requirements by laying down short term plans,
- To lay down long term plans based on sustainable development of industrial sector of the State and GDP (Gross Domestic Product) to be able to meet the increased demand for electricity,
- To generate electricity with the use of coal as in many other countries as there has been greater demand for electricity and to use CCT (Clean Coal Technology) aimed at placing emphasis on environmental conservation,
- To strive for generating electricity depending on regions and topographical situation with the use of solar power, hydropower, wind power, geothermal, biomass and biofuel to be able to meet the public demand for electricity,
- To take systematic measures in laying down development plans to be able to cover three sectors as energy, industrial and electrical sectors are mutually dependent,
- To prioritize and supervise oil, natural gas and natural resources to be able to meet domestic demands, etc.

EDC consists of Union Minister of MOE, Deputy Ministers of MOE, MOEP, MOAI, MOECAF and MOI, Director General of MOM and MOST and other experts.

There are twenty-two duties and functions of EDC. Main substances are as follows:

- To participate in laying down the energy development policy and plans of NEMC,
- To lay down objectives and adopt rules and regulations for short term and long term implementation in accordance with the energy development policy laid down by NEMC,
- To carry out yearly review over the weak and strong points when implementing objectives in accordance with short term and long term rules and regulations, and to amend the rules and regulations if necessary,
- To lay down objectives and strategies after making assessment to opportunities and limitations regarding the tasks for energy development,

- To adopt pricing policy and form pricing committee for purchase and sale of energy product,

- To lay down plans to attract foreign and domestic investments in renewable energy projects such as solar energy, wind power geothermal energy, biomass and biofuel projects, etc.

As of June 2014, based on discussions in NEMC, the draft of the National Energy Policy (Burmese version) had been compiled and submitted to the President Office in April 2014, and its English version was made with ADB (Asian Development Bank) support in May 2014. Authorization procedure of the National Energy Policy will be judged by the President Office.

2.1.3 Electricity Policy

The National Energy Policy, which is to be prepared by NEMC, is a policy including all related sectors. Each sector will not make an individual policy but will implement each sector policy in accordance with the Energy Policy.

MOEP makes the following items of the draft policy in power sector:

- For sufficient electricity supply throughout the country, to expand the national power grid for effective utilization of generated power from the available energy resources such as hydro, wind, solar, thermal and other alternative ones;

- To conduct the electricity generation and distribution in accordance with advanced technologies and to uplift and enhance private participation in regional distribution activates;

- To conduct EIA (Environmental Impact Assessment) and SIA (Social Impact Assessment) for power generation and transmission projects in order to minimize these impacts;

- To restructure the power sector with cooperation, boards, private companies and regional organizations for more participation of local and foreign investments and formation of competitive power utilities;

- To formulate the electricity acts and regulations with the assistances of the local and international experts to be line with the open economic era;

These implementation policies show only above-mentioned items, thus specific implementation plans for the respective items should be studied.

2.1.4 Electricity Law

The draft of the Electricity Law was publicized in November 2013. Deliberation of the law has been implemented through a committee of the Parliament and it will be enacted after the approval of the Parliament. The English version is under preparation.

The objectives of the draft are shown as follows:

- Systematically manage electricity-related work in the country in order to satisfy the country’s need for electric power;

- To develop the electric power sector of the country in order to contribute to the implementation of present policies of the GoM relating to economic, social and environmental conservation and development;

- To further encourage medium- and small-scale generation and distribution of electric power in the regions and the states to supplement large-scale power generation and distribution which is to be managed by the Union;

- To enable the wider use of electric power in a safe way in the urban and rural areas in the whole country;

- To ensure that electricity-related work in the country is performed in accordance with the stipulated standards and norms;

- To develop modern electrical technology and to increase the number of electrical technicians and professionals;

- To promote standards, norms and quality of electrical appliances;

- To control and supervise electricity-related work in conformity with the policies of the state;

- To prevent in advance the occurrence of electrical hazards and to implement effective penalties and specific rules in order to prevent losses to the public and the state when electricity-related work is performed;

- To increase foreign and local investments in electricity-related work;

- To write and promulgate equitable, transparent and reasonable rules and regulations for fixing electric power rates which are economically viable and sufficient to cover the investment costs;

- To respect and comply with, the international conventions on environmental conservation which were approved and signed by the Union.

Chapter 3 of the draft of the Electricity Law shows that the GoM shall form the Electricity Regulatory Commission headed by a person from a union level ministry, which consists of professionals and other suitable persons, in order to effectively and successfully perform electricity-related work. The duties and responsibilities of the electricity regulatory commission are as follows:

- to compile and write the National Electricity Policy after consultation with the relevant ministries and organizations;

- to compile and submit the matters relating to the electricity tariff policy in order to fix modern and systematic electricity power rates;

- to advise, as necessary, the relevant ministries according to the guidance of the GoM in order to systematically develop electricity-related work;

- to form, as necessary, electricity regulatory sub-commission in the regions, states and the respective self-administered zones and divisions and prescribe their duties and responsibilities;

- to survey, assess and review the status of the electricity sector in comparison to the international electricity standards and norms and communicate the findings to the relevant ministries for them to take necessary action;

- to form an inspection team comprising of suitable persons in order to check whether the production, import, export distribution and use of electrical appliances is done in conformity with the specified standards and norms;

- to perform other duties related to electricity as assigned by the GoM.

As for electricity-related work, the GoM will give authority to the relevant ministries, the relevant regions or state governments, and the relevant self-administered zones or self-administered divisions. Ministries continue to implement power development projects with large scale of more than 30MW, and regions or state governments will have the right to implement mid-sized projects of 10 to 30MW and small-scale projects of up to 10MW with prior approval from the relevant ministry.

2.2 PRESENT STATE OF POWER SECTOR

2.2.1 Power Sector Structure

In 2006, the former MOEP was divided into MOEP(1) and MOEP(2), and MEPE (Myanma Electric Power Enterprise), which was a vertical integration sector for generation, transmission and distribution, was divided into four stated-owned enterprises with asset division, MEPE (generation and transmission), HPGE (Hydropower Generation Enterprise) (generation), ESE (Energy Supply Enterprise) (distribution except Yangon Region) and YESB (Yangon City Electricity Supply Board) (distribution in Yangon Region).

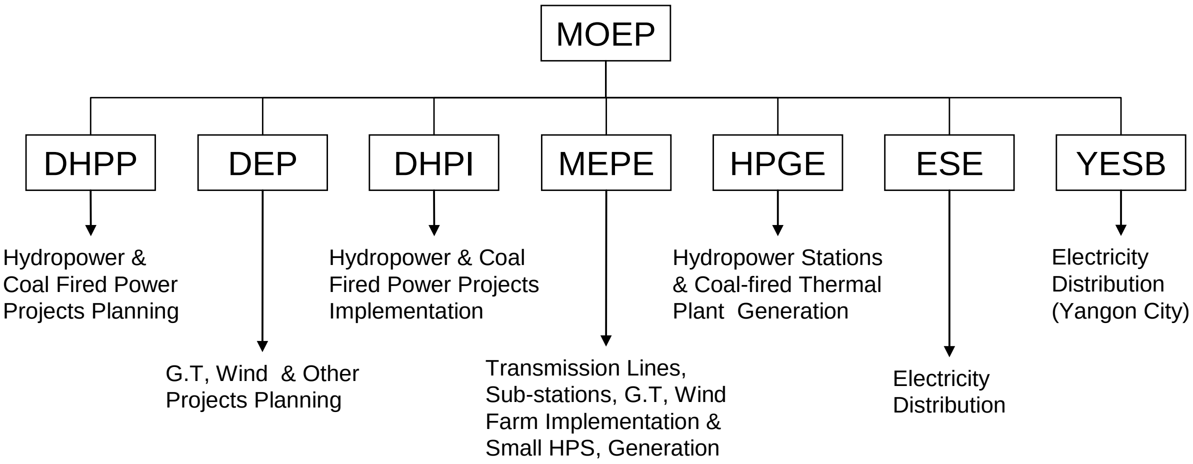
MOEP(1) and MOEP(2) were consolidated into MOEP again in September 2012. All previous three governmental departments and four SOEs (State Owned Enterprise(s)) still remain in the present organization of MOEP. In the current power sector structure, MEPE plays a role of a single-buyer. A single-buyer is defined to be a governmental entity or public power company who buys all the electricity generated by private companies and sells the electricity to a distribution company. Organization and function of MOEP and electric power supply system are shown in Fig.2.2-1 and Fig.2.2-2 respectively.

The GoM is implementing to corporatize SOEs and to make their management system more transparent and efficient. If accounts of SOEs in fiscal year are deficit, the GoM put government subsidies into them by maximum 20% of expenditure of purchasing raw materials including wholesale electricity. Other expenditure of SOE such as capital expenditure, financial expenditure, wage and salary, etc., is budgeted from government account.

Processes to decide electricity tariff rate are: (1) MEPE, HPGE, ESE and YESB calculate cost per kWh based on all the expenses necessary to supply electricity corresponding to the demand and submit it to DEP (Department of Electric Power), (2) DEP makes a draft of tariff rate through discussion with each enterprise and submit it to Minister's office of MOEP, (3) Minister approves it and submits to the president office. The tariff rate is discussed and approved in the Cabinet.

In November 2013, MOEP planned to raise tariff rate to apply the new specific system by introduction of specific price corresponding to consuming amount instead of uniform residential and industrial tariffs per kWh. However, there were a lot of opponents and the GoM discussed new tariff rate in the Parliament but couldn't finalize it. It was discussed again in the next Parliament in January 2014. The GoM applied new tariff rate from the new fiscal year 2014.

MOEP has proceeded with a lot of IPP (Independent Power Producer) projects, and MEPE had contracted six PPAs (Power Purchase Agreement(s)) for two hydropower projects of Shweli-1 and Thauk Ye Khat-2, three GE (gas engine) projects of Zeya at Hlawga. Myan Shwe Pyi at Ywama and Central International Corporation at Thaketa and one GT (gas turbine) project of Toyo-Thai at Ahlone as of April 2014. MEPE has negotiated PPA including other ongoing IPP projects mostly from the nearly-completed time or after completion of project construction. PPAs for completed Baluchaung-3 hydropower project in 2014 is under negotiation between Future Energy and MOEP. MEPE has set different terms of PPA contracts in each project, which effective term is one year and renewal negotiation is necessary every year or long period.

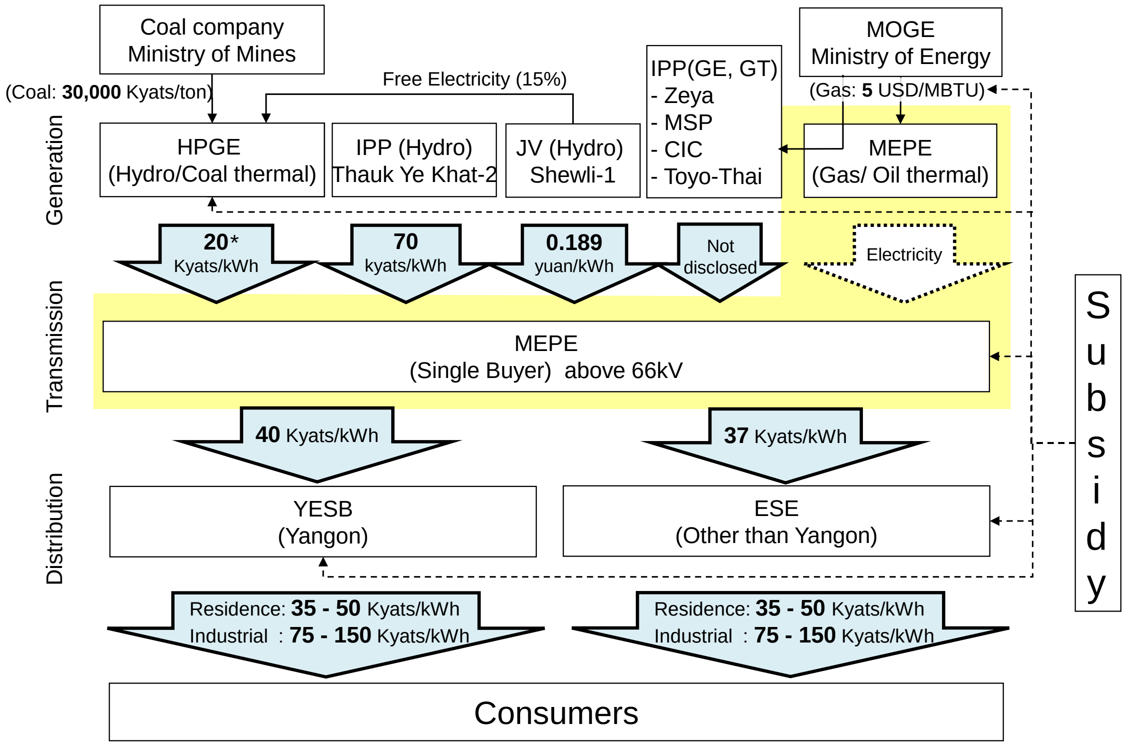


DHPP: Department of Hydropower Planning
DEP : Department of Electric Power
DHPI : Department of Hydropower Implementation

MEPE: Myanma Electric Power Enterprise
HPGE: Hydropower Generation Enterprise
ESE : Electricity Supply Enterprise
YESB: Yangon City Electricity Supply Board

Source: MOEP

Fig.2.2-1 Organization and Function of MOEP (April 2014)



* 18 Kyats/kWh as of August 2014

Source: prepared by JICA Study Team based on local newspaper and/or MOEP information

Fig.2.2-2 Electric Power Supply System (April 2014)

2.2.2 Power Development Plan

(1) PDP

In July 2013, MOEP made PDPs by power sources in Myanmar; (1) up to 2015-2016, development of ongoing hydropower and gas-fired thermal power projects; (2) from 2016-2017 to 2020-2021, development of coal-fired thermal power and hydropower projects; (3) from 2021-2022 to 2030-2031, development of mainly hydropower projects.

MOEP compiles each plan of gas-fired power development and transmission line by MEPE, hydro and coal-fired power development with BOT (Build Operate and Transfer) and JV (Joint Venture)/BOT scheme by DHPP (Department of Hydropower Planning), hydropower development with MOEP own investment by DHPI (Department of Hydropower Implementation). In PDP, MOEP adopts 100% of installed capacity of existing power plants and new gas- and coal-fired power plant, hydropower plant with MOEP sole development and BOT scheme, and 50% of hydropower plant with JV/BOT scheme as domestic power supply.

MOEP estimates power demand increases by 13% per year. The peak demand in 2030-2031 will be 19,216MW and power supply of 24,981MW will be required including reserve capacity. MOEP plans to implement power development to increase installed capacity up to 29,189MW in total in 2030-2031, which consist of hydropower of 21,247MW, coal-fired power of 2,390MW, gas-fired power of 4,093MW and renewable energy (solar, wind and geothermal) of 1,459MW.

MOEP has implemented power development of hydropower, gas-fired and coal-fired power using three schemes, (1) MOEP sole development, (2) BOT scheme by investment of Myanmar local companies, (3) JV/BOT scheme by investment of foreign companies. As for renewable energy development, MOEP is in charge of solar and wind power project with IPP development. As of April 2014, IPP plants of Shweli-1 and Thauk Ye Khat-2 hydropower, and Zeya GE at Hlawga. Myan Shwe Pyi GE at Ywama, Central International Corporation GE at Thaketa and Toyo-Thai GT at Ahlone have been operating according to PPA contracts. MOEP plans to implement power developments with BOT and JV/BOT schemes except about 10 hydropower and few thermal power projects. The ratio of IPPs capacity in the total installed one for Myanmar supply increases more than 80% in 2030-2031.

Current procedure for new IPP projects is that MOEP officially invites by newspaper local and foreign companies who willing to invest to the power sector, and MOEP discusses a proposed project with the investors including a planned project area, power type, etc. MOEP has rarely followed the procedure that MOEP decides to select the IPP scheme among development projects and select its developer through an international bidding.

As for the existing thermal power plants, current output capability is much less than installed capacity due to insufficient maintenance, gas quality and gas supply amount. Rehabilitation is ongoing with financial supports from some donors. As for the existing hydropower plants, MOEP has been implementing to rehabilitate turbines and generators of Baluchaung-2 with JICA (Japan International Cooperation Agency) support.

As for procedure of EIA for power development, MOECAF has been preparing laws and regulations for EIA after enactment of the Environmental Conservation Law.

(2) Procedure of IPP (BOT, JV/BOT) for Power Development

BOT scheme is the scheme to be developed by Myanmar local companies to supply all generated electricity to the grid in Myanmar.

JV/BOT scheme is the scheme to be developed by investment of foreign companies under JV with MOEP, and the GoM gets 10 - 15% of shares and 10 - 15% of electricity as royalty, being free of charge. JV company negotiates a domestic supply amount within maximum 50% including this free electricity. MOEP has adopted this JV/BOT scheme for hydropower projects, and MOEP has studied and negotiated concrete schemes separately for gas-fired and coal-fired IPP power projects.

According to DHPP, in MOU (Memorandum of Understanding) phase in both BOT scheme and JV/BOT scheme, the GoM can divest the developer of the development right if the developer doesn't submit F/S (Feasibility Study) report. However, in the MOA (Memorandum of Agreement) phase of JV/BOT scheme, there is no contract clause for the GoM to divest the developer of the development right.

In both BOT scheme and JV/BOT scheme, negotiation rules for PPA are not clear.

Concrete procedures of BOT and JV/BOT scheme in Myanmar are as follows.

1) Procedure of BOT scheme

Phase-1

- A developer gets an approval based on initial contract with MOEP to implement investigation for a proposed project.
- The developer submits a proposal of project development according to investigation results.
- MOEP reviews the proposal, makes a draft MOU and submits it to three authorities (1) UAGO (Union Attorney General Office), (2) NPED, (3) MOF (Ministry of Finance). After getting comments and approvals from three authorities, MOEP submits the MOU to the Union Cabinet.
- After getting the approval of the Cabinet, the MOU is signed between MOEP and the developer.

Phase-2

- The developer implements F/S within 12 months (maximum 18 months) and submits the F/S report.
- MOEP reviews the report in detail. MOEP discusses with the developer the project cost, financial analysis and financial arrangement.
- After approval of the financial analysis and arrangement, MOEP submits a draft BOT contract to the three authorities to get the approval.

Phase-3

- The developer implements EIA/SIA by a third party and submits the EIA/SIA reports to MOECAF through MOEP for approval.
- After the approval of MOECAF, MOEP submits a draft BOT contract to MIC (Myanmar Investment Committee).

Phase-4

- After getting the approval of MIC, MOEP submits the draft BOT contract to the Cabinet.
- After the approval of the Cabinet, MOEP contracts a BOT agreement with the developer.
- The developer implements construction and operation.
- PPA should be basically renewed every year (however, negotiation rules for PPA are not clear).

2) Procedure of JV/BOT scheme

Phase-1

- A foreign developer gets an approval based on initial contract with MOEP to implement investigation for a proposed project.
- The foreign developer submits a proposal of project development according to investigation results.
- MOEP reviews the proposal, makes a draft MOU and submits it to three authorities (1) UAGO, (2) NPED, (3) MOF. After getting comments and approvals from three authorities, MOEP submits the MOU to the Cabinet.
- After the approval of the Cabinet, the MOU is signed between MOEP and the foreign developer.

Phase-2

- The foreign developer implements F/S within 12 months (maximum 18 months) and submits the F/S report.
- MOEP reviews the report in detail. MOEP discusses with the foreign developer the project cost, financial analysis and financial arrangement.
- After approval of the financial analysis and arrangement, MOEP submit a draft MOA to the three authorities to get the approval. And MOEP submits the MOA to the Cabinet.
- After the approval of the Cabinet, MOA is signed between MOEP and the foreign developer.

Phase-3

- The foreign developer implements EIA/SIA by a third party and submits the EIA/SIA reports to MOECAF through MOEP.
- After the approval of MOECAF, MOEP submits a draft MOA to MIC.

Phase-4

- After the approval of MIC, MOEP submits a draft JV Agreement to the three authorities, and the Union Cabinet.
- After the approval of the Union Cabinet, JV Agreement is signed between MOEP and the foreign developer.

Phase-5

- MOEP applies registration of JV company to NPED.
- UAGO reviews the application including a loan agreement.
- MOEP gets the permission of project development as the investment project.
- The JV company implements the construction and operation.
- PPA should be basically renewed every year (negotiation rules for PPA are not clear).

2.2.3 Procurement of Power Fuel

Though Yadana, Shwe, and Zawtika supply twenty percent of their offshore natural gas for domestic use, the amount of domestic use has increased from 150 to 225 mmscfd at Yadana and from 60 to 100 mmscfd at Zawtika after negotiation for buy-back of exported gas to Thailand to ensure necessary gas amount for power generation. Priority order of domestic supply is (1) electric power, (2) industry, (3) transportation. Sixty five percent out of domestic supply is used for MOEP.

The existing gas-fired power plants use domestic gas supplied by MOE. MOEP is promoting to develop new IPP gas-fired power projects to cope with increasing power demand, but necessary gas amount for these new projects are beyond the amount of the present domestic gas supply. When new gas-fired power plants start to operate, MOEP will stop to operate existing old plants, resulting in increasing power supply with the high efficiency of the new plants under a limited amount of domestic gas.

MOEP implemented an international bidding on 15th August 2013 to purchase LNG (Liquid Natural Gas) for the shortage gas amount of the short term power generation. Though MOEP has planned a FSRU (Floating Storage and Regasification Unit) near Yangon to supply LNG to the gas-fired thermal power plants, a result of bidding is not preferable and a LNG supply plan is now re-studied as shown in Section 4.1.4.

MOE will make the draft of the Gas Supply Plan for the domestic market until 2031, in which estimated amount includes supply from new gas fields to be developed after 2020, but it is a presumption under investigation stage.

Wholesale price of gas from MOE to MOEP is 5 USD/Mbtu, which is less than half of market price. As of January 2014, MOE applies to the GoM for raising wholesale price from 5 USD/Mbtu to 7.5 USD/Mbtu. MOE has proposed the new prices for approval of the GoM, but MOE is waiting for conclusion of electricity tariff discussion in Parliament because wholesale price of gas is related to it.

2.2.4 Rural Development (Rural Electrification/Grid Expansion)

According to ADB report, “New Energy Architecture: Myanmar, June 2013”, approximately 26% of the population can access to grid-connected electricity as of 2011.

From an interview with DRD (Department of Rural Development) of MOLFRD (Ministry of Livestock, Fisheries and Rural Development) in January 2014, the number of electrification village is 21,675 out of the total number of village of 64,917 as of 2012-2013, which is equivalent to 33.4%. Electrification includes not only access to grid-connected electricity but also access to mini-grid and off-grid ones.

In September 2013, the GoM established “Rural Region Electrification and Water Supply Committee” to reinforce the rural electrification and drinking water supply works. The Committee consists of Union Minister of MOLFRD, eight related Deputy Ministers of NPED, MOAI, MOLFRD, MOECAF, MOEP, MOE, MOI, Ministry of Construction and other experts. Local government is not included.

NEMC is discussing concrete measures to improve rural electrification.

2.2.5 Activities of Donors

ADB and WB (The World Bank) Group have implemented and being planning the supporting projects to Myanmar power sector. Supporting activities to the power sector are being discussed and adjusted through the Electric Power Sector Working Group as shown in Table 2.2-1.

Table 2.2-1 Projects related to Myanmar Power Sector (December 2013)

Sector Planning	Legal and Regulatory	Financial Sustainability	Transmission & Distribution	Generation	Rural Energy
Analytical Basis for Strategic Decisions (WB)	EITI[1] Application Support (WB)	Financial Viability Action Plan (WB)	Distribution Improvement in Yangon (JICA)	New GTCC[2] for MEPE & IPPs; PPP[3] Transactions (WB)	Off-grid power Program (ADB)
Energy Master Plan for NEMC (ADB, Japan/JFPR[4])	Electricity Law & Electricity Regulation (ADB/Norway)	Strengthening Financial Management (Multi-donor)	4-region Distribution System Improvement (ADB)	Donated GT and Generators (GOT[5], Japan/JICA)	Rural Electrification Project (WB)
National Electricity Master Plan (JICA)			National Power Transmission Network (ADB-JICA-Korea)	Urgent Rehabilitation and Upgrade (Yangon, Thilawa, Baluchaung, Hlaingtharyar) (JICA)	Rural Power Infrastructure (electrification in 14 regions/states) (JICA)
National Electrification Plan (WB)	Rural Electrification Law (AD)	Economic Valuation of Natural Gas in domestic mkt. (WB)	Advisor for Yangon Electricity Supply System (JICA)	National Electrification Plan (WB)	Rural Electrification Law (ADB)
Energy Efficiency Policy and Renewable Energy Development Plan (ADB)	Environmental and Social Safeguard and Conservation (ADB)		YESB Corporatization Support through Investment and Advisory Support (WBG)	Energy Efficiency Policy and Renewable Energy Development Plan (ADB)	Environmental and Social Safeguard and Conservation (ADB)

1) EITI Extractive Industries Transparency Initiative
2) GTCC Gas Turbine Combined Cycle
3) PPP Public Private Partnership
4) JFPR Japan Fund for Poverty Reduction Program
5) GOT Government of Thailand

Source: DEP

(1) ADB

As of April 2014, ADB implements and plans supporting project to Myanmar power sector as shown in Table 2.2-2 and Table 2.2-3.

Table 2.2-2 Ongoing Projects on Myanmar Power Sector by ADB

Project Name	Type	Term	Amount (USD thousand)
Institutional Strengthening of NEMC in Energy Policy and Planning	TA	From 29-Aug-2013 To 31-Oct-2014	1,350
Preparing the Power Transmission and Distribution Improvement Project	TA	From 29-Aug-2013 To 30-Jun-2015	1,500
Financial Management Assessment of Energy Sector	TA	From 19-Nov-2012 To 30-Apr-2014	160
Enhancing Power Sector's Legal and Regulatory Framework	TA	From 12-Nov-2013 To 30-Sep-2015	850
Power Distribution Improvement Project	Loan	From 28-Jan-2014 To 31-Dec-2018	60,000

* TA: Technical Assistance

Source: ADB HP

Table 2.2-3 Planned Projects on Myanmar Power Sector by ADB

Project Name	Type	State (1) Concept clearance, (2) Management Review Meeting	Amount (USD thousand)
Power Transmission and Distribution Improvement Project	Loan	(1) 22-Mar-2013 (2) 22-Oct-2014	150,000
Support for Public-Private Partnership Framework Development	TA	(1) - (2) -	2,000
Off-Grid Renewable Energy Demonstration Project	TA	(1) 27-Nov-2013 (2) -	N/A

Source: ADB HP

1) Summary of ongoing projects

a) Institutional strengthening of NEMC in energy policy and planning

- To prepare the Long Term Energy Master Plan. (This technical assistance will complement JICA's work in preparing the Long Term Power Sector Development Plan.)
- To strengthen the institutional arrangements and intellectual development within the NEMC and related ministries for sustainable and inclusive development.

b) Preparing the power transmission and distribution improvement project

Technical assistance for the rehabilitation of existing transmission and distribution network and expansion in next 5 years to increase supply of electricity and electrification ratio in Myanmar.

c) Financial management assessment of energy sector

To strengthen the financial management practices and to support making standards of Myanmar's power sector agencies as well as to increase understanding of basic ADB policies and procedures.

d) Enhancing power sector's legal and regulatory framework

- Support to enhance legal and regulatory framework for the power sector

e) Power distribution improvement project

This project will help to reduce the system losses and increase reliable electricity supply to urban and rural consumers for the country’s inclusive and sustainable economic development.

- Rehabilitation of distribution network in five townships Yangon Region (Hlaingtharyar, Insein, Kamayut, Mayangone, and Mingaladon), four districts in Mandalay Region (Kyause, Meikhtila, Myin Gyan, and Yameethin), five districts in Sagaing Region (Kalay, Katha, Monyawa, Sagaing and Shwebo) and two townships in Magway Region (Aungland and Magway).

2) Summary of planned projects

a) Power transmission and distribution improvement project

This project will help to increase reliable supply of electricity to urban and rural consumers for country’s inclusive and sustainable economic development.

- Expansion of transmission lines between (1) Kamarnat and Hlaingtharyar in Yangon, (2) Baluchaung-2 and Taungoo, (3) Taungoo and Shwedaung, (4) Thaketa and Ahlone in Yangon.
- Preparation of the Five-Year Investment Plan in Transmission and Distribution System (2013 ~ 2018).

b) Support for PPP framework development

This project will help the GoM establish fair and balanced terms for private sector investment into power generation projects, establish principles for international competitive tendering, assist the GoM in prioritizing PPP (Public Private Partnership) investment projects, and strengthen the design and management of future PPP procurements.

c) Off-grid renewable energy demonstration project

This project will support the creation of rural infrastructure; (1) to support the installation of clean energy-based systems for providing energy access to schools and other infrastructure in at least 25 villages, (2) to develop geospatial least cost energy access plans and an investment plan to select states and regions, (3) to strengthen the capacity of the governmental institutions and the private sectors.

(2) WB Group

As of April 2014, WB Group implements and plans the following projects which are to enable poor rural communities to benefit from improved access, use of basic infrastructure and services, etc.

1) Myanmar National Community Driven Development Project

Project term:	from November 2012 to January 2019
Amount:	80 million USD

Project components:	This project consists of 5 components. As for rural electrification, component 1 (52.2 million USD) is to finance to about 640 villages tracts in 15 townships for priority community level infrastructure. The infrastructure to be financed will typically include small feeder roads, foot-paths and bridges, drinking water systems, rehabilitation of school class rooms and health centers, and small-scale rural electrification.

2) Myanmar Electric Power Project

Project term:	from January 2014 to April 2018 (Project signed between the GoM and WB in September 2013)
Amount:	140 million USD

Project components:

a) Expansion of the Thaton GT into GTCC power plant
Phase-1: Thaton GT @ 2 units 12-15 months
Phase-2: Thaton ST (Steam Turbine) @ one unit 15-18 months after Phase-1

b) Technical assistant and advisory services

Area-1: Capacity building for making policies and regulations in the power sector
Development of National Electrification Plan
  - Geospatial least cost electrification rollout plan toward universal access to electricity by 2030
  - Road map and investment financing prospectus

Area-2: Capacity building for expansion project implementation

3) Support for the Corporatization of YESB

IFC (International Finance Corporation)'s technical support and assistance in transforming YESB (The mandate signing on 26th February 2014).

2.3 REFORM OF POWER SECTOR

2.3.1 Points to be discussed on Power Sector

(1) Power Sector Structure

1) Reasonable organization of MOEP

MOEP has not been restructured after MOEP(1) and MOEP(2) were consolidated into one ministry in September 2012. Three governmental departments (DEP, DHPP, DHPI) and four SOEs (MEPE, HPGE, ESE, YESB) exist under MOEP, and governance doesn't function effectively. DEP doesn't have a section to study a structure of electric power sector. Though DEP simply plans to increase employees in the present departments and enterprises of MOEP, they need a new organization and specialized persons for new tasks. Support of experts and capacity building to the power sector are essential.

2) Establishment of an appropriate pricing policy

An appropriate pricing policy on power tariff for retail and wholesale is necessary to improve financial situation of SOEs in the power sector. In the case that the GoM develops most of new power projects through IPP scheme due to shortage of project finance, financial burdens of Myanmar will increase as shown in Fig. 8.5-13. Thus, introduction of IPP projects, setting of power tariff, and injection of governmental subsidy should be implemented appropriately.

3) PPA procedures based on international standards

In general, PPA of each project is finalized before construction. In Myanmar, MOEP starts to negotiate PPA mostly after completion of project construction. This PPA negotiation takes time and IPP plants cannot start operation just after completion. According to MOEP, effective PPA period for hydropower IPPs is one year and renewal negotiation is necessary every year, but PPA period for gas-fired and coal-fired IPPs differs from project to project. And also MOF doesn't give Myanmar governmental guarantees for IPP projects. This could be hard situation in project finance for foreign investors to participate in IPP projects at present. The present circumstance seems to be not sufficient to introduce private investment widely in Myanmar.

(2) PDP

1) Long term PDP corresponding to an expansion plan of bulk transmission lines

MOEP makes a long term PDP in Myanmar based on the maximum installed capacity of each project. However, it would be necessary to study a development plan against peak demand in dry season in consideration of plant utilization factors of hydropower stations in dry season and types of hydropower stations such as run-of-river, regulation-pond and reservoir types. Moreover, most hydropower projects are located in the north area and the present main transmission lines of 230kV running from north to south does not have enough capacity to transmit full electricity from north to south. Therefore, the long term PDP should correspond with an expansion plan of bulk transmission lines.

2) Appropriate installed capacity ratio of IPP

According to the MOEP's PDP made in July 2013, MOEP will have more than 50 plans to be constructed by BOT scheme and JV/BOT in addition to about 10 hydropower and a few thermal power projects to be newly developed by MOEP own investment. This PDP presents that the IPP projects will generate power of more than 80% of the total installed capacity in 2030-2031. As described in Chapter 8, financial burdens of Myanmar will increase, provided that the installed capacity ratio of IPP to the total capacity is substantial. MOEP should study this situation focusing on appropriateness of planned annual supply and demand balance, agreement of the transmission line expansion plan, and effects to power tariff.

Power supply in rainy season is usually 1.4 times as large as that in dry season. Power supply of gas-fired and coal-fired plants can be reduced by the increase of hydropower generation in rainy season to minimize power generation cost of the national grid. Though most of gas-fired and coal-fired thermal power plants are planned to be developed though BOT and JV/BOT schemes, MOEP should study various sources for procurement of electricity in dry season, including development of thermal power plants own by MOEP and import of electricity from surrounding countries, so that MOEP can ensure capacity of electricity supply corresponding to the demand and minimize the generation cost of the national grid.

3) New coal-fired thermal power plants developed by MOEP

Though MOEP makes every effort to forward new IPP projects such as GE and gas-fired thermal plants around the existing thermal power plants in Yangon Area for short term countermeasures for power supply, MOEP needs to make a middle-long term gas-fired development plan considering gas procurement for power generation.

MOEP needs to study new coal-fired thermal power projects utilizing domestic coal and/or imported coal in view of diversity power sources, future stable power supply, future gas supply amount, etc.

4) Planning rehabilitation of existing power plants

In short term PDP, it is necessary to consider the capacity increased by rehabilitation of the existing power plants with completion time of the projects.

To secure the design installed capacity of the existing power plants, MOEP should reinforce organizations, arrange rules and manuals to implement proper operation & maintenance, and secure sufficient consumables to keep good condition of the existing facilities.

5) Establishment of procedures for power developments

Laws and regulations for EIA are now in preparation by MOECAF, which will be completed after enactment of the Environmental Conservation Law. Therefore, present evaluation sequences of EIA for the ongoing projects are unclear. In the planning of PDP, MOEP should consider development schedule of each project assuming appropriate periods required for environmental investigations and evaluation procedures. Moreover, new department in charge of environmental assessment should be established in MOEP so as to keep sustainable development of power facilities. For the establishment of the new department, MOEP should plan capacity building from now on.

At present, regulatory ministry on water right of rivers is unclear. MOAI controls water rights for irrigation and agriculture, and the City Development Committees in local governments control water rights for clean water. A regulatory ministry would be necessary to control water right of rivers for development of hydropower, irrigation and agriculture, water supply, etc.

Though attention to renewable energy such as solar and wind power is increasing for future power resources, there is no circumstance to introduce them by promoting measures against relatively high generation cost.

(3) Procurement of Power Fuel

MOEP is responsible for gas supply to ongoing gas-fired IPP projects. MOEP needs to study how to reflect cost of gas procurement into the electricity tariff. On the contrary, MOEP plans new IPPs of coal-fired thermal power projects, for which the developers should procure necessary coal for power generation by themselves. In this case, procurement cost of coal is to be included in the electricity tariff from IPP.

If a new gas-fired IPP project is planned from now, securing of required gas amount would be a critical issue. Gas ingredients are different among locations of gas production. MOEP needs to study not only required gas amount but also installation of gas pipes and plan of supply facilities according to gas ingredients.

MOE supplies domestic gas for the existing gas-fired power plants of MOEP. Demarcation between MOEP and MOE should be defined in gas procurement and supply for new gas-fired thermal generation.

(4) Rural Development (Rural Electrification)

An expansion plan of the national grid should be coordinated with the National Electrification Plan on Rural Electrification presently supported by WB.

DRD and ESE are in charge of making the Master Plan on Rural Electrification, showing the future electrification plan until 2030.

2.3.2 Power Sector of Other Countries

After 1990s, ASEAN (Association of Southeast Asian Nations) countries have promoted liberalization and privatization in each power sector referring to the liberalization models of the Western countries. Up to that time, many ASEAN countries had implemented power supply from SOEs with a vertical integration system.

In the reform of power sectors in the Western countries, an additional large investment was not required because the main purpose of the reform was to improve efficiency in electricity markets by deregulation and more competitive system for power purchase. However, ASEAN countries had different circumstances when they challenged reforms of their power sectors in the following points.

- ♦ The government needs to reduce financial burden for the power sector, and promote privatization and introduce private investment rather than competitive system in the power sector.
- ♦ The power sector needs to develop many power projects to cope with rapid increase of power demand.
- ♦ The power sector has problems such as shortage of power supply, insufficient facilities of transmission and distribution lines, unstable transmission line systems, power losses of transmission and distribution lines, weak financial state of power industry, etc.

- The government needs to invest without profit to rural electrification for many low-income people.

Present situation of Myanmar power sector is similar to the previous situations in ASEAN countries. The GoM should promote structural reform in the power industry, gradually. To find key points for the structural reform in the Myanmar power sector, issues in the power sectors in Thailand and Indonesia which had similar power sector structures to Myanmar, Vietnam whose sector reform is on-going, and Philippines which has well liberalized power sector, Cambodia which has the high IPP ratio in the total installed capacity, and Pakistan which has been suffering from power shortage, will be good references.

Differences of the power sector structure among Thailand, Indonesia, Cambodia, Pakistan, Vietnam and Philippines are shown in Table 2.3-1. (Detailed sector structures are shown in Appendix-3.)

In Fig.2.3-1, a structure of power sectors is classified into four general models; (1) vertical integration, (2) single buyer, (3) wholesale sector competition, (4) wholesale/retail sector competition.

Table 2.3-1 Differences of Power Sector Structure

Country	Myanmar	Thailand	Indonesia	Cambodia	Pakistan	Vietnam	Philippines
Liberalization model	Single buyer model	Single buyer model	Single buyer model	Single buyer model	Single buyer model	Single buyer model	Wholesale/ retail sector competitive model
Possible field of private company participation	Generation	Generation	Generation	Generation	Generation	Generation, distribution	Generation, transmission, distribution
Power development	Plan of implementation based on PDP	Implementation based on PDP	Implementation based on PDP	Implementation based on PDP	No PDP (only Hydro Vision 2005)	Implementation based on PDP	Full liberalization

Source: prepared by JICA Study Team based on JEPIC (Japan Electric Power information Center Inc.) reports

(1) Vertical Integration Model

Each IPP contracts PPA with public utility or government.

(2) Single Buyer Model

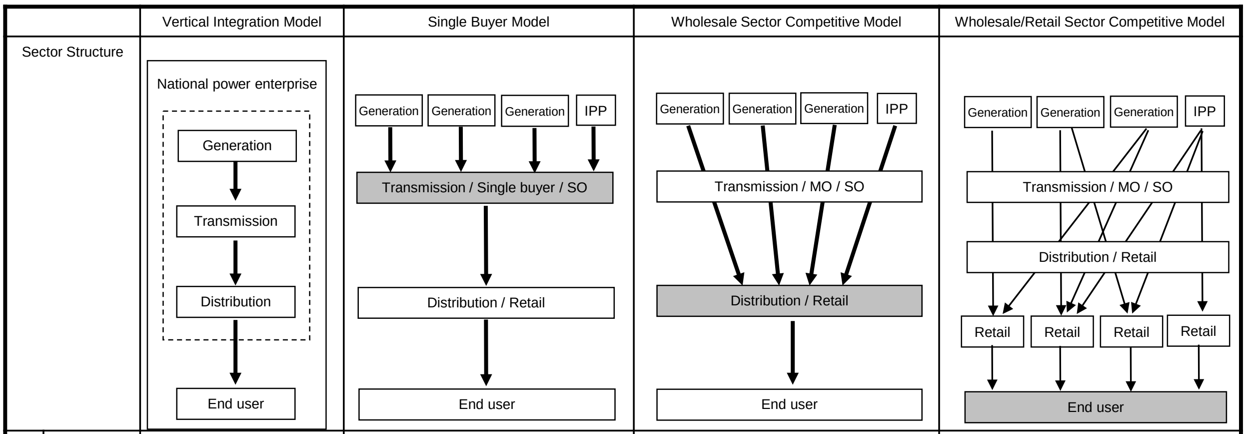
Competition is introduced only to the electricity wholesale sector. The independent single buyer procures wholesale electric power based on fixed contracts with the power producer through competitive bidding.

(3) Wholesale Sector Competition Model

Competition is introduced only to the electricity wholesale sector. Wholesale electric power is dealt with in a form required by market participants, irrespective of the presence of electric power pool market.

(4) Wholesale/Retail Sector Competition Model

Competition is introduced to both electricity wholesale and retail electric power sector. Consumer can select power providers other than conventional power company (power distribution company).



	Vertical Integration Model	Single Buyer Model	Wholesale Sector Competitive Model	Wholesale/Retail Sector Competitive Model
Advanced country	Switzerland, South Africa, Hong Kong	Korea（Cost based pool）	–	(JAPAN), Austria, US, Australia, Belgium, Ireland, Italy, Netherland, Spain, UK, New Zealand, Canada, Denmark, Finland, France, Germany, Greece, Luxembourg, Norway, Portugal, Sweden
Asia	Lao PDR, Nepal	**Vietnam (Cost based pool)**, China, **Indonesia**, **Thailand**, Malaysia, Bangladesh, **Pakistan**, Lao PDR, **Cambodia**, **Myanmar**	India	Singapore, **Philippine**, Turkey
Latin America	Cuba, Haiti, Paraguay, Uruguay, Costa Rica, Jamaica	Honduras, Jamaica, Peru, Trinidad and Tobago, Venezuela	Argentina, Bolivia, Brazil, Colombia, Dominica, Ecuador, Guatemala, Nicaragua, Panama, Chili	EL Salvador
Former Soviet Union, East Europe	Slovakia, Uzbekistan, Turkmenistan, Albania, Azerbaijan, Bosnia-Herzegovina, Bulgaria, State Union Serbia and Montenegro, Tadzhikistan	Kyrgyz, Kazakhstan, Armenia, Croatia, Georgia, Hungary	Ukraine, Latvia, Russia, Poland	Romania, Czech republic, Estonia, Moldavia, Slovenia, Lithuania

[Note] SO: System operator, MO: Market Operator,

Source: "Political economics of the unbundling of electricity generation and transmission", 2012, Hiroaki NAGAYAMA

Fig.2.3-1 Types of Electric Power Liberalization Model

In 2006, Myanmar power sector was reformed from the vertical integration by MEPE to four enterprises, generation by HPGE, MEPE and IPPs, transmission by MEPE, distribution by YESB and ESE. MEPE plays a role of the single buyer similar to the power sector of Thailand and Indonesia.

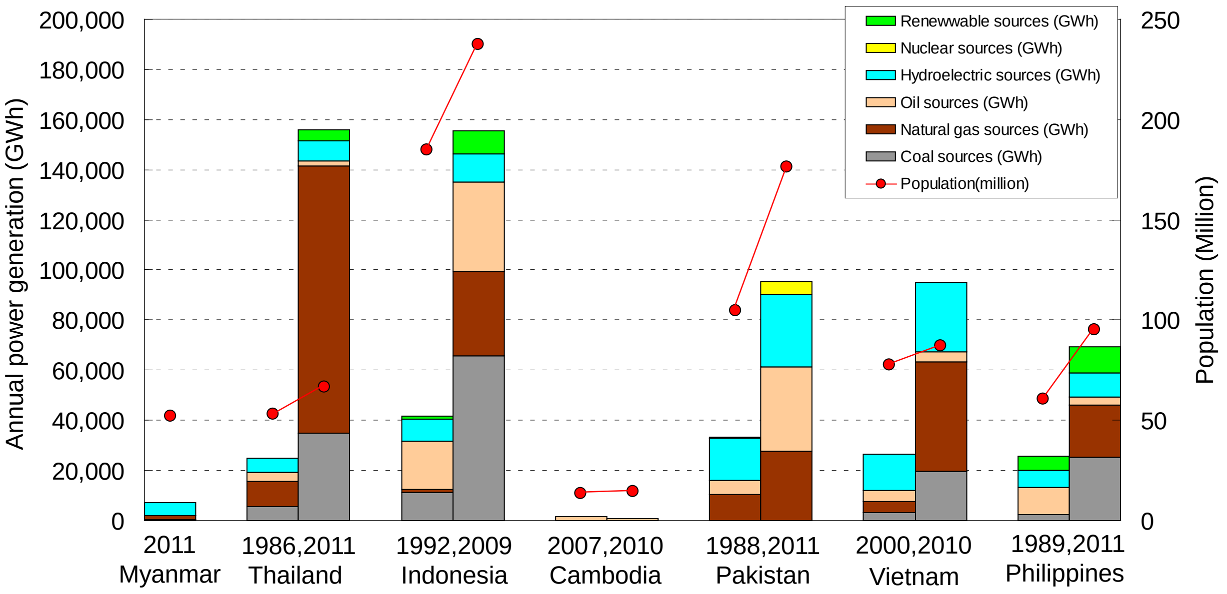
Table 2.3-2 shows benchmark year of each country that the real GDP per capita of each country is nearly equivalent to 783 USD of Myanmar in 2011. Fig. 2.3-2 and Fig. 2.3-3 show change of annual power generation of each country from the benchmark year and change of IPP ratio of each country's installed capacity from the benchmark year respectively.

Table 2.3-2 Real GDP per Capita of Each Country

Country	Myanmar	Thailand	Indonesia	Cambodia	Pakistan	Vietnam	Philippines
Year	2011	1986	1992	2007	1988	2000	1989
Real GDP per capita (USD)	783	813	746	770	784	791	785

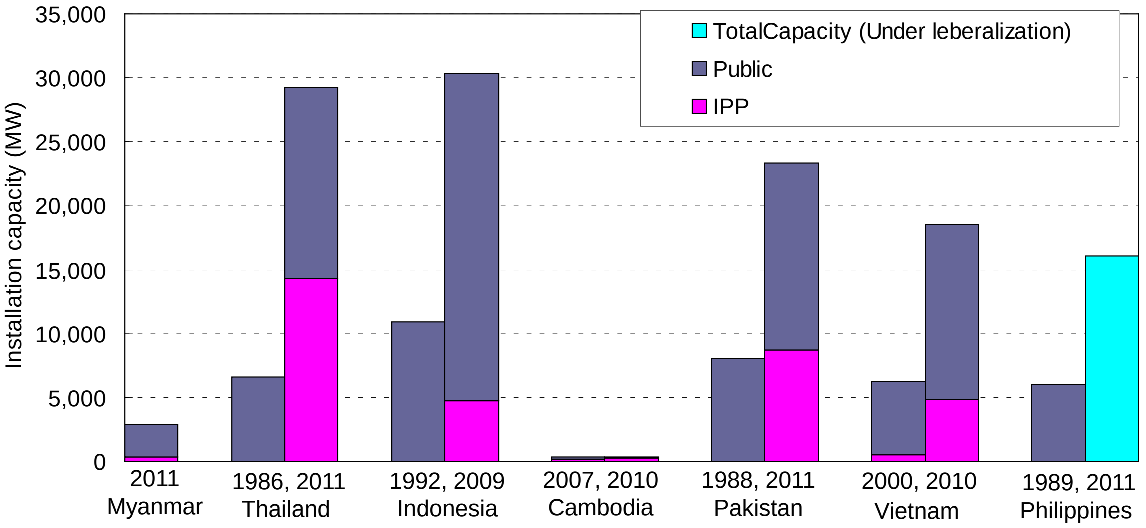
(Notes) Nominal GDP per capita in Thailand, Indonesia and Philippines

Source: Estimated from IMF (International Monetary Fund) Economic Outlook



Source: World Development Index

Fig. 2.3-2 Change of Annual Power Generation of Each Country from Benchmark Year



		Thailand		Indonesia		Cambodia		Pakistan		Vietnam		Philippines	
(%)	2011												2011
	11%	0%		0%		64%		0%	37%	8%	26%	0%	Under

Source: Myanmar: MOEP, Thailand: EGAT HP, JEPIC report (2012), Indonesia: JEPIC report (1998, 2002, 2003, 2010), Cambodia: JEPIC report (2009, 2010), JICA report (2012), Pakistan: JEPIC report (2002), State of Industry Report 2012 (NPRA), Vietnam: JEPIC report (2000, 2003, 2010, 2011), Philippines: JEPIC report (1998, 2012).

Fig. 2.3-3 Change of Each Country's Installed Capacity Ratio of IPP to the Total Capacity from Benchmark Year

The governments of Thailand, Indonesia and Vietnam have been implementing power development with an attempt to utilize domestic natural resources and/or introduce IPPs used in order to meet increase of power demand.

As of 1986, it was proved that there were a certain amount of natural resources such as natural gas in ***Thailand***. However, the amount of each resource was not sufficient to satisfy the domestic energy demands for a long time. In 1980, 80% of the total power output was generated by oil-fired thermal power plants. Since the second oil shock, which had occurred in 1979, caused the increase of the power generation cost in Thailand, the government promoted to diversify kinds of fuel for thermal power plants.

As of 1986, it was said that the expected reserves of natural gas in the Gulf of Thailand were 14 trillion cubic feet and that the proved ones were 4 trillion cubic feet. The reserves of the natural gas were not large, compared with other ones which had been proved in the world. However, the reserves took important roles as one of alternative resources to oil. Reserves of natural gas in Thailand have been exploited in parallel to construction of onshore and offshore gas pipelines, since the development of the reserves in Gulf of Thailand. Hence, it became easy to supply natural gas to power plants so that gas-fired thermal power plants could be the main power source in Thailand. In 2010, power generation with natural gas reached 75% of the total and that with oil became almost 0%.

In Thailand, private investment to the power market was permitted in 1992 so as to promote introduction of private investment and reduction of capital expenditure of EGAT (Electricity Generating Authority of Thailand). Power producers, which are IPP (more than 90MW, procurement with open bidding), Small Power Producer (more than 10MW up to 90MW) and Very Small Power Producer (less than 10MW), have entered into the power market. The ratio of the power producers' capacity of the total installed one became about 49% as of 2012.

In the beginning of 1990s, ***Indonesia*** had adequate supply networks for oil. It was easy to supply oil to demand areas by using both sea and land transportation routes. As of 1991, proved reserves of oil were 5,780 million barrels and expected reserves were 5,520 million barrels. Oil had several advantages in use for power generation such as lower price than international markets, abundant reserves, and adequate supply networks to demand areas. Hence, oil-fired thermal power plants had been initially installed as the main power source.

As of 1993, proved reserves and expected reserves of natural gas were 64.4 trillion cubic feet and 37.2 trillion cubic feet respectively. Since gas-fired thermal power plants had merits of the second lowest power generation cost behind that of coal and acceptable supply networks, the plants have been installed as base or middle power sources in parallel to construction of gas pipelines and development of LNG from the beginning of 1990s.

As of 1993, expected reserves of coal were 36 billion tons. However, infrastructures from mines to demand areas were not established sufficiently to transport coal to the area. Based on the government policy which stipulated that the reliance on oil should be decreased, the government planned to construct more coal-fired thermal power plants including the IPP plants, because the power generation cost of the plants was lowest. Infrastructures were also developed based on the government PDP. Since 1990, coal-fired thermal power plants have been installed one after another.

In Indonesia, introduction of IPPs was permitted by a president decree in 1992, and IPP projects have been promoted with economic growth. Private investment slowed down temporarily due to Asian currency crisis in 1997, and IPP ratio of the total installed capacity became 16% as of 2009.

As of 2010, proved oil reserves are 4.4 billion barrels in ***Vietnam***. Most of oil production has been exported for acquisition of foreign currencies. Hence, the oil has not been used for power generation.

As of 2010, expected reserves of natural gas including associated gas are 24 trillion cubic feet. Natural gas production had increased rapidly from the late 1990s and more than 80% of the natural gas production was used for power generation. Since the price of natural gas for power generation was lower than international market prices, gas-fired thermal power plants have been installed as base or middle power sources.

Vietnam holds hydropower resources, of which 20,500MW can be developed, all over the country. The government policy stipulates that hydropower resources should be exploited positively provided that they will be economical power sources. As of 2009, 92% of the total installed capacity of existing hydropower plants are owned by EVN (Electricity of Vietnam) and its subsidiaries. Hydropower plants have been constructed not only by EVN but also by IPP to meet rapidly increasing energy demand. The plants have been operated mainly as base power sources. The IPP ratio of the total installed capacity in Vietnam became 26% in 2010.

Since hydropower developments will have been nearly completed by 2020, the government plans to construct mainly coal-fired thermal power plants hereafter.

In ***Cambodia*** and ***Pakistan***, installation of IPP plants using expensive fuel has caused large increase of electricity tariff and increase of fiscal burden of the government.

As of 2010, electricity tariff in ***Cambodia*** is higher than those in surrounding countries such as Thailand, Laos and Vietnam. Reliance on small-scale diesel power plants has increased electricity tariff due to high power generation cost. In addition, most of installed small-scale diesel power plants are IPP plants. As of 2010, approximately 93% of the total domestic power output is generated by diesel power plants. 91% of the output is generated by IPP and the ratio of IPP plants' installed capacities to the total ones is 68%.

The Cambodian power sector's issue would be a good example that excess installation of IPP plants of which fuel costs fluctuate significantly would give large impacts on electricity tariff.

In ***Pakistan***, excessive reliance on oil-fired thermal power plants causes an increase of power generation cost. As of 2011, the ratio of IPP plants' installed capacities of the total ones is 37%, and most of the IPP plants are oil-fired thermal power plants. The fuel cost of oil-fired thermal power plants reaches approximately 75% of the total fuel cost for power generation. Out of 75%, oil-fired IPP plants cover approximately 65%. Most of the fuel has been being imported from the outside of the country.

Since the government has kept electricity tariff low, power generation cost is higher than the electricity tariff according to the records from 2008 to 2011. The gap between the power generation cost and the electricity tariff decreases energy supply and leads to deficiency of energy supply.

The National Power Policy 2013 stipulated that Pakistan's power sources should shift to low cost ones such as hydropower, gas, coal, nuclear, and biomass.

As mentioned above, in the PDP, it is necessary to carefully consider adequate utilization of nation's energy resources, constitution of power sources, generation types of IPP plants, and an installed ratio of IPP plants, which are strongly related to electricity tariff.

2.3.3 Reform of Power Sector

(1) Points to be reformed in Present Power Sector Structure

After MOEP(1) and MOEP(2) were consolidated into MOEP in September 2012, re-organization of MOEP has not been executed. Function of governmental departments and SOEs should be clearer, and items to be improved and studied are as follows considering situations of power sectors in other countries as shown in Section 2.3.2:

- In the present Myanmar power sector, it is recommendable that governmental departments should make a power development policy, give approval and license for new power development, regulate periodical inspection of the existing power plants, and SOEs should implement power generation, transmission service, distribution service following the governmental policy and regulations. Two planning departments, DEP and DHPP, in MOEP should be integrated to one department.

- At present, MEPE implements not only transmission service as a single buyer but also gas-fired thermal power generation. In order to make MEPE more efficient entity as a single-buyer, MOEP should carefully study to control all thermal power plants by a new SOE, which the gas-fired thermal department is separated from MEPE and coal-fired thermal power operated by HPGE is included. Since MEPE should have responsibility for electricity supply to the national grid, one of the options is that MEPE owns reservoir type hydropower plants such as Yeywa and Paunglaung, which have large capacity to adjust load fluctuation in the grid.

- In the draft of the new Electricity Law, formation of the electricity regulatory commission for electricity-related works and its duties and responsibilities are stipulated. From now, the GoM should study how to control the power sector by reinforcement of governmental organization further or establishment of an electricity regulatory authority which is politically and financially independent organization.

- For planning of PDP, MOEP needs to implement and evaluate F/S for all power development projects in advance, and to study development priority and the ratio of MOEP's sole development and IPPs' development.

  In the case of IPP development, MOEP should decide its priority, make necessary specifications, select developer by international bidding and implement the project with appropriate cost. As for development schedule of the IPP projects, clear rules are necessary to keep smooth progress of IPP projects. There should be the new rule that MOEP can confiscate a development right from developers, if inappropriate progress of the IPP projects are detected.

- MOEP is developing gas-fired thermal IPP projects. Procurement price of gas for IPPs and wholesale price from IPPs will affect retail electricity tariff. Especially, though MOEP procures gas for power generation with subsidy price from MOE, subsidy will be decreased and wholesale price will increase. MOEP studies to procure shortage of gas amount by LNG international bidding and its procurement price is expected to be high, which largely affects wholesale price and/or financial state of MEPE. Since MOEP needs power development by IPPs because of lack of finance, MOEP should study future effect to the electricity tariff depending on power sources of each IPP type such as hydro, gas, and coal while reserved margin of power supply keeps constant to prevent excess capital investment.

- The GoM puts subsidies to the power sector for procurement of power fuel and wholesale price to keep retail electricity tariff at low level now. To reduce the amount of the governmental subsidies and stabilize financial conditions of generation, transmission and distribution enterprises, an appropriate cost-pass-through system is necessary, through which the retail electricity tariff properly includes construction cost of power facilities, fuel cost, purchase cost from IPPs, operation & maintenance cost etc.

- Since wholesale prices from IPP affect largely electricity tariff, MOEP should fix PPA before giving construction permission to the developer. Provision of rules and procedures of PPA is urgent.

- In view of energy security, MOEP should introduce various power resources and make the best mix with each power resource for electricity supply. In the case of procurement of gas and coal from foreign countries, MOEP should combine domestic and import fuel amount to have bargaining power for price negotiation, keeping stable procurement for fuel demand. Since coal-fired thermal power will be necessary against increment of power demand from now, adoption of CCT should be studied for reduction of environmental burden as growing international concerns. Moreover, introduction of USC (Ultra Supercritical) plant, which is relatively high initial cost but lower fuel cost with high power efficiency, should be studied to reduce emission of carbon dioxide.

- To keep the design capacity of the existing power plants for the long term, MOEP should secure sufficient consumables for each power plant, reinforce the organization and arrange rules and manuals on operation & maintenance, and implement continuous capacity building for management of power plants.

- Under rapid change of circumstance of the Myanmar power sector surrounding, it is urgent to strength human resource development and capacity building of MOEP staff, so as to handle appropriate introduction of IPP (international bidding, PPA negotiation), environmental laws and regulations (EIA, accountability), corporatization of SOEs (pricing policy, subsidy), establishment of electricity regulatory commission (the national electricity policy, the electricity tariff policy), etc.

(2) Points to be studied based on Power Sector Structure of ASEAN Countries

Thailand, Indonesia, Cambodia, Pakistan, Vietnam and Philippines in Asian countries have different steps for the structural reform of power sectors. Background of the sector reform is to develop power plants against rapidly increase of power demand. The situation of them is the same as the present Myanmar power sector. To reform Myanmar power sector, the GoM should consider the following points for study and improvement:

<Structure and Function of Organizations >

- To reinforce governmental organization or to establish the politically and financially independent electricity regulatory authority with sufficient human capacity for promoting liberalization of the power sector.
- To clarify organization responsible for electricity supply.
- To clarify responsible authority on rural electrification and grid expansion.
- Capacity building to the power sector on bidding procedure and PPA negotiation against introduction of many IPP projects.
- To make rules and regulations on operation, maintenance and rehabilitation for ensuring

supply capacity of the existing power plants (Guidance and supervision by electricity regulatory authority).

- To implement environmental and social considerations (EIA, SIA, etc.) and their evaluations for power development projects.
- To establish an organization and make its capacity building for implementation of environmental matters in MOEP.
- To formulate a roadmap to reform the power sector structure.

<PDP>

- To formulate and periodically revise the Energy Master Plan and Electric Master Plan based on forecast of power demand.
- To diversify power resources by utilizing domestic energy (gas, coal) and renewable energy (hydro, wind, solar) for enhancement of energy security.
- To make consistency between PDP and transmission expansion plan, and to eliminate capacity shortage of transmission lines against future PDP.
- To evaluate risks on increase of IPP ratio to the total installed capacity in PDP.
- To arrange a framework to introduce investment; (1) laws such as the Investment Law, the Electricity Law, environmental laws, etc., (2) utilization of capacity payment, (3) stable currency exchange, (4) transparent and clear investment rule (bidding or mutual negotiation), (5) strong macro-economic policy, and so on.
- To utilize governmental subsidy effective to promote renewable energy.
- Governmental guarantee for PPA obligations, obligations of fuel supply, etc., toward investment to power development.

<Electricity Tariff Structure>

- To ensure transparent procedure to determine electricity tariff, and to pass appropriate costs (construction cost of power facilities, fuel cost, purchase cost from IPPs, O&M (Operation & Maintenance) cost, etc.) to electricity tariff.
- To adjust and set proper electricity tariff according to economic growth, and to introduce specific tariff system in accordance with consumption of electricity.
- To inject clear and appropriate governmental subsidies as short term countermeasures and as long term strategy for power development.
- To formulate reduction of subsidies to the power sector.
- To improve financial condition of power generation company (HPGE), power generation and transmission company (MEPE) and distribution company (ESE and YESB).

2.4 CONCLUSION AND RECOMMENDATIONS FOR PRESENT STATE AND ISSUES OF POWER SECTOR

(1) Conclusion

To meet social needs for stable and sustainable power supply, the GoM should implement the following measures for reform of the Myanmar power sector.

- Power sector structure has not been restructured after establishment of new MOEP in September 2012. Therefore, the GoM needs to clarify duties and functions of the present governmental departments (DEP, DHPP, DHPI) and SOEs (MEPE, HPGE, ESE, YESB), and make each function more effective on role and activity. The GoM should implement reform of the present power sector structure and appropriate corporatization of SOEs according to the national electricity policy and the electricity tariff policy by the Electricity Regulatory Commission in accordance with the new Electricity Law. The GoM should implement electricity policies based on the National Energy Policy by effective procedure of decision-making of electricity policies, proper compliance of new environmental and foreign investment laws and regulations, etc.

- PDP to cope with increasing power demand should be an overall plan to keep a constant reserved margin to the power supply to prevent excess capital investment. PDP should be considered appropriate utilization of natural resources of hydro and gas, procurement of power fuel and power introduction in view of energy security, transparent IPP (PPA) rules and regulations, IPP ratio to total installed capacity securing financial soundness and stable power supply, social and environmental considerations with international standards, etc. The GoM should revise periodically the PDP considering power demand and the related master plans such as an energy master plan, a rural electrification master plan, etc.

- The GoM should implement investment to power projects for generation, transmission and distribution according to rational, effective and comprehensive plan of private investment and the governmental budget. And the GoM should implement the transparent pricing policy based on appropriate subsidies and power generation cost to secure financial soundness and proper investment circumstance.

- Under rapid change of circumstances of the Myanmar power sector, it is urgently required to strength human resource development and capacity building of the GoM (MOEP and relevant authorities) staff so as to handle restructure of the power sector, newly related laws and regulations, increment of IPP introduction with international bidding and PPA negotiation, accountability of social and environmental considerations of power projects, the electricity tariff policy by electricity regulatory authority, etc. Improvement of planning ability on the whole power sector and appropriate redistribution of authority are necessary.

(2) Recommendations

It is recommendable that the GoM takes the following concrete actions to reform the power sector efficiently and effectively and to secure stable and sustainable power supply.

- The GoM should make a roadmap to reform the power sector and implement it steadily and concretely.

- It is urgent for the GoM (MOEP and relevant authorities) staff to improve not only designing and planning ability on the national electricity policy, electricity tariff policy and PDP but also management ability of O&M for rapidly increasing power facilities. For implementing necessary capacity building effectively for the GoM staffs in law, planning, finance and technical fields by donor supports, appropriate experts in each field should be obtained and assigned. In addition, these developed experts will be properly re-arranged to appropriate fields to improve the organizational power of electric power sector.

♦ As described in Chapter 8, financial burdens of Myanmar will increase, provided that the installed capacity ratio of IPP to the total capacity is substantial. MOEP should study this situation focusing on appropriateness of planned annual supply and demand balance, agreement of the transmission line expansion plan, and effects to power tariff.

Power supply in rainy season is usually 1.4 times as large as that in dry season. Power supply of gas-fired and coal-fired plants can be reduced by the increase of hydropower generation in rainy season to minimize power generation cost of the national grid. Though most of gas-fired and coal-fired thermal power plants are planned to be developed through BOT and JV/BOT schemes, MOEP should study various sources for procurement of electricity in dry season, including development of thermal power plants own by MOEP and import of electricity from surrounding countries, so that MOEP can how to ensure capacity of electricity supply corresponding to the demand and minimize the generation cost of the national grid.

CHAPTER 3

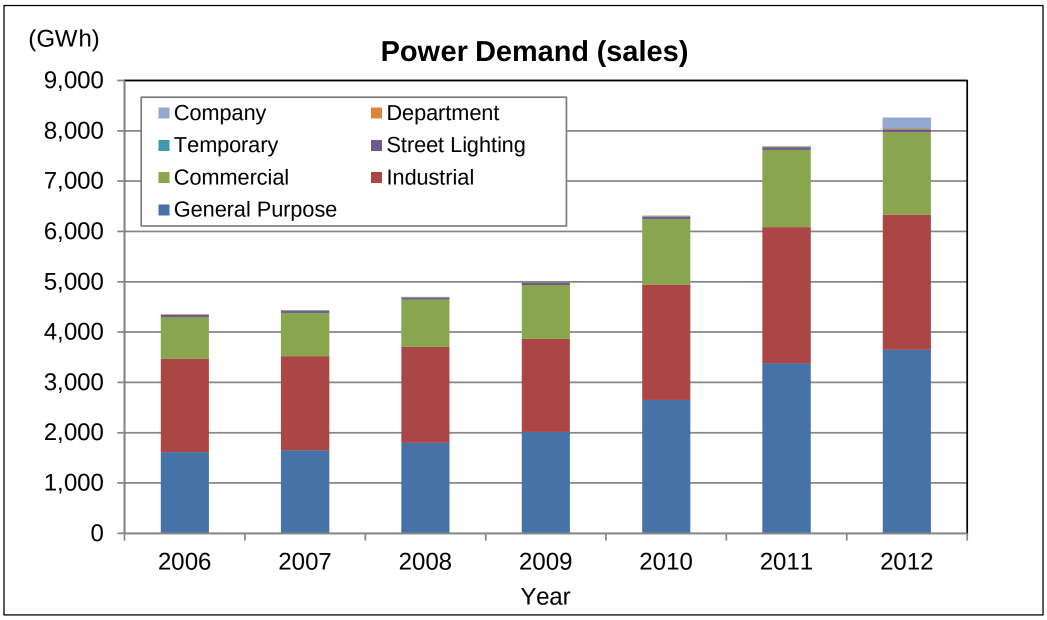
POWER DEMAND FORECAST

CHAPTER 3 POWER DEMAND FORECAST

3.1 CURRENT POWER DEMAND AND FORECAST OF MYANMAR

3.1.1 Current Power Demand Trend of Myanmar

During the 2000s, the power demand in Myanmar recorded annual increase rate by several percent. However, from 2010 rapid development and investment progressed concurrently with transition to democratization evolution. As a result, power consumption also showed a sharp growth, with a growth of 26.5% from 2009 to 2010, 21.9% from 2010 to 2011, and 7.2% in 2012.



Source : MEPE (Myanmar Electric Power Enterprise) Administration Internal Data

Fig. 3.1-1 Power Consumption Trends in Myanmar

Table 3.1-1 Power Consumption in Myanmar

(Unit: GWh)

	General Purpose	Industrial	Commercial	Street Lighting	Temporary	Departmental	Company	TOTAL	Growth
2006	1,614	1,854	827	44	10	6	0	4,355	-
2007	1,647	1,872	864	35	13	7	0	4,438	1.9%
2008	1,799	1,904	945	36	9	8	0	4,701	5.9%
2009	2,015	1,850	1,071	40	9	8	0	4,993	6.2%
2010	2,653	2,287	1,306	44	14	11	0	6,315	26.5%
2011	3,378	2,711	1,531	45	16	15	0	7,696	21.9%
2012	3,650	2,681	1,643	48	15	17	202	8,254	7.2%

Source : MEPE Administration Internal Data

Although the above trends are the base for forecasting power consumption, it is uncertain if the abnormal growth rate of the past few years will continue in the future.

In addition to the apparent demand, it is necessary to properly grasp the potential demand not indicated in the current statistical data in consideration of the following factors:

① Frequent suspension of power supply associated with equipment failure and/or shortage of power supply

② Significant supply restrictions (5 hours a day) towards industrial districts, and resultant increase of non-utility generation

3.1.2 Planned Power Outage (Load Shedding) / Suspension of Power Supply

In Myanmar, especially in Yangon, power supply could not catch up with the sharp growth of demand, and as a result, planned power outage was conducted to respond to the gap between supply and demand. However, due to the occurrence of the large-scale demonstration in May 2012 that protested the shortage of electricity, planned power outage in residential and commercial areas is currently not conducted, and the shortage of electricity is responded to by restricting the electric supply to industrial complexes from 0 to 5 hours a day.

In addition, power outages are occurring due to equipment failure and/or power overload. Although the causes of the power outages are not necessarily the same, according to the data obtained from MEPE (Myanma Electric Power Enterprise) up to 22% in 2012 (February results) on the peak power supply base on consumption showed and at least 4.4% of latent outage is envisaged. The maximum Load shedding results by months are indicated below.

Table 3.1-2 Load Shedding Results (Maximum)

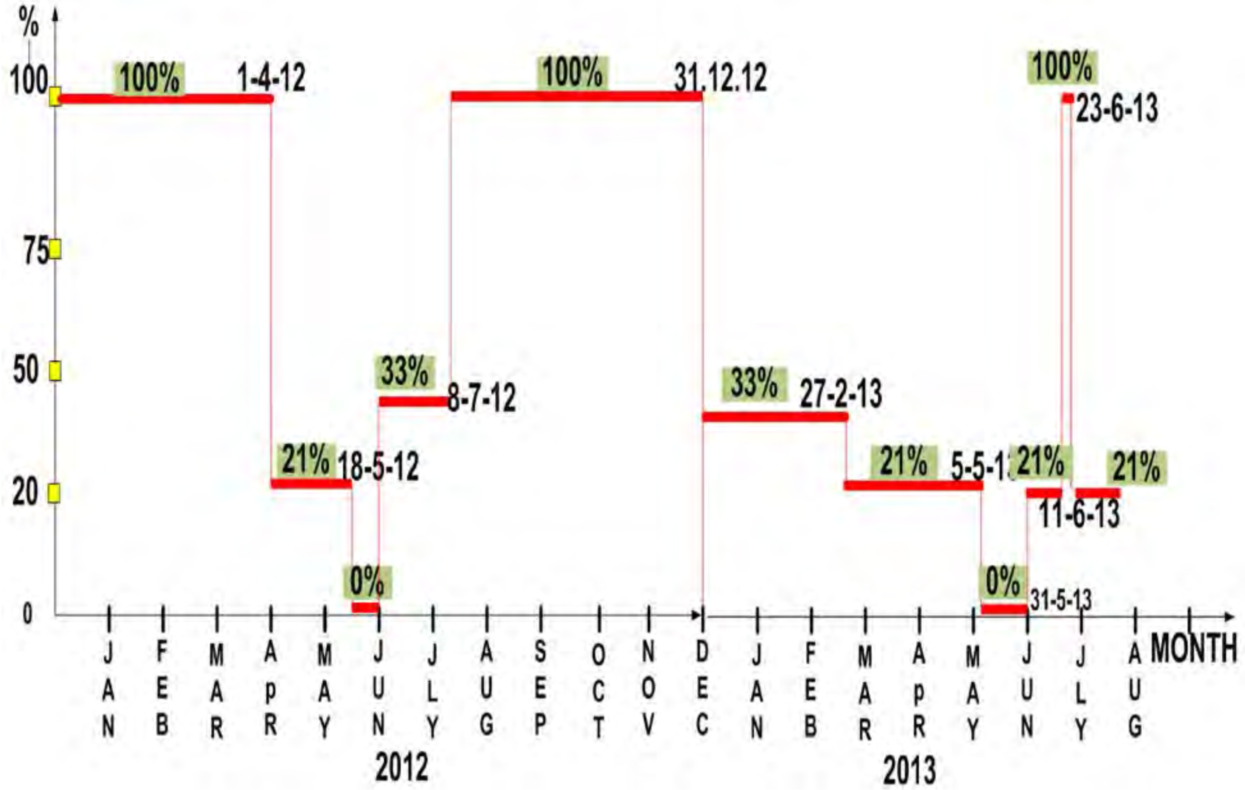
No.	Month	FY 2010 Load Shed (Maximum)	on Consumption	FY 2011 Load Shed (Maximum)	on Consumption	FY 2012 Load Shed (Maximum)	on Consumption
1	April	230	16%	203	14%	211	14%
2	May	283	19%	254	17%	230	16%
3	June	184	13%	179	12%	100	7%
4	July	51	4%	125	9%	0	0%
5	August	84	6%	159	11%	0	0%
6	September	187	13%	27	2%	0	0%
7	October	0	0%	158	11%	0	0%
8	November	0	0%	0	0%	269	19%
9	December	0	0%	0	0%	175	12%
10	January	89	6%	0	0%	304	21%
11	February	153	11%	0	0%	325	22%
12	March	214	15%	286	20%	284	20%
Average		123	8.46%	116	7.98%	158	10.9%

Source : MEPE Administration Internal Data

3.1.3 Industrial Complex

Currently 32 industrial complex locations exist in Myanmar and approximately 14 thereof are concentrated in the Yangon region. As stated, due to the current shortage in the supply of power, only extremely limited supplying of power is conducted to these industrial complexes. Even in August, which is during the rainy season, the supply of power to each industrial complex was limited to 5 hours per day, and a power outage continued for a month in May 2013.

A stable factory operation is impossible under these conditions, thus power is supplied by own non-utility generation facility. Since precise investigations are not carried out on the amount of power consumption by these non-utility generations, the real situation is not fully grasped. In the Yangon region, however, maximum power data are available for each industrial complex, by which it is possible to estimate the current power demand. In addition, it is possible to estimate it by the data of supplied energy amount for regions other than Yangon.



Source : YESB (Yangon City Electricity Supply Board) "Infrastructure of Yangon City Electricity Supply Board"

Fig.3.1-2 Power Supply Trends for YESB Industrial Complex

Table 3.1-3 Yangon Region Industrial Complex

Name	Open	Area (ha)	No of Factories	Capacity (MVA)	Peak Load (MW)
Dagon	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
Mingaladon Pyinmabin	1996	89.8	6	15	5.25
Wartaya	2004	445	3	10	1.8
Shwe Pyi Thar	1996	535.6	240	55	21.2
Yangon Industrial Zone	2000	365.2	31	20	4.5
Myaungtagar (Hmawbi)	2006	411	22	100	32.3
Total	**-**	**4,143.9**	**3,772**	**525**	**168.78**

Source : YESB “Infrastructure of Yangon City Electricity Supply Board”, JETRO (Japan External Trade Organization)
“Myanmar Industrial Complex Research Report”

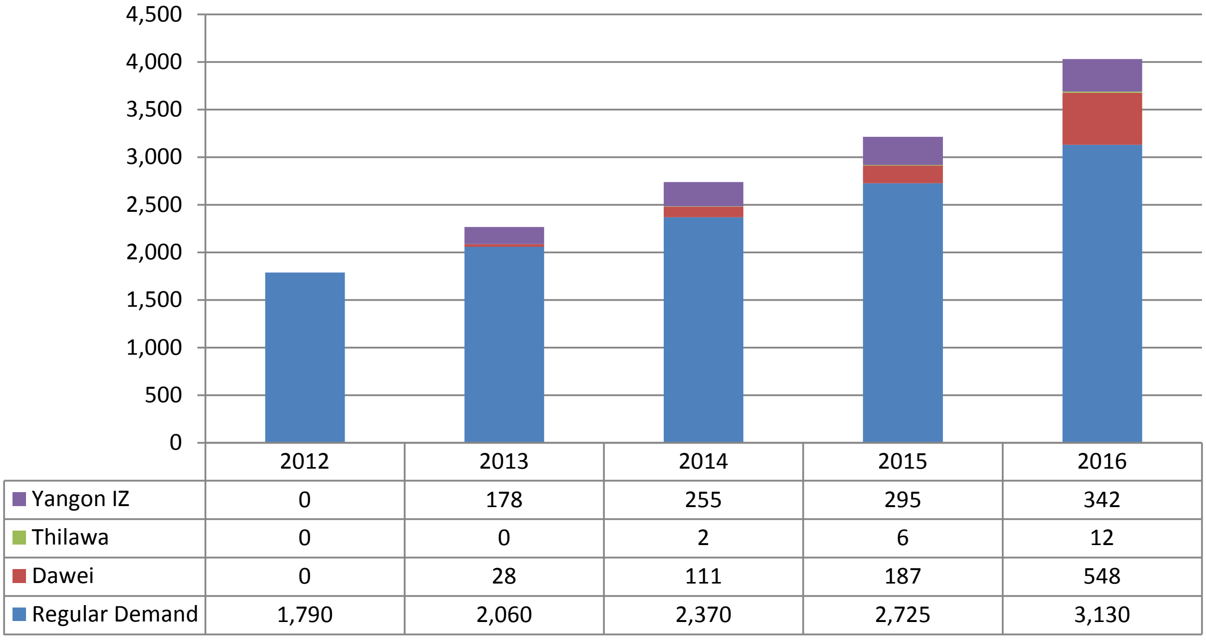
Table 3.1-4 Industrial Complex except Yangon Region

No.	State / Region	Industrial Zone	Max Peak Load (MW)
1	Kachin State	Myintkyina Zone	0.1
2	Kayah State	Loikaw Zone	0.5
3	Kayin State	Hpa-an Zone	-
4	Mon State	Mawlamying Zone	0.5
5	Shan (South) State	Ayetharyar Zone	3
6	Mandalay Region	Zone (1)	20
		Zone (2)	20
		Meikhtila Zone	4.8
		Myin Gyan Zone	1.2
7	Sagaing Region	Ruby Zone	5
		Nandawon Zone	6
		Monywa Zone	2.5
8	Magway	Yaenanchaung	0.6
		Pakokku	1.2
9	Bago (West) region	Zone (1)	2.5
		Zone (2)	0.3
10	Ayeyarwady Region	Pathein Zone	0.25
		Myaungmya	1.56
Total			**70.01**

Source : MEPE Administration Internal Data

The maximum output in the Yangon region is approximately 170MW, whereas the same in regions other than Yangon is only approximately 70 MW, thus in regard to the power demand, the concentration to Yangon is even more predominant. It is considered that this trend will continue.

Other than the above listed industrial complexes (mainly the Yangon industrial district), development plans are underway for 3 SEZ (Special Economic Zone (s)) in Myanmar by Japan, Thailand, Chinese companies, and government cooperation. The DEP (Department of Electric Power) is estimating the power demand of Thilawa SEZ and Dawei SEZ to have a particularly high demand as shown in Fig.3.1-3.



	2012	2013	2014	2015	2016
🟪 Yangon IZ	0	178	255	295	342
🟩 Thilawa	0	0	2	6	12
🟥 Dawei	0	28	111	187	548
🟦 Regular Demand	1,790	2,060	2,370	2,725	3,130

※Yangon IZ = Yangon Industrial Zone

Source : DEP "Power Development Plan in Myanmar in 2013"

Fig.3.1-3 Power Demand Forecast of SEZ (MW)

However, the SEZ development is still underway, and it is necessary to reexamine the demand forecast while taking all progress into consideration. In fact, Dawei SEZs have plans to develop thermal power plant for supplying power to its factories, it is unclear when these SEZ will start to operate and who will supply electricity to them in this moment. Overall national demand is forecasted on macro analysis using GDP (Gross Domestic Product) growth rate and elasticity. The power demand for these SEZs is counted as a part of overall national demand.

In addition, the MOEP (Ministry of Electric Power) will suspend supplying of power to industrial complexes from 2014 and has decided they should procure power by building a power station at each industrial complex, or from a nearby private power producer. If this policy is realized, the power supply for the industrial complexes will be covered privately by each management organization and will not be included in the MOEP's demand.

Though this supply policy seems to have been decided based on a short term less-supply countermeasure, when considering the importance in terms of both policy and technical side, it was believed MOEP should restart policy. From the technical aspect, if electric power supply to the SEZ is assembled in the isolated power system by IPP (Independent Power Producer), it is difficult to ensure the supply reliability in case of emergency accidents. Therefore industrial zones are generally connected to power system. From the political aspect, SEZ development is one of the significant projects for the economic growth in Myanmar. Although electric power is planned to be supplied to the SEZ system by IPP at this moment, it is recognized that the GoM (Government of Myanmar) should support/promote the development of electric power infrastructures.

Currently, in November 2013, MOEP has yet to come up with a mid to long term supply restart policy, which will likely to fluctuate depending on future situations. Therefore, this study conducts a separate demand forecasting for industry and non-industry to make a power development plan for respective demands.

3.2 DEMAND FORECAST

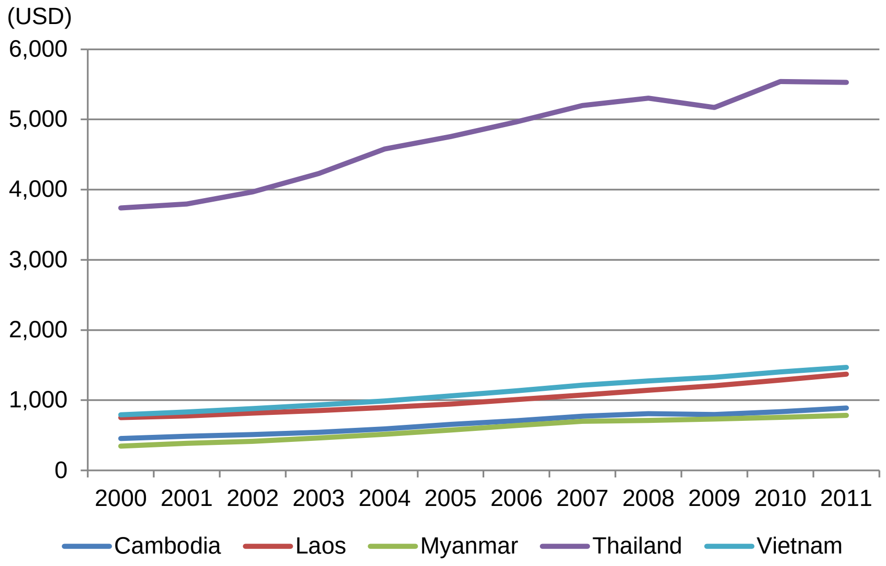
3.2.1 Our Methodology of Demand Forecast

There are various methods when JICA (Japan International Cooperation Agency) Study Team forecasts the power demand. In this analysis, top line forecasting methodology was selected based on the macro trend analysis and it is believed this is the eligible one compared to other methodology such as accumulated forecasting which requires various assumptions for analysis when recognizing the present conditions of Myanmar such as inadequate statistics and no reliable future plan. This methodology could be reviewed in the future when the various statistical data are updated and validated.

3.2.2 Other Countries Way of Thinking of Benchmarks

As described in the following paragraphs, the relevant statistics in Myanmar are still inadequate, both in quality and quantity as to demand, economic development programs or industry development programs for the basis when executing a quantitative future forecast. However, no appropriate references are available as of November 2013. With the start of the President U Thein Sein administration in 2011, a long term economic development plan and a short term 5-year plan developing were studied, however, approval and adjustments by the Parliament was prolonged and have not yet led to an official announcement to the public. In addition, standard economic indicators such as GDP, population, future estimations and goals for the industry composition which are all to be included in those plans, are not announced to the public to date.

Under these conditions, making the power demand data of Myanmar's neighboring countries as the benchmark is considered to be one approach to be taken in order to figure out a mid-to-long term future for 2020, 2030. Since the power demand has the strong correlation between GDP and population, they are to be compared using the GDP per capita standard. The following figure shows the transitions in the real GDP per capita of Myanmar and 4 other countries located in the Mekong economic zone from 2000 to 2011.



Source: Estimated from IMF (International Monetary Fund) Economic Outlook

Fig.3.2-1 GDP per Capita of Myanmar compared with Neighboring Countries

Statistics of the IMF (International Monetary Fund) shows the real GDP per capita in Myanmar was 783 USD in 2011. Thailand and Vietnam, having similar population size, was at an equivalent level with each at 791 USD in 1986 and 813 USD in 2000, and it is considered ideal to make Thailand's 1986 and Vietnam's 2000 situation as the benchmark.

3.2.3 Demand Growth Estimation

Power demand increase in Myanmar currently shows a sharp growth focused in the urban areas. When considering trends of long term demand increase, the estimated future demand differs greatly depending on the initial year or duration. As mentioned above, the growth rate in recent years is 26.5%, 21.9%, and 7.2%, and is in unstable situation. In particular, the approach changes significantly to consider whether or not the growth rate in 2010 and 2011 is to be a trend.

The current forecast by MEPE predicts that the annual rate of power consumption (excluding the industry investment portion) will continue to grow 13% until the year 2030. First, from the results of the power demand from 2001 to 2010, the value of elasticity between GDP and power demand is set at approximately 1.49, then the future numerical value of 13% is calculated multiplying the elasticity value by the 8.74% of economic growth rate in 2011.

First, adequacy of the validity of the value of elasticity estimated by MEPE, is examined as follows. The values of elasticity in Vietnam estimated around the year 2000 as shown in below, are comparable to the current situation in Myanmar. It shows that the standard for the elasticity value of 1.49 set by the GoM is similar to the standard of Vietnam at that time.

2001-2005 : 1.62
2006-2010 : 1.48
2011-2020 : 1.39

Next, the future economic growth rate is considered. MEPE predicts 8.74% growth rate in 2011 will continue at the same growth rate until 2030. Although the past trends of economic growth rate is likely to be used in mature countries, there is a low probability of a scenario in which past trends continue in a country like Myanmar where bigger growth is expected. Furthermore, as described herein above, the future economic development plan in Myanmar and an economic growth forecast based on that plan, has not been provided, MEPE's presumption is hard to be used in a similar way. Therefore, in order to verify the adequacy of the current forecast value and the substitutability of other indicators, the forecast value provided by external international organizations is utilized. In the "Economic Outlook 2012", the IMF expects a 6.7% economic growth rate in Myanmar until 2017. In addition, ADB (Asian Development Bank) forecasts in the country report of Myanmar that the growth of approximately 7 ~ 8% in Myanmar's economy is achievable by 2010 ~ 2030, on the premise that various risks are properly responded. While there is a difference in the period and so forth of the future estimate made by both organizations, the value is lower than the value currently estimated by the GoM.

Summing up the above-mentioned forecasts, both the growth trend estimated by MEPE and economic forecast by IMF is used as a high case and low case respectively in this study. In addition, looking at the industrial demand, it has shown 20% increase over the years. Therefore JICA Study Team will assume that even in the low case the power demand in industry sector will grow at 13% till 2020. (After that, it drops to 9.6% as of IMF base till 2030.)

Significant errors can occur in the final result of the above-mentioned forecast depending on how the future of Myanmar's economy, especially the GDP growth rate, is estimated. Although the trends of the present state and IMF numerical value are being used in this study, substitution with a forecast value based on a defined investment plan is ideal in the future.

3.2.4 Power Consumption Forecast (Consuming End)

A demand forecast is made based on the above. For industrial complexes, with the basis of the current peak demand, the potential demand was added to the assumed relative flat load curve of the industrial complex.

The results are shown below.

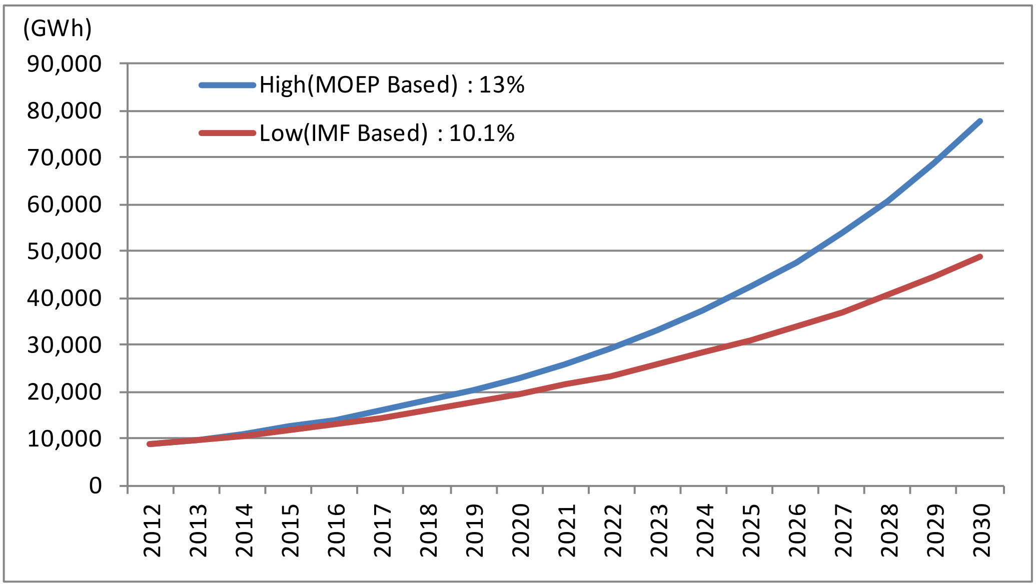
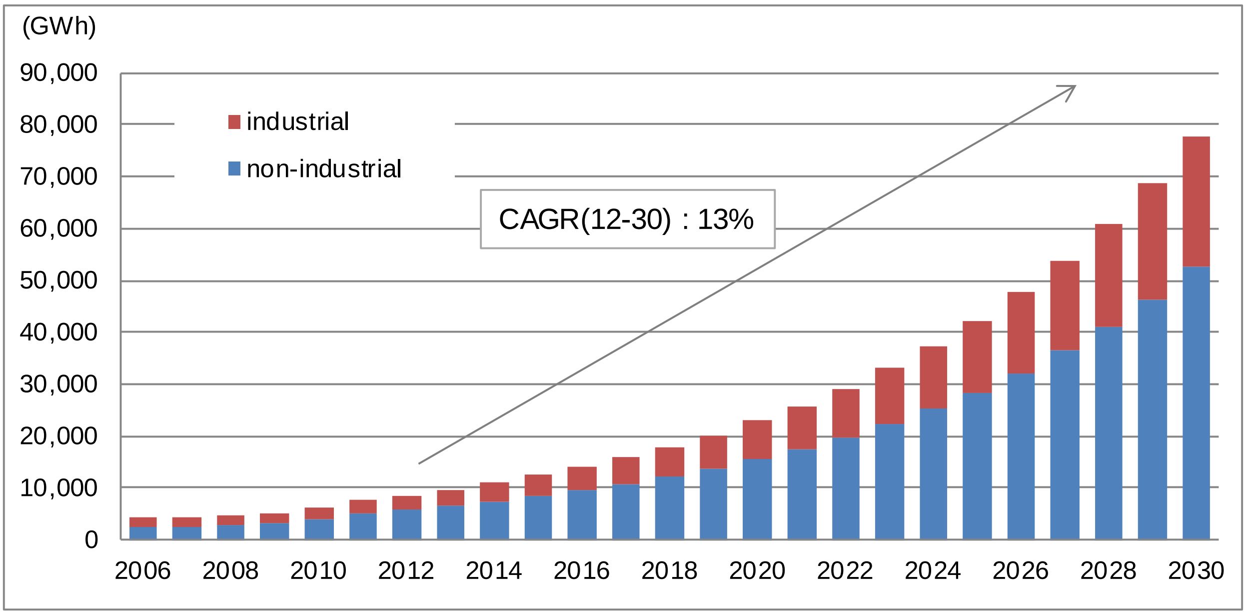


Fig.3.2-2 Power Consumption Forecast of Myanmar

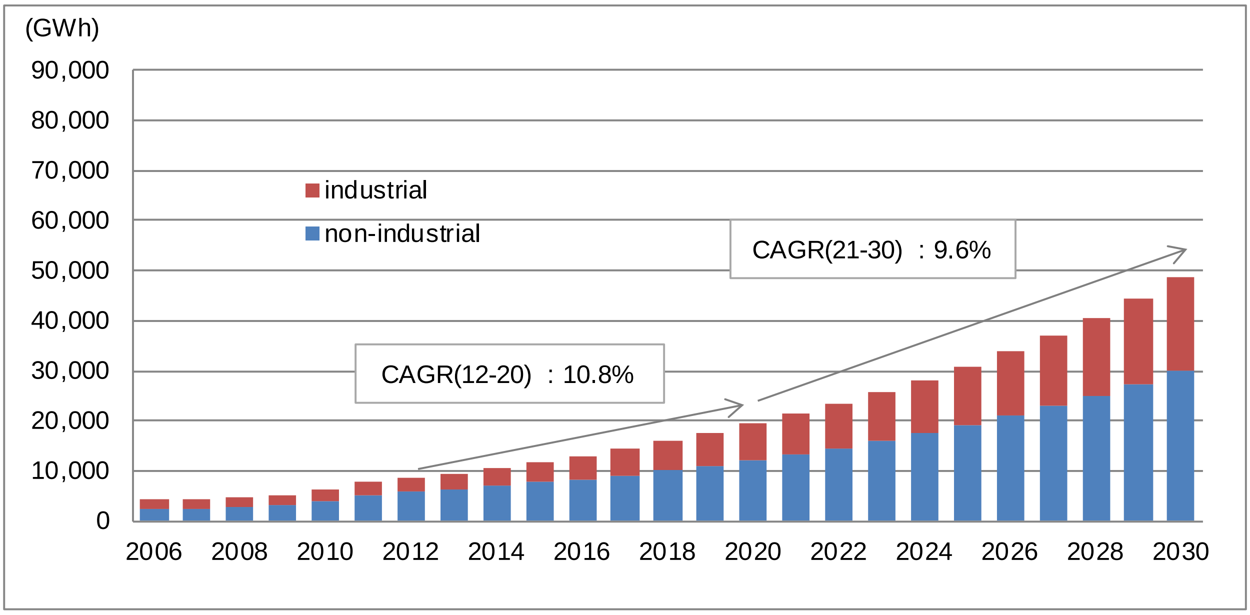
Although the power consumption in 2012 was 8,254GWh, it is projected to be 8,613 GWh when including the potential power demand due to the aforementioned Load shedding and suspension in power supply. When projecting the power consumption based on this, it is estimated at 19,514 GWh in 2020 for the low case (high case: 22,898 GWh) which will be more than twice the present values, and more than five times the present at 48,639 GWh in 2030 for the low case (high case: 77,730 GWh).

It is assumed that the demand for industry in both the high case and low case will keep firm for the short term, and that a definite difference will not appear for both cases until 2020. Assumed power consumption for industrial and for non-industrial sector is shown below.



*CAGR=Compound Average Growth Rate

Fig.3.2-3 Power Demand (GWh, High-case) of Myanmar Separated by Sector



*CAGR=Compound Average Growth Rate

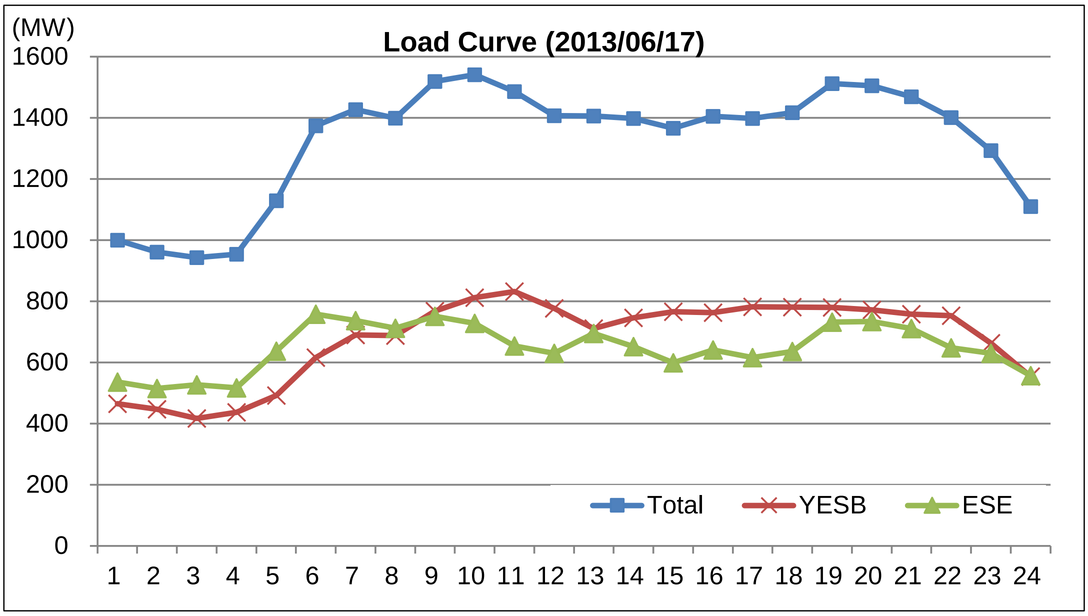
Fig.3.2-4 Power Demand (GWh, Low-case) of Myanmar Separated by Sector

3.2.5 Peak Demand Forecast (Generating End)

(1) Load Curve Comparison

Peak demand based on the amount of power calculated in the preceding section is examined as follows.

First, the peak demand trends must be considered. The peak demand load curve of June 17th, 2013 is shown as an example. The load curve in Myanmar currently shows different tendencies in Yangon region and other regions. In the ESE (Electricity Supply Enterprise) jurisdiction area daytime demands are stable, whereas the YESB jurisdiction area indicates a day demand value is closer to the peak time, thus it can be considered that the differences are due to economic development difference. However when viewing Myanmar in its entirety, 2 peaks in the morning and in the evening are seen, which is identical to those generally appearing in early stages of economic development.



Source : MEPE Administration Internal Data

Fig.3.2-5 Load Curve of the Power Demand (17th June 2013)

In other hands, load factor (daily mean load / peak load) shows the trends in Table 3.2-1 below.

Table 3.2-1 Load Factor Trends in Myanmar

	2010	2011	2012	2013*	Average
Generated Energy (MWh)	7,809,369	10,033,596	10,834,569	11,679,629	10,089,291
Peak Load(MW)	1,371	1,588	1,796	1,969	1,681
Load Factor	65.0%	72.1%	68.9%	67.7%	68.4%

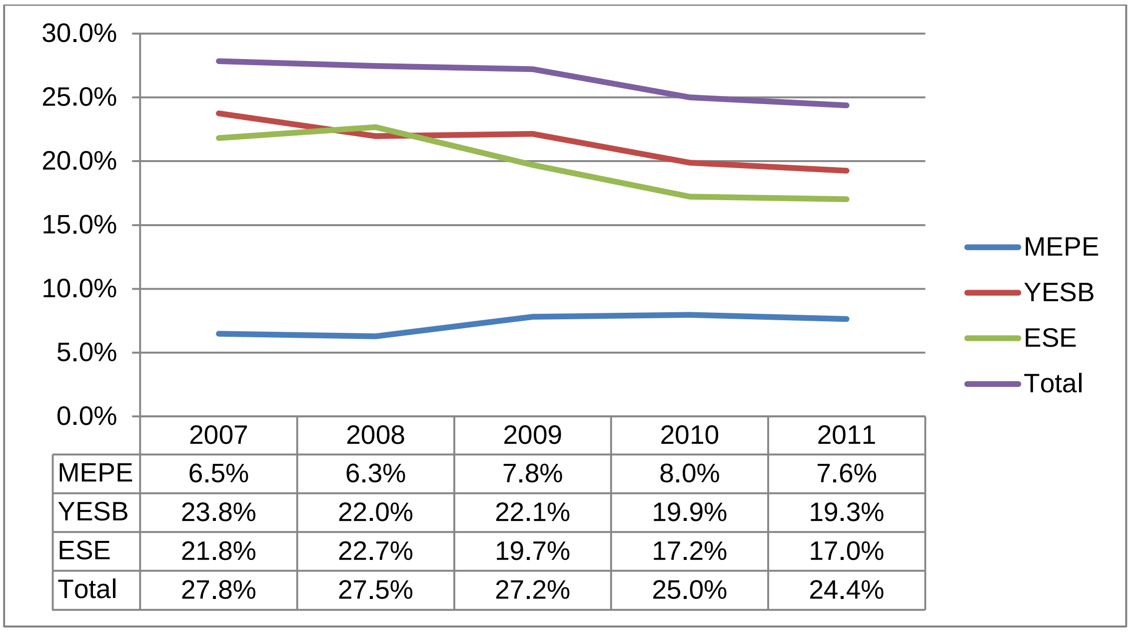
* Actual performance from May to December in 2013

The load factor in Myanmar reaches 72.1% in 2011, and keeps a little drop, 68% in past 2 years. The annual load factor in Thailand, a neighboring country of Myanmar, recorded 71 to 72 % from 1996 to 2006, indicating no trend of change regardless of dispersion found in some years. As the figure in 2013 is incomplete, JICA Study Team assumes future load factor in Myanmar as 68.9% in 2012.

(2) Transmission and Distribution Loss, Study of Internal Use

The analysis above is the estimation of power consumption. JICA Study Team will estimate the power demand of generation-side by setting the future transmission and distribution losses and internal consumption of substations.

In Myanmar, the improvement of power transmission and distribution efficiency is regarded as an important issue, due to the need of supplying power to the vast lands which spread out north and south. Approximately 24% in transmission and distribution loss exist in 2012 as a result of deteriorated power transmission and distribution network facilities and stealing of electricity. While the MEPE power transmission situation has worsened due to increased supply, on the other hand the distribution loss of ESE and YESB tends to be decreasing. Seeing the power transmission and distribution in a comprehensive manner, the total power transmission and distribution loss improved by 3.4 points in the past 5 years from 27.8% in 2007 to 24.4% in 2011.

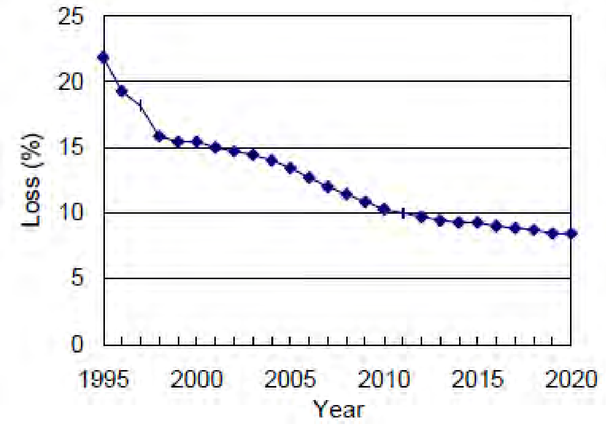


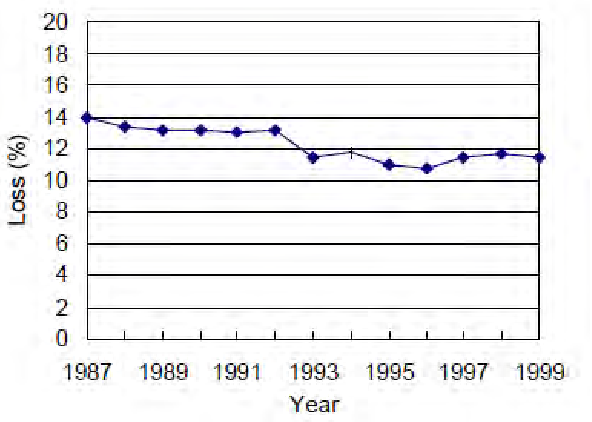
	2007	2008	2009	2010	2011
MEPE	6.5%	6.3%	7.8%	8.0%	7.6%
YESB	23.8%	22.0%	22.1%	19.9%	19.3%
ESE	21.8%	22.7%	19.7%	17.2%	17.0%
Total	27.8%	27.5%	27.2%	25.0%	24.4%

Source : MEPE, YESB, ESE

Fig. 3.2-6 Power Transmission and Distribution Loss Trends in Myanmar

The maximum power of the power supply base is calculated by returning this loss. In addition, it is also necessary to estimate the future power transmission and distribution loss for this analysis. Therefore, a target is set referring to the examples of other countries in the same manner as load factors.





Source : JBIC (Japan Bank for International Cooperation) "Regional Cooperation Strategy on Interconnected Power Networks in Indochina"

Fig. 3.2-7 Power Transmission and Distribution Loss of Vietnam in 2000 and Target Value

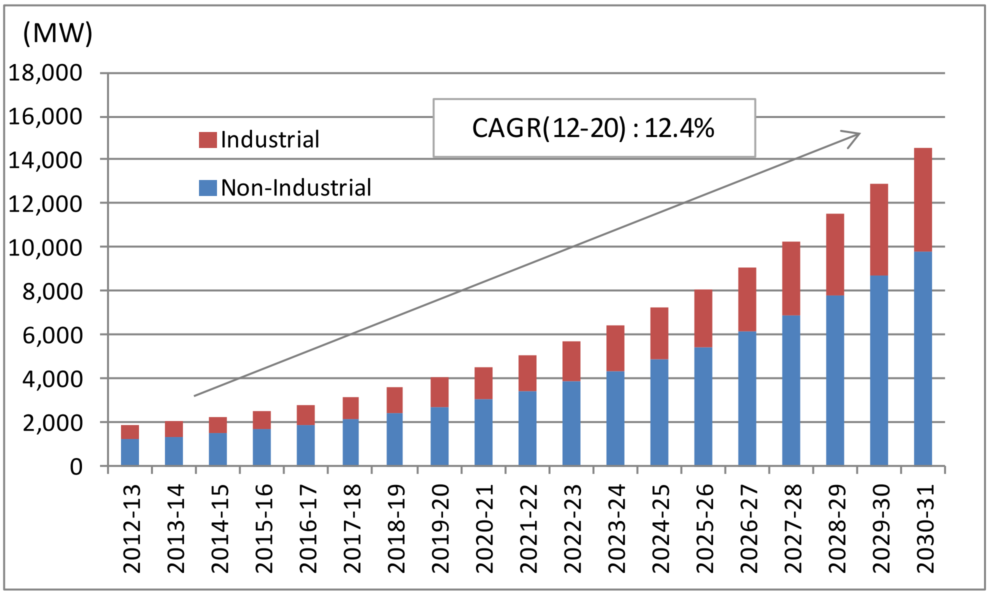
Fig. 3.2-8 Power Transmission and Distribution Loss of Thailand from 1986 to 2000

The power transmission and distribution loss in Vietnam was approximately 15% in 2000, which was lower than that of Myanmar currently. A goal of 9% reduction by 2020 in accordance with the master plan in 2001 was aimed in Vietnam, however, it would be considerably impossible even seeing the case of Thailand that reached 12% finally in 2000. From these facts, the prospective power transmission and distribution loss is set at 12% for 2030, to calculate maximum power of the supply side.

Furthermore, in addition to the power transmission and distribution loss, it is necessary to return the power consumed at each power station and substation in consideration of the future trend. According to the Annual Report of MEPE, YESB, and ESE, the internal use ratio that each company grasps shifted at around 1% from 2007 until 2011. Calculations are conducted assuming that the average value of 0.86% for the past 5 years will continue in the future, because major changes will unlikely to occur in the future in the internal power usage.

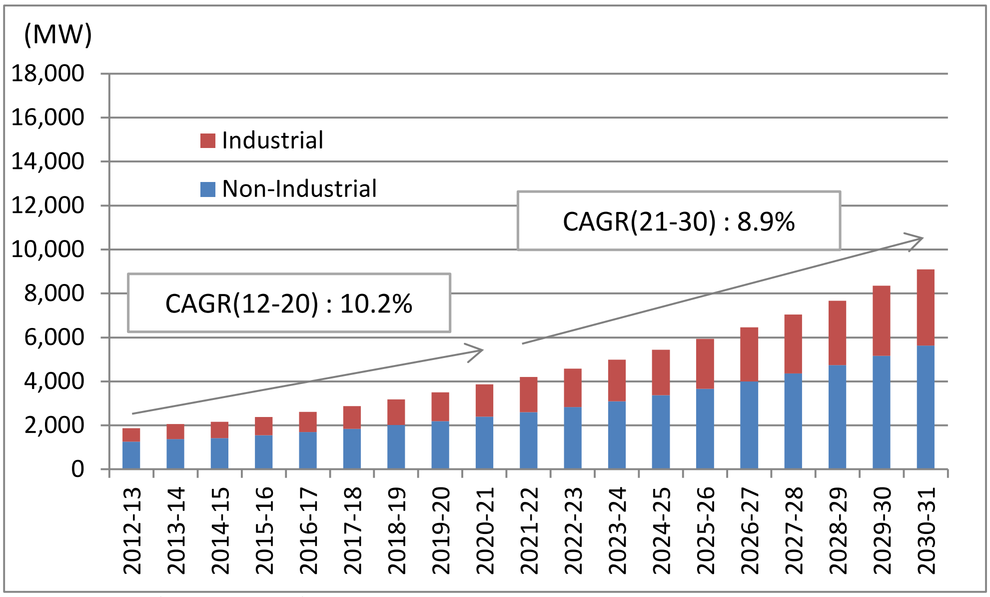
(3) Calculation of Peak Demand

The peak demand calculated under the conditions above is shown below.



*CAGR=Compound Average Growth Rate

Fig. 3.2-9 Maximum Power Demand Forecast (High-case)



*CAGR=Compound Average Growth Rate

Fig. 3.2-10 Maximum Power Demand Forecast (Low-case)

In the industrial sector the maximum power demand in 2020 is 1,472MW for both the high case and low case because it is set equally as the growth rate, however, in the non-industrial sector, 3,060MW in the high case shows a little bit larger than 2,390MW but no notable difference.

These differences become noticeable in 2030, and as a result, the maximum power demand of Myanmar including both industrial and non-industrial is 14,542MW for high case 9,100MW for low case, and the gap will spread more than 5,000MW.

In order to contribute to the better understanding for readers, per capita power consumption is described below.

Table 3.2-2 Per Capita Power Consumption

	Power Consumption per Person (kWh/Capita)		Number (Thousand)
	High Case	Low Case	
2012	163		52,813
2020	408	348	56,125
2030	1,324	829	58,698

Source : United Nations Population

It must be noted that this demand forecast for both cases are calculated based on considerably limited data. Therefore, it can be predicted that the situation will change significantly in and after 2013. Since the load factor, etc. depends on the development pattern of industries, the current forecast also may not necessarily represent an accurate figure. Therefore, it is recommended that the demand forecast shall continue to be revised on year basis.

3.2.6 Distribution of Peak Power Demand by Region

In this study, power demand forecast is aimed to estimate the whole demand of Myanmar from the macro approach and power generation development plan is also studied to satisfy it. Meanwhile it is also necessary for power system development plan to obtain the regional demand forecast and the peak demand calculated as above is allocated by region based on the discussion with MOEP. In the regional demand forecast by MOEP, the MOEP staff sets the growth rate by state and region as follows using the GDP and population data of 2012 as a reference taking each region's characteristics into account.

In Kayin State and Mon State, an abnormal value can be seen against overall trend, and although the power demand growth rate until 2015 is 56% and 38% respectively, this is because of new industrial complexes being planned in both states, and MOEP explains that the calculation is a result of the new demand portions added to the trend.

Although fundamentally it is most ideal to forecast using the prospective future GDP growth rate assumption by region, as conducted for the total demand forecast, unfortunately appropriate data are not currently maintained in Myanmar. Nevertheless, the MOEP's prospective estimate by region is not far off the mark from the base trend of GDP grow rate by region, and can be considered to be accurate for the most part.

Therefore, in this analysis, the demand by region will be allocated with the use of demand forecast results of the Yangon power distribution development plan for the Yangon region and with the MOEP's growth rate estimate as the base for other regions. Besides, JICA Study Team modifies the figure of each region and state with considering individual characteristics through the discussion with MOEP.

Table 3.2-3 MOEP's Estimate of Power Demand Growth Rate by Region/State

Region/State	Growth Rate (%, FY2012)		Growth Rate (%)			
	GDP	Population	-FY2015	-FY2020	-FY2025	-FY2030
Kachin	7.1%	1.3%	12%	7%	7%	7%
Kayah	5.0%	1.5%	5%	4%	4%	4%
Kayin	10.6%	1.2%	56%	11%	7%	7%
Chin	6.9%	1.6%	7%	9%	6%	6%
Mon	9.3%	1.0%	38%	11%	11%	11%
Rakhine	8.4%	1.1%	10%	9%	9%	9%
Shan	7.3%	1.2%	9%	9%	9%	9%
Sagaing	10.2%	1.0%	10%	9%	9%	9%
Tanintharyi	8.8%	1.3%	9%	20%	9%	9%
Bago	10.3%	1.1%	12%	11%	11%	11%
Magway	13.2%	1.1%	11%	10%	6%	5%
Mandalay	13.5%	1.1%	14%	12%	12%	12%
Ayeyarwady	5.8%	1.1%	11%	11%	11%	11%
Yangon	9.5%	1.2%	15%	15%	15%	15%
Total	**8.7%**	**1.1%**	**13%**	**13%**	**13%**	**13%**

Source : MEPE Administration Internal Data

Based on the premises described above, the demand forecast is calculated as follows.

Table 3.2-4 Power Demand Forecast by Region

Region /State	Power Demand (MW, High Casen)		Power Demand (MW, Low Case)	
	FY2012	FY2030	FY2012	FY2030
Kachin	21	185	21	140
Kayah	8	162	8	130
Kayin	13	165	13	135
Chin	3	90	3	60
Mon	45	418	45	338
Rakhine	10	243	10	180
Shan	103	355	103	288
Sagaing	98	349	98	282
Tanintharyi	52	290	52	235
Bago	131	646	131	523
Magway	106	293	106	238
Mandalay	457	2,731	457	2,203
Ayeyarwady	85	406	85	329
Yangon	742	8,209	742	4,019
Total	**1,874**	**14,542**	**1,874**	**9,100**

Lastly, a summary of the demand forecast method and results from the Yangon power distribution development plan by JICA that took place in parallel with this study is presented as a supplement.

In the Yangon demand forecast, similarly to this study, the maximum power is calculated based on the future estimated load curve and load factor from the power consumption. Furthermore, the future power demand growth rate is calculated in a similar way, by setting the prospective GDP predicted value adding value of elasticity. The GDP estimation has 2 patterns, one is the MOEP case (high case as above) with the MOEP forecast as the base, and the other is the alternative scenario (low case as above) with the IMF forecast as the base.

The results calculated in such way as above are shown in Table 3.2-5 below.

Table 3.2-5 Power Demand Forecast Results for Yangon Power Distribution Development Plan

		Power Demand			CAGR*	
		2012	2020	2030	2012 - 2020	2021 - 2030
Consumption (GWh)	High case	4,496	10,801	61,377	11.6%	19.0%
	Low case	2,551	7,459	18,998	14.4%	9.8%
Peak Demand (MW)	High case	938	2,869	9,740	15.0%	13.0%
	Low case	938	2,163	4,769	11.0%	8.2%

*CAGR=Compound Average Growth Rate

3.3 CONCLUSION AND RECOMMENDATIONS FOR POWER DEMAND FORECAST

3.3.1 Conclusion based on the Research Results

A conclusion based on the above-mentioned research results is summarized below.

1) Current power demand and forecast of Myanmar
   - The power demand of Myanmar is increasing remarkably with the recent rapid economic growth. However, it cannot be estimated this trend, which can be said to be an abnormal value, will continue in the future.
   - In addition, it cannot be said that the present value fully represents the present state unless frequent planned power outages and suspension in power supply and significant supply restrictions towards industrial districts are added.
   - The potential demand estimates that the power consumption in the present situation is around 4.4% based on power consumption amount.

2) MOEP will completely suspend supplying power to industrial complexes from 2014, letting each industrial complex procure the power independently. It is not realistic that this policy will apply in the future. It is beneficial for GoM to commit stable power supply to industrial complexes to invite foreign investment. The demand is calculated for both industrial and non-industrial respectively in this study to meet future demand

3) Demand Forecast

   < Our methodology of demand forecast >

   - In this analysis, top line forecasting methodology based on the macro trend analysis is applied. JICA Study Team believes this is the one eligible compared to other methodology such as accumulated forecasting when JICA Study Team recognizes the present conditions of Myanmar such as inadequate statistics and no reliable future plan.
   - Besides, methodology should be simple enough for MOEP staffs to manage to utilize it.
   - This methodology could be reviewed in the future when the various statistical data are updated and validated and MOEP staffs acquire the characteristic of methodologies such as macro and accumulated approaches.

   < Premise of demand forecast >

   - It is ideal to refer to other countries as a benchmark in order to forecast the future of Myanmar due to its undeveloped statistics or future planning. Nearby countries of Thailand and Vietnam is referred to, due to their similar composition of population etc. to Myanmar.
   - The demand growth is calculated by the GDP future estimate and value of elasticity (power demand growth rate / GDP growth rate). Since the 1.49 value of elasticity that the MOEP is using for the power development plan is considered to be valid even comparing with other countries circumstances as well, the same value is used in this study.
   - When making a future forecast, 2 patterns, a high case and a low case, are calculated. The former is the 2011-2012 growth rate estimated by MOEP (13%), and the latter is the calculated based on the IMF forecast (6.4%).

< Power consumption forecast (Consuming end)>

- By the conditions mentioned above, the power consumption is expected to be over double the present at 19,514GWh in 2020 for the low case (high case: 22,898GWh), and approximately five times more than the present at 48,639GWh in 2030 for the low case (high case: 77,730GWh).

< Maximum power forecast (Generating end)>

- The maximum power is calculated with the power consumption as the base, and adds the estimated future daily load curve, power transmission and distribution loss, and internal use.
- The load factor in Myanmar reaches 72.1% in 2011, and keeps a little drop, 68% in past 2 years. In this study JICA Study Team assumes future load factor in Myanmar as 68.9%, which is the actual figures in 2012.
  The annual load factor in Thailand, a neighboring country of Myanmar, recorded 71 to 72 % from 1996 to 2006, indicating no trend of change regardless of dispersion found in some years.
- The future power transmission and distribution loss is assumed to gradually improve to the 12% standard of Thailand in 2000. On the other hand, the internal use rate should not significantly change in the future, and the current standard of a little less than 1% is set out to continue.
- By the conditions mentioned above, it is estimated that the maximum power demand in Myanmar will be in transition at around maximum 14,542MW to minimum 9,100MW by 2030.
- When making power development plan, both high and low case should be taken into study for the preparation toward unpredictable future. In the implementation phase, high case scenario should be chosen to avoid supply shortage which is the most serious problem in power sector.

< Demand forecast by region >

- For the demand forecast by region, the results presumed in the power improvement project by JICA are introduced for the Yangon region, the suppositions by MOEP are judged to be valid for other regions, and based on this the demand excluding the Yangon region is assigned.

3.3.2 Recommendations

In conclusion, a proposal is presented to MOEP. As described above, it is estimated that the power demand in Myanmar will change in a level of 14,542MW maximum to 9,100WM (minimum). In the power forecast by MOEP prepared prior to this study, it is forecasted to be 19,217MW in 2030, which is possible that the forecast is higher than in reality, because the MOEP is calculating without setting the future estimate of the load factor and the power transmission and distribution loss. Transmission and distribution loss is regarded as the important issue to be solved by MEPE and their effort to reduce it is expected to be continued in the future. Therefore it may be higher estimation than actual without considering these factors. In addition, as mentioned herein above, this estimate is calculated on the condition that the current high growth will continue in the future, and the viability of that is uncertain.

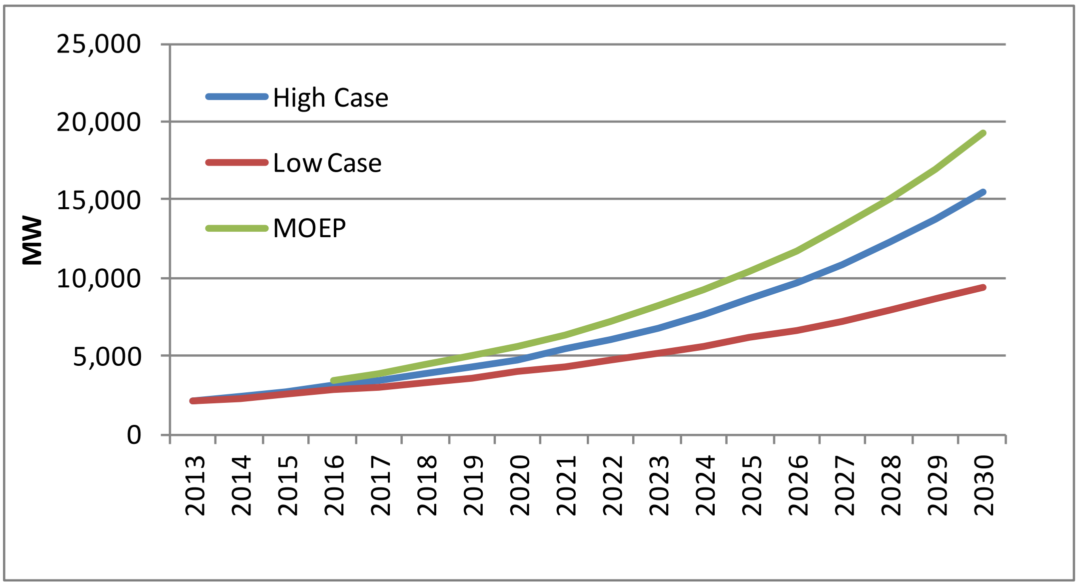


Fig. 3.3-1 Results of Demand Forecast

Table 3.3-1 Results of Demand Forecast

FY	Power Demand (MW, High Case)			Power Demand (MW, Low Case)			MOEP
	Total	Non-Industry	Industry	Total	Non-Industry	Industry	
2012	1,874	1,265	609	1,874	1,265	609	1,666
2020	4,531	3,060	1,472	3,862	2,390	1,472	5,661
2030	14,542	9,819	4,723	9,100	5,631	3,468	19,217

Ideally, the GoM designs highly probable economic development plans and industrial development plans at an early stage, and this demand forecast should be revised in accordance with the objective thereof. Furthermore, the consistency of each parameter should be examined in accordance with the internal and external environment that changes each year, and conducting an annual review is recommended.

CHAPTER 4

PRIMARY ENERGY

CHAPTER 4 PRIMARY ENERGY

4.1 STATUS OF PRIMARY ENERGY IN MYANMAR

4.1.1 Overview

Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower potential in the four main river basins of Ayeyarwady, Chindwin, Thanlwin and Sittoung, is estimated to be more than 100 GW. Many potential large hydropower projects with a total capacity of more than 40 GW are being planned in whole country.

Proven oil reserves 145 MMbbl, in which 102 MMbbl is from onshore oil fields, and proven gas reserves 16.6 TCF, in which 11 TCF gas is from offshore gas fields. Offshore gas is the country's most important source of export revenues, currently supplying to Thailand and China by gas pipelines.

Coal reserve is estimated at 540 Million ton, in which the proven reserve is only 1%. With regard to renewable energy, Myanmar has abundant potential in wind, solar, biomass, etc.

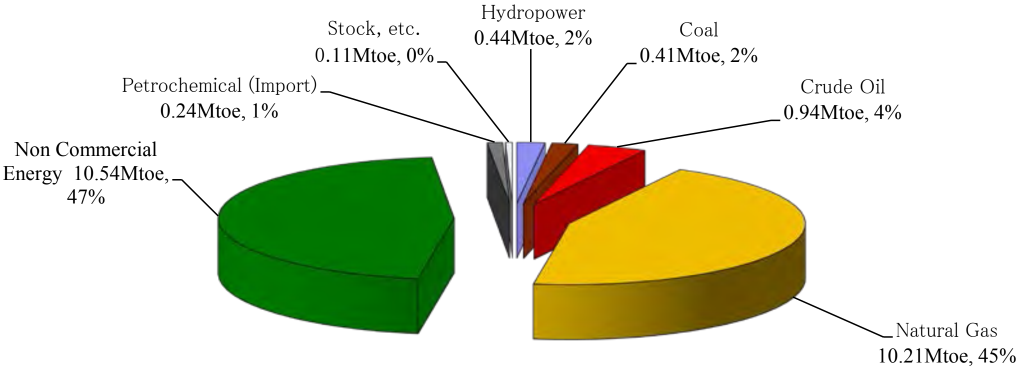
Table 4.1-1 Energy Resources in Myanmar

Resource		Reserve
Hydropower		>100 GW (Estimate)
Crude Oil	Onshore	102 MMbbl (Proven)
	Offshore	43 MMbbl (Proven)
Natural Gas	Onshore	5.6 TCF (Proven)
	Offshore	11 TCF (Proven)
Coal		540 million tons (Estimate)
Wind		365 TWh/year
Solar		52,000 TWh/year

Source: MOE (Ministry of Energy) (2013), ADB (Asian Development Bank) (2012) and JEPIC (Japan Electric Power information Center) (2012) Documents.

According to the energy statistics by IEA (International Energy Agency) 2010 version, the primary energy production (including non-commercial energy such as fuel wood) in Myanmar was 22.5 Mtoe. The breakdown is that non-commercial energy was 10.54 Mtoe (47%), natural gas was 10.21 Mtoe (45%), crude oil was 0.94 Mtoe (4%), coal is 0.41 Mtoe (2%) and hydropower was 0.44 Mtoe (2%).

On the other hand, energy import of Myanmar in 2010 was only petrochemical product (0.24 Mtoe) that marked only 1% of total primary energy production (22.5 Mtoe).



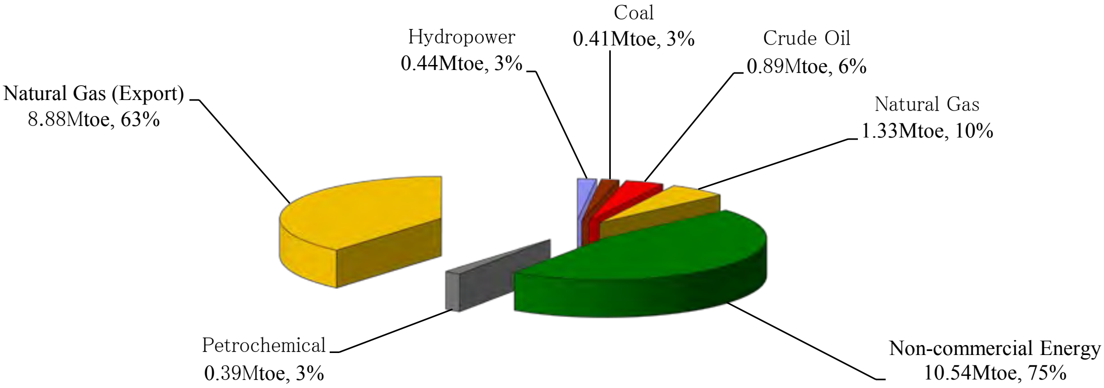
The numbers are in proportion to the total primary energy production (22.5Mtoe).

Source: IEA, Energy Balances of Non-OECD (Organisation for Economic Co-operation and Development) countries 2012

Fig. 4.1-1 Primary Energy Production and Import in Myanmar (2010)

According to energy statistics by IEA, domestic supply of primary energy in Myanmar (2010) was 14.0 Mtoe consisting of hydropower, coal, oil, natural gas, non-commercial energy and petrochemical product. Non-commercial energy occupied 75% (10.54 Mtoe) of total domestic supply (14.0 Mtoe), and natural gas and oil with petrochemical product are 10% (1.33 Mtoe), 9% (1.28 Mtoe) respectively. Hydropower and coal only occupied 3% each.

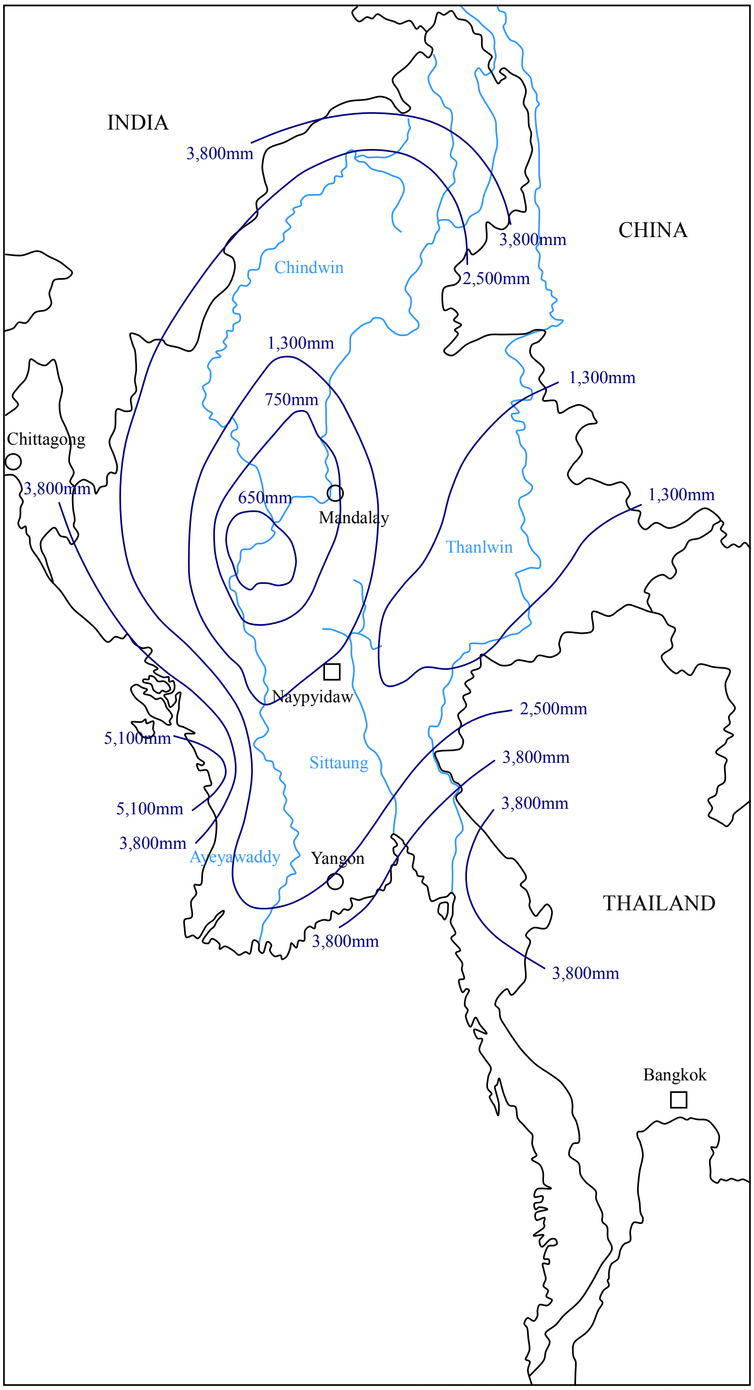
Energy export of Myanmar in 2010 was 8.88 Mtoe by natural gas equivalent to 87% of natural gas production (10.21 Mtoe) and equivalent to 63% of total domestic supply of primary energy (14.0 Mtoe) in Myanmar.



The numbers are in proportion to the total primary energy supply (14.0Mtoe).

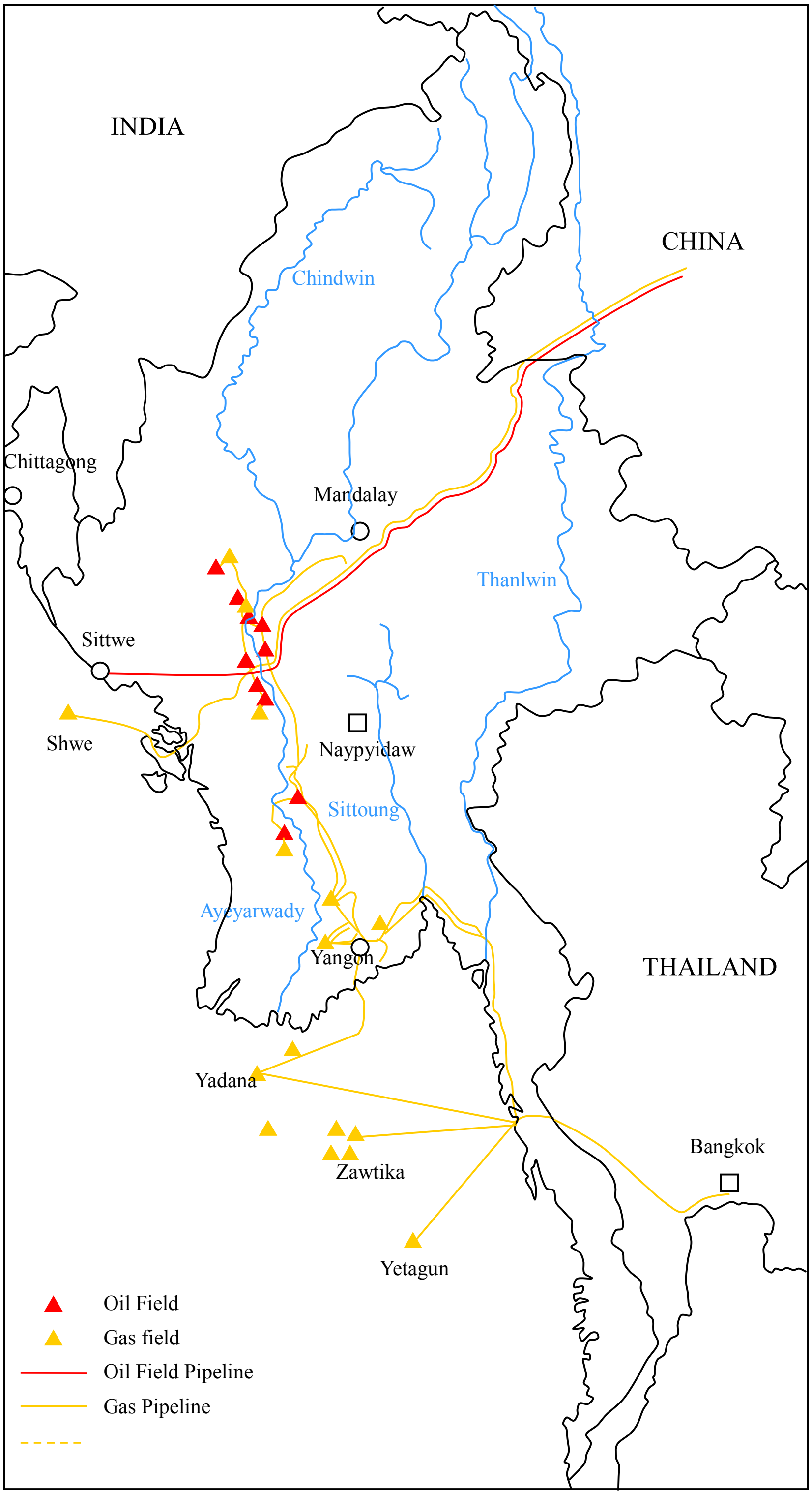
Source: IEA, Energy Balances of Non-OECD countries 2012

Fig. 4.1-2 Primary Energy Domestic Supply and Export in Myanmar (2010)



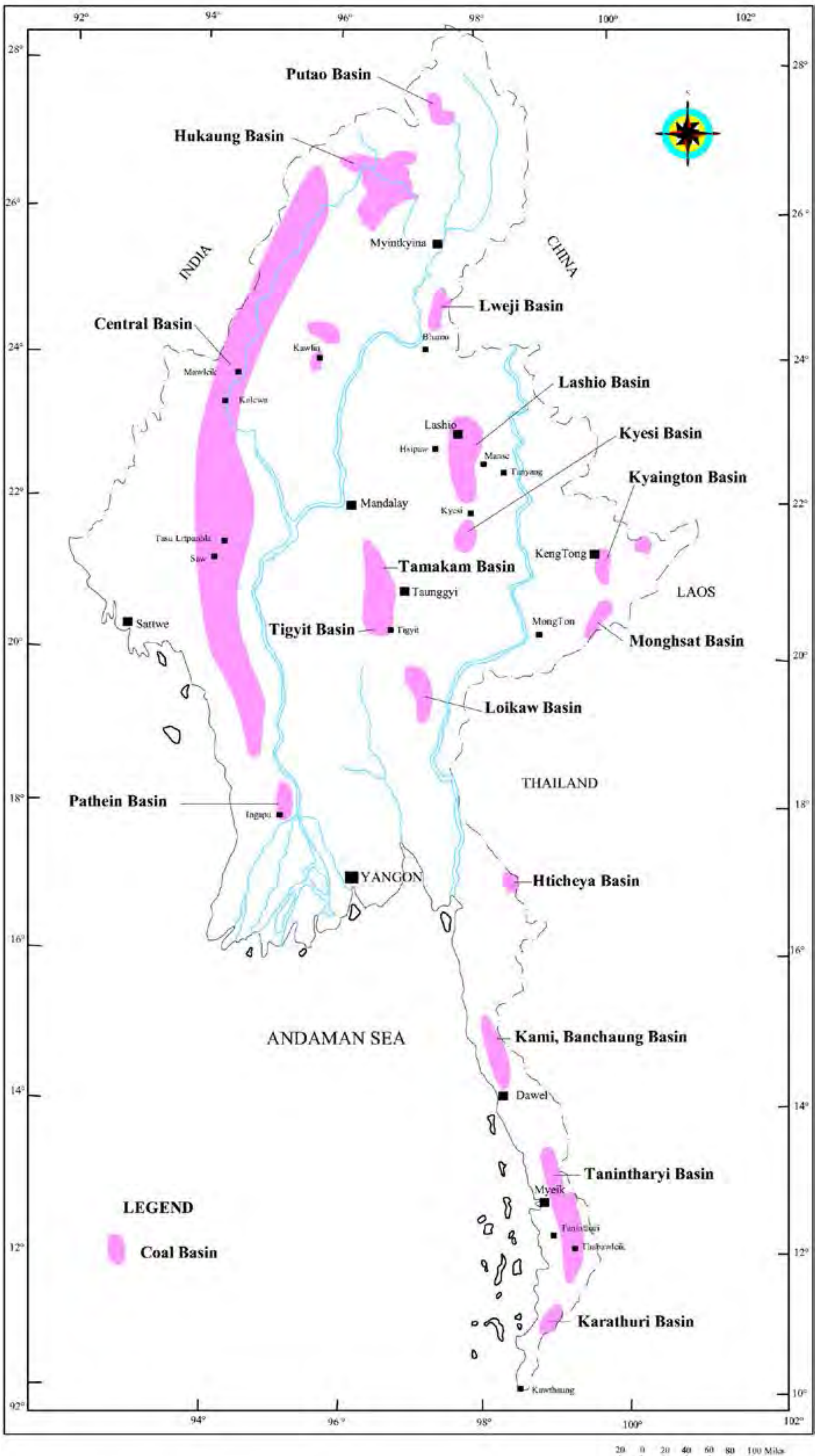
Source: Meteorological Observation Bureau of Myanmar

Fig. 4.1-3 Four Large Rivers and Isohyet Map in Myanmar



Source: prepared by JICA (Japan International Cooperation Agency) Study Team with MOE, JOGMEC (Japan Oil, Gas and Metal National Corporation), JEPIC data

Fig. 4.1-4 Gas and Oil Fields and Pipeline Routes



Source: MOM (Ministry of Mines)

Fig. 4.1-5 Coal Basins in Myanmar

4.1.2 Hydropower

(1) Status and Development Potential

Hydro is the cheapest power resource with abundant potential in Myanmar. However, it is necessary to consider the change of power output capacity between in dry season and in rainy season in the power development plan.[1]

Overall hydro power potential in Myanmar is estimated at 108GW (100%), and possible and primary potential is estimated at 48.5GW (44.9%) so far. The potential of 48.5GW breakdowns into 3.0GW (2.8%, developed), 9.4GW (8.7%, primary) and 36.1GW (33.4%, possible).

Considering relatively small development compared with large resources, hydropower has the huge potential as future electric power sources. It is expected that possible and primary potential will increase through hydro surveys from now on, and the final figure will be between 108GW and 48.5GW.

The capacity of 42.1GW (86.8%) out of the remaining possible and primary potential 48.5GW (100%) is planned to be developed by IPP (Independent Power Producer) of China or Thailand, and a half of electrical generation will be exported to these countries.

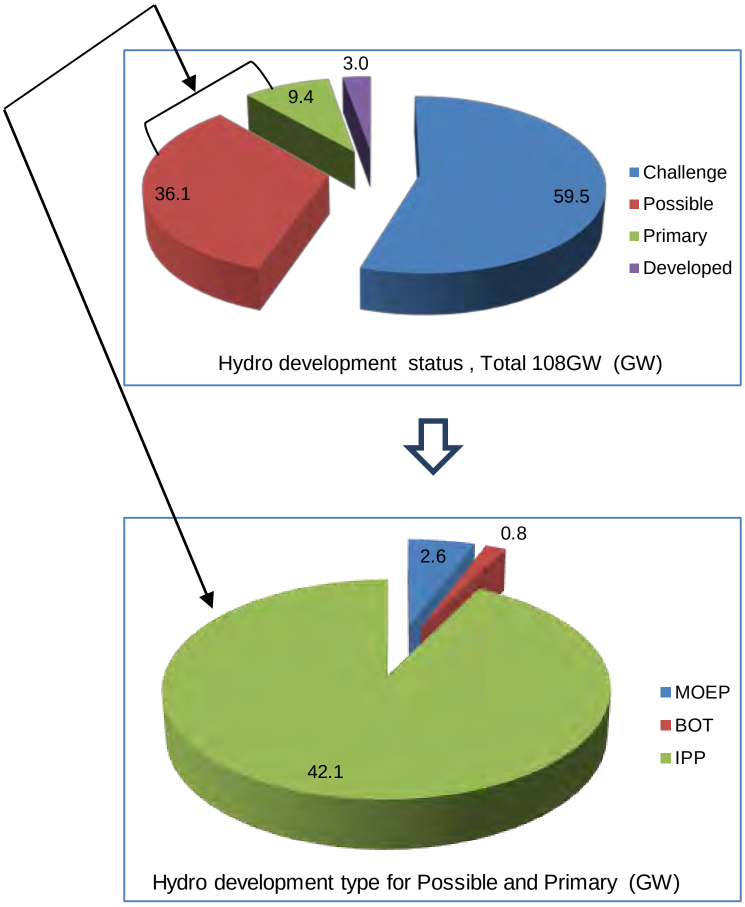


Fig. 4.1-6 Status of Hydro Development

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[1] The detail is explained in Chapter 5

(2) Issues for the Hydropower Development

Although the development potential of hydropower is abundant in Myanmar, there are some issues for the large scale hydropower developments as shown below.

- It is necessary to develop the double installed capacity with development risks and initial investment increase against the demand due to the reduction of power generation in dry season (approximately 50% according to existing records).
- Impacts on the social and natural environment such as resettlements are significant.
- Lead time for the development (survey, design, construction and commissioning) is long.

4.1.3 Natural Gas

(1) Natural Gas Reserves

Natural gas reserves in Myanmar are briefly explained in Section 4.1.1, and the detail is shown in Table 4.1-2.

Table 4.1-2 Product Volume and Future Recoverable Volume as of April 2014

	Proved Reserve	Recoverable Volume	Cumulative Production	Future Recoverable Volume
Onshore (TCF)	9.5	7	1.56	5.44
Offshore (TCF)	19	15	5	10
Total	**28.5**	**22**	**6.56**	**15.44**

Source: MOE as of April 2014

Future recoverable volume is increased from 12.27 described in MOE (Ministry of Energy) data (2012) to 15.44 TCF because proved reserve of onshore gas is increased from 2.5 TCF to 9.5 TCF.

(2) Main Gas Fields and Developers

Fig. 4.1-7 shows gas blocks in Myanmar.

1) Onshore oil/gas fields

According to MOGE (Myanma Oil and Gas Enterprise) presentation material at the Tokyo seminar on July 2014, out of 53 oil/gas fields, 28 oil/gas fields are discovered, 22 oil/gas fields (17 oil fields and 5 gas fields) are operating, 5 oil fields are suspended, 1 oil field is under test and 1 oil field is appraised. The detail explanation is omitted here because gas production from onshore is relatively small compared with that from offshore.

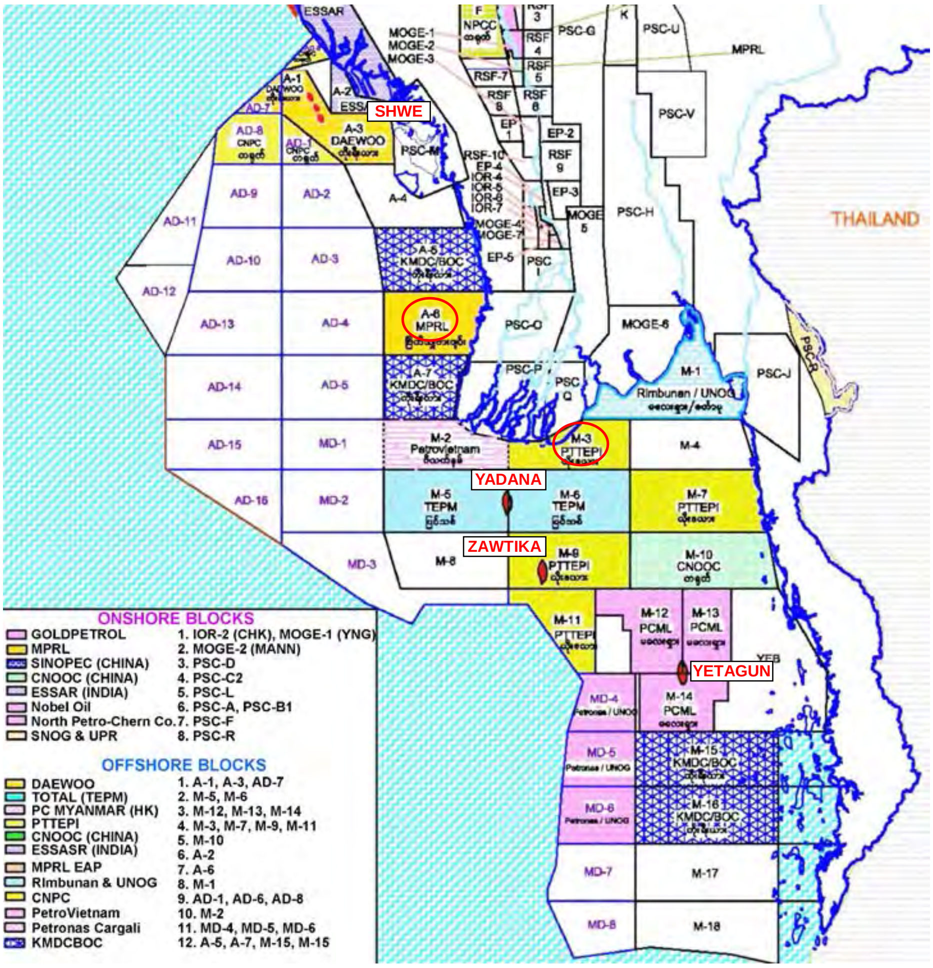
Notable points of onshore gas are as follows;

i) Onshore gas used for gas fired power stations in Yangon Area was replaced by Yadana gas with low heating value. Therefore the existing combustors of GTs (gas turbine(s)) in Hlawga and Ahlone power stations are now being modified.

ii) Kyungchaung and Mann power stations still use onshore gas.

2) Offshore gas fields

According to the information by MOGE as of August 2014, out of 50 gas fields, 4 gas fields (Yadana, Yetagun, Shwe, Zawtika) are operating, 2 gas field (M-3, M-2[2]) are under preparation of the production, 1 gas field (A-6) is appraised[3] and 6 gas fields are under test drilling. Except Yetagun, 20% of gas production is used for domestic consumption. After M-3 gas field, gas from newly developed gas fields will be exclusively used for domestic consumption.



Source: MOE (2012)

Fig. 4.1-7 Gas Blocks in Myanmar

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[2] A gas reserve of M-3 is confirmed, but gas reserve of M-2 is still confirming.

[3] Drillings for evaluation of gas reserve will start in 2015.

Table 4.1-3 Status of Offshore Gas Fields Development

Phase	Gas Field	2P reserves (TCF)	Block	Main Developer	Export	Domestic Supply
Existing	Yadana	6.9	M-5, M-6	Total	Thailand	20%
	Yetagun	4.2	M-12, M-13, M-14	Petronas	Thailand	0%
	Shwe	5.4	A-1, A-3	Daewoo	China	20%
	Zawtika	1.8	M-9	PTTEPI	Thailand	20%
Ongoing		1.6	M-3	PTTEPI		100%
			M-2	Petrovietnam		100%
Appraisal			A-6	MPRL E&P[4]		100%
Under Test			M-11, MD-7, MD-8, AD-1, AD-6, AD-8	PTTEPI CNPC International LTD		100%
Cancel			M-1, M-10			

Source: MOGE Information as of August 2014

(3) Status of Gas Contract System in Myanmar

Fig. 4.1-8 shows the gas contract system in Myanmar. The developer who agrees PSC (Product Shearing Contract) with the GoM (Government of Myanmar) makes GTA (Gas Transportation Agreement) with a gas pipeline operator in Myanmar, and makes GPSA (Gas Purchase Sales Agreement) with a foreign gas distributor. The foreign gas distributor makes GTA with a foreign gas pipeline operator except the case that the foreign gas distributor operates gas pipelines, and makes GSA (Gas Sales Agreement) with foreign consumers.

With regard to domestic consumption, domestic gas pipelines from gas fields or branched pipelines from export gas pipelines are owned by MOGE. Therefore, there is no GTA in the domestic market.

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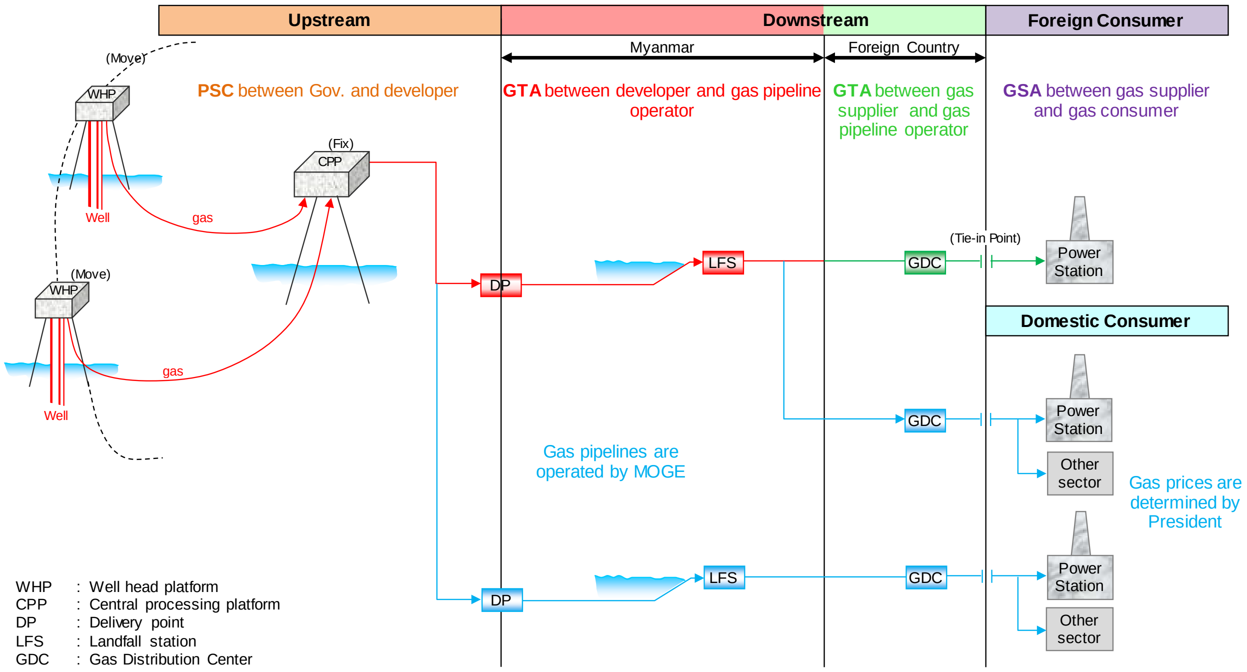
[4] Myanmar Petroleum Resources Ltd. Exploration & Production



Source: prepared by JICA Study Team with hearings of MOE

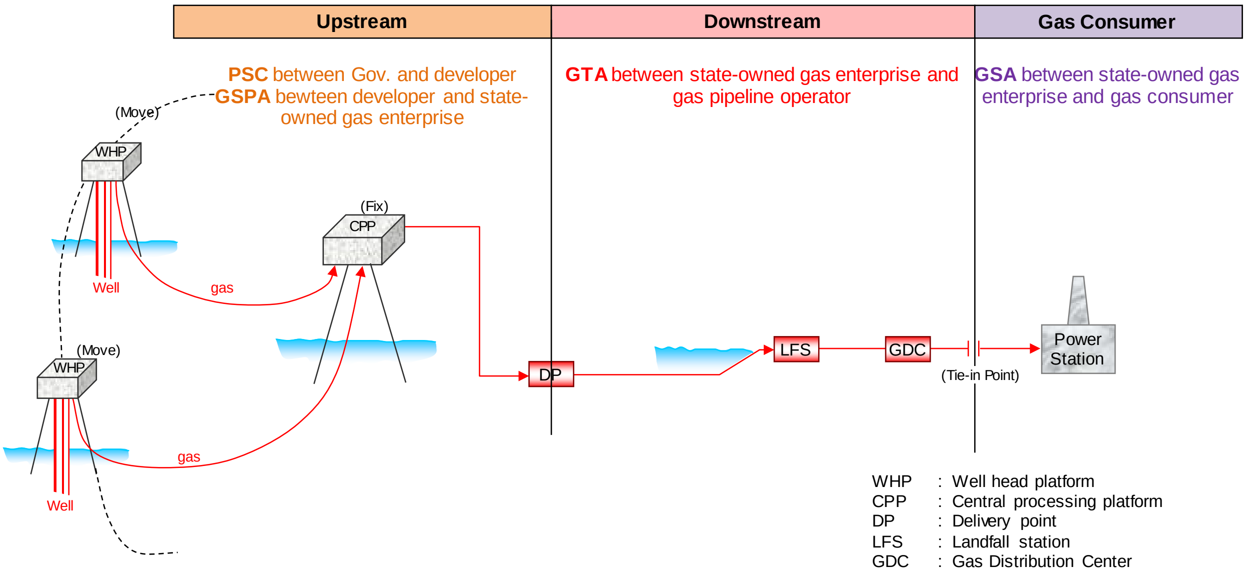
Fig. 4.1-8 Gas Contract System in Myanmar

There are GSAs between MOE and domestic gas consumers (MOEP (Ministry of Electric Power), MOI (Ministry of Industry) and MOT (Ministry of Transportation), etc.). For Yadana gas and Zawtika gas, there is no “Take or Pay” contract for domestic gas, though there is “Take or Pay” contract for export gas.

However, there is “Take or Pay” contract for Shwe gas even for domestic gas. MOE intends to make “Take or Pay” contract for future new gas from now on that will supply 100% for domestic consumers. “Take or Pay” contract for Shwe gas stipulates the following sentence;

“In case that gas consumption is less than 50% of DCQ (Daily Contract Quantity), MOEP must pay for gas quantity equivalent to 50% of DCQ”.

Fig. 4.1-9 shows the gas contract system in Indonesia and Vietnam for reference purpose. A developer who agrees PSC with Government of Indonesia/Government of Vietnam makes GPSA with the state owned gas enterprise. The state owned gas enterprise makes GTA with the gas pipeline operator, and makes GSA with the gas consumers. The state owned gas enterprise controls all agreements.



Source: prepared by JICA Study Team

Fig. 4.1-9 Gas Contract Systems in Indonesia and Vietnam

(4) Gas Production and Domestic Gas Supply

Table 4.1-4 shows gas production in 2012 and Table 4.1-5 shows gas supply forecast in 2013-2014.

Table 4.1-4 Gas Production as of June 2012

Project/Daily Product	Gas (mmcfd)	for Export Gas (mmcfd)	for Domestic Gas (mmcfd)
Yadana (Offshore)	885	684	187
Yetagun (Offshore)	465	465	0
Onshore	70	0	70
Total	**1,420**	**1,149**	**257**

Source: MOE (2012)

Table 4.1-5 Domestic Gas Supply Forecast in 2013-2014

Project	Demand (mmcfd)	Supply (mmcfd)
Onshore + Offshore	590	290
Zawtika	73	60
Shwe	130	20
Total	**793**	**370 (47%)**

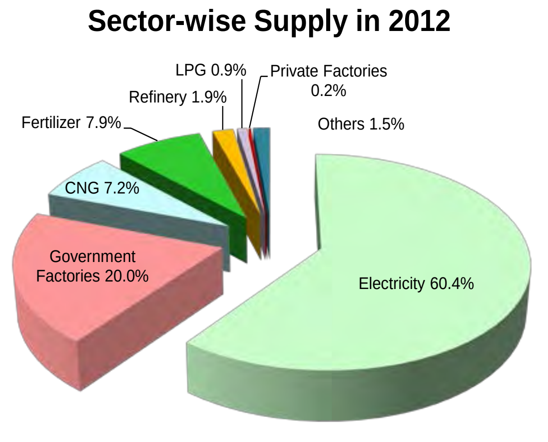
Source: EPD (Energy Planning Department)

Gas production from Zawtika and Shwe starts from 2013-2014 and 20% of the production is supplied for the domestic market.

(5) Countermeasures against Domestic Gas Supply Shortage and Gas Allocation to Gas Consuming Sectors

Fig. 4.1-10 shows sector-wise gas supply ratio in 2012. The power sector received 60% of total gas supply, and will receive about 65% of total gas supply from now on.

Table 4.1-6 shows the short term gas supply and demand balance (2013-2014 ~ 2015-2016) based on MEPE (Myanma Electric Power Enterprise) data prepared in July 2013. Gas shortages of 120, 330, 590 mmscfd are expected in 2013-2014, 2014-2015, 2015-2016 respectively (Outputs and CODs (Commercial Operation Date(s)) of future projects in the table are revised by MOEP and JICA (Japan International Cooperation Agency) Study Team on June 2014, and the results are shown in Section 4.2).



Source: MOE (2012)

Fig. 4.1-10 Sector-wise Gas Supply

Table 4.1-6 Gas Supply and Demand Forecast (2013-2014 ~ 2015-2016) as of July 2013

Location			COD	Output (MW)		New Output (MW)			Required Gas Aomunt for Existing	As of 2013.0		Newly Required Gas			Gas Source
				Existing	Additional	2013-2014	2014-2015	2015-2016		Gas supply (MMSCFD)	Gas shortage (MMSCFD)	2013-2014	2014-2015	2015-2016	
Local	Kyungchung	Existing	1974	54.30					18.00	9.92	8.08				Onshore
	Mann	Existing	1980	36.90					12.00	0.00	12.00				
	Shwedaung	Existing	1984	55.35					27.00	14.35	12.65				Yadana→Shwe→Yadana?
	Mawlamyaing	Existing	1980	12.00					4.00	2.17	1.83				Yadana→Zawtika (2014)
		Myanmar Lighting	2014.04		100.00		100.00						21.00		
			2015.10		130.00			130.00						29.00	
	Myanaung	Existing	1975/1984	34.70					9.00	6.00	3.00				Yadana
	Thaton	Existing	1985/2001	50.95					25.00	22.34	2.66				Yadana→Zawtika (2014)
Yangon	Hlawga	Existing GT/ST	1996/1999	154.20					39.00	33.80	5.20				Yadana
		Zeya	2013.05 (26MW) 2014.02 (28.55W)		54.55	54.55						15.86			
		Hydrolancang (China)	2014.11		243.00		243.00						53.50		LNG
		Hydrolancang (China)	2015.05		243.00			243.00						53.50	
	Ywama	Existing GT/ST	1980/2004	70.30					28.00	24.64	3.36				Yadana
		MSP	2013.07		52.00	52.00						16.57			
		EGAT	2014.02		240.00	240.00						80.00			
	Ahlone	Existing GT/ST	1995/1999	154.20					39.00	30.60	8.40				Yadana
		Toyo-Thai	2013.06		82.00	82.00						29.80			
			2014.09		39.00		39.00								
	Thaketa	Existing GT/ST	1990/1997	92.00					29.00	28.03	0.97				Yadana
		CIC	2013.07		53.60	53.60						15.00			
		BKB(Korea)	2015.02		167.00		167.00						40.00		LNG
			2016.01		336.00			336.00						40.00	
		UREC(China)	2014.12		127.00		127.00						30.00		
			2016.03		386.00			386.00						89.00	
New	Kyaukphyu	MOEP	2014.12		100.00		100.00						20.00		Shwe
	Kanpouk	Dawei Power Utilities	2015.03		175.00		175.00						50.00		Yadana
			2016.02		350.00			350.00						50.00	
Total				**714.90**	**2,878.15**	**482.15**	**951.00**	**1,445.00**	**230.00**	**171.85**	**58.15**	**157.23**	**214.50**	**261.50**	
				3,593.05		**2,878.15**									

☐ Existing 🟨 On-going 🟦 Future

	2013-2014	2014-2015	2015-2016
Total Gas Supply Amount (MMSCFD)	271.85	271.85	271.85
Total Gas Required Amount (MMSCFD)	387.23	601.73	863.23
Total Gas Shortage Amount (MMSCFD)	115.38	329.88	591.38

Additional gas of 100MMSCFD will be supplied on Jan. 2014.

Source: prepared by JICA Study Team based on MEPE presentation material[5]

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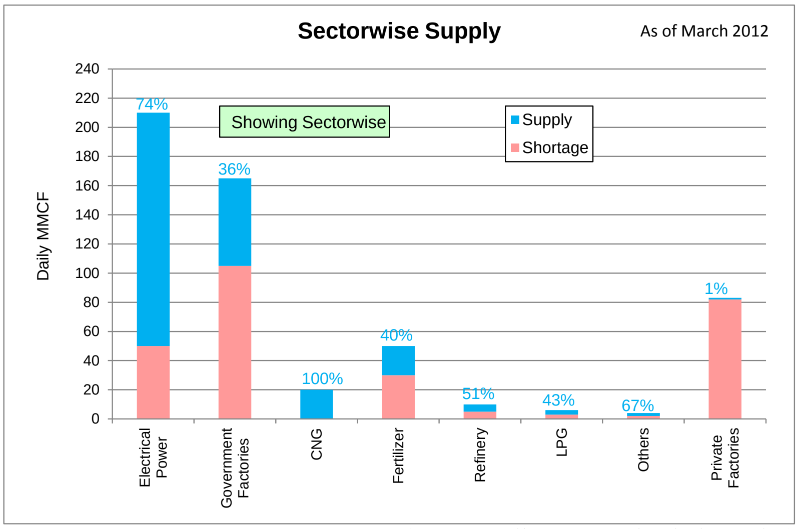
[5] "Power System Development Scheme of MEPE" presented in Naypyitaw on 2nd July 2013



Source: MOGE & JOGMEC (Myanmar Oil, Gas, Petrochemicals Meeting)

Fig. 4.1-11 Gas Supply in Each Sector

Although there are no option clauses on repurchase of gas in GPSA, MOE has negotiated with the gas purchasers of Thailand.
As the results, MOE success in increasing of domestic gas supply is as follows;

Yadana: 150→225 mmcfd
(from April 2014)

Zawtika: 60→100 mmcfd
(from Nov. 2014)

On the other hand, to solve the gas shortage, MOEP is independently trying to purchase LNG (Liquid Natural Gas) (refer to Section 4.1.3). As shown Fig. 4.1-11, other sectors than the power sector also suffer from gas shortage.

To address the gas supply shortage, gas allocation meetings between MOE and gas consuming sectors are held at one- or two-month interval. In the gas supply plan, the one year is divided into 4 ~ 5 periods.

(6) Gas Properties

Table 4.1-7 shows the calorific value (GCV: Gross Calorific Value[6]) and properties of offshore and onshore gases being produced in Myanmar.

Table 4.1-7 Myanmar Offshore and Onshore Gas Properties

Field Name	Offshore			Onland	
	Yadana	Zawtika	Shwe	NDN	AYD
Component	MOLE %	MOLE %	MOLE %	MOLE %	MOLE %
METHANE	69.8801	91.786	97.00	91.2	99.28
ETHANE	1.0106	0.401	0.0	6.4	0
PROPANE	0.1694	0.111	0.0	1.12	0.11
I-BUTANE	0.0184	0.035	0.0	0.57	0.1
N-BUTANE	0.0279	0.021	0.0	0.29	0
I-PENTANE	0.0065	0.01	0.0	0.26	0.05
N-PENTANE	0.0037	0.007	0.0	0.16	0.02
Neo-PENTANE	0.0024				0.01
HEXANE					0
HEXANE & >	0.0211	0.031	0.08	0	0.22
N_2	24.727	7.537	0	0	0
CO_2	4.1298		2.5 0.5	0	0.21
H_2O	0.0011		0.0011	0	
H_2S	0.0021		0.0001	0	
	100	100	100	100	100
GCV (BTU/SCF)	**722.698**	**944.8**	**987.765**	**1007.00**	**1026.489**

Source: MOE

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[6] Same meaning as HHV (higher heating value)

As Yadana contains 30% of inert gases (N_2 and CO_2), the gas heating value (GCV) is considerably low. On the other hand, Zawtika and Shwe contains almost no inert gas. Therefore, the gas heating values are similar to conventional natural gas.

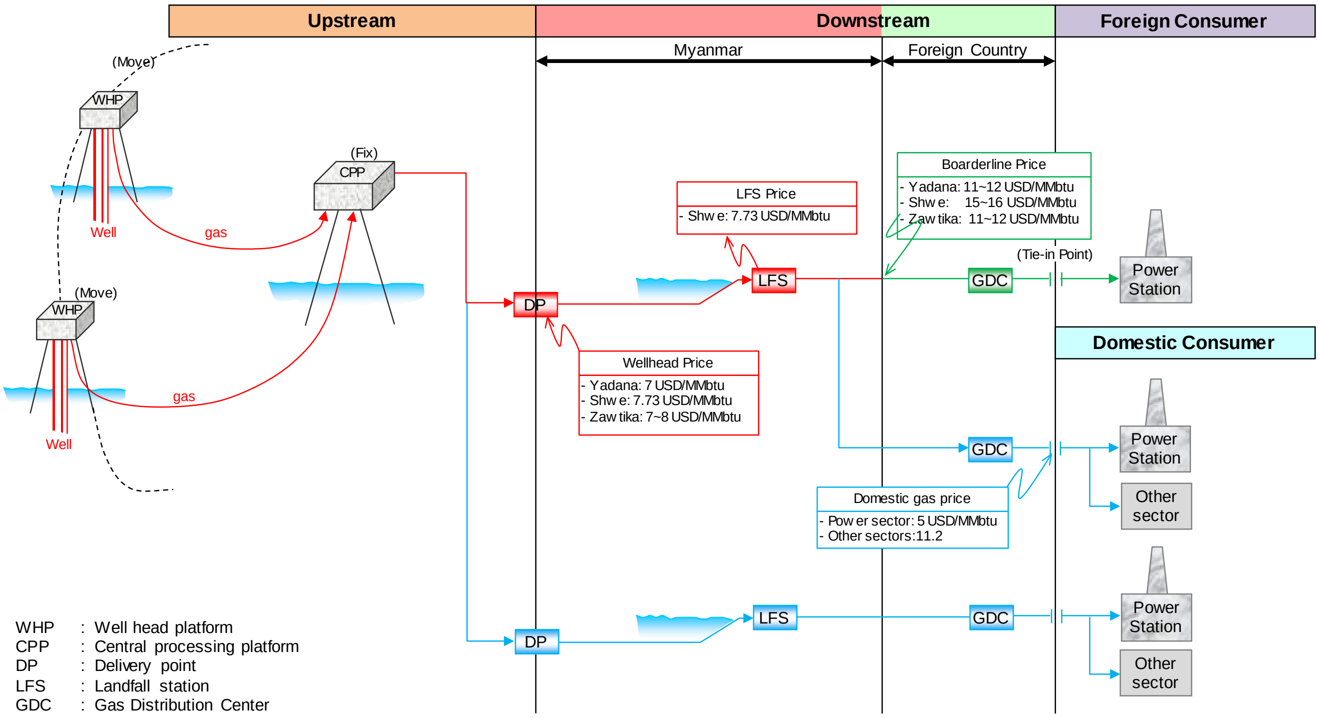
(7) Gas Prices

Fig. 4.1-12 shows gas prices in Myanmar. Although gas prices of Yadana are 7 USD/MMbtu (Wellhead) and 11 ~ 12 USD/MMbtu (Borderline[7]), gas is sold to MEPE at 5 USD/MMbtu with subsidy by the Presidential Decree. Other sectors than the power sector pay 11.2 USD/MMbtu without subsidy.

However, the Parliament deliberated price-up from 5 USD/MMbtu to 7.5 USD/MMbtu in the fall of 2013 and, if approved, MOE will apply for further price-up to 11.2 USD/MMbtu next year (The gas price-up is not yet approved as of August 2014).

In case of Shwe, gas prices are 7.73 USD/MMbtu (Wellhead), 8.59 USD/MMbtu (LFS[8]) and 15 ~ 16 USD/MMbtu (Borderline) respectively.

On the other hand, gas prices of Zawtika recently operated are 7 ~ 8 USD/MMbtu (Wellhead) 8 and 11 ~ 12 USD/MMbtu (Borderline) respectively. Gas prices are fluctuated with American consumer price index and high sulfur fuel oil price at every three (3) month.



Source: prepared by JICA Study Team with hearings of MOE

Fig. 4.1-12 Gas Prices in Myanmar

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[7] Borderline price = Wellhead price + Gas transportation price in Myanmar

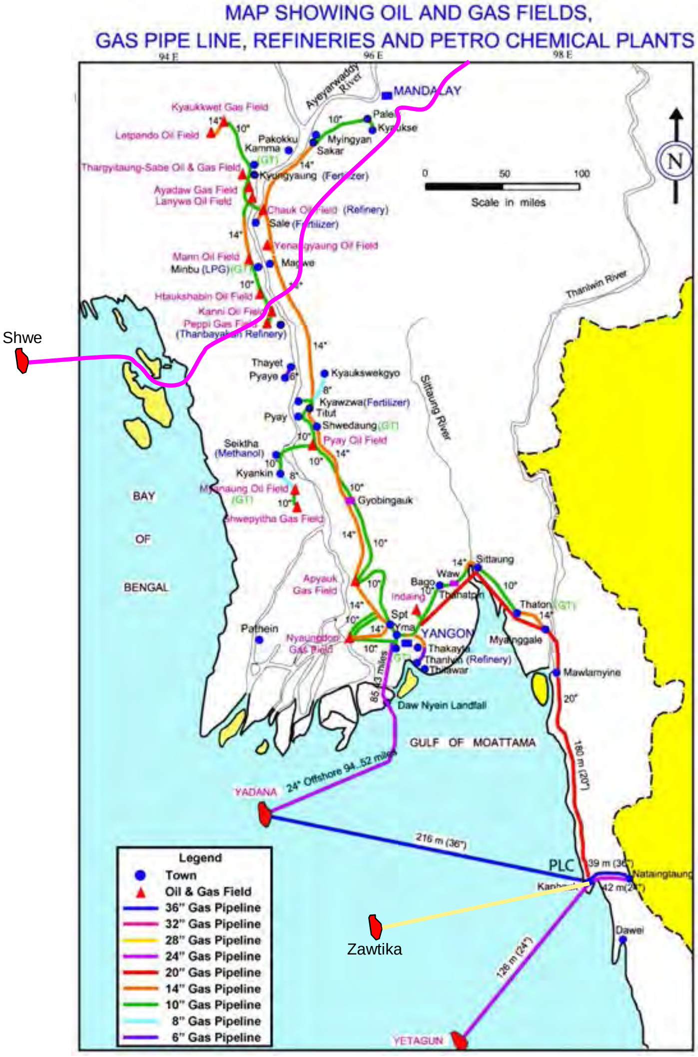
[8] In case of Shwe, gas pipeline form DP (Delivery Point) to the LFS (Landfall Station) is operated by the developer (Daewoo), therefore, gas price is also set at this point.

(8) Gas Pipelines

Fig. 4.1-13 shows onshore and offshore gas pipelines in Myanmar. Domestic gas pipelines are constructed and operated by MOGE, and their total length is 2,278 miles including oil pipelines. The total length of export gas pipelines is 1,172 miles, and the pipeline are operated by foreign firms. In parallel to the Shwe gas pipeline reaching to Yunnan Province of China, a crude oil pipeline is under preparation for commercial operation as of July 2014 (Fig. 4.1-14).

Fig. 4.1-15 shows gas pipelines in Yangon Area. There are two routes form Yadana gas field. The gas pipeline with 24 inch diameter still supply Yadana gas in Yangon Area. However, the gas pipeline through Kanpouk has transported Zawtika gas to Yangon Area instead of Yadana gas since March 2014. Zawtika gas is supplied for Thaketa gas-fired TPP (thermal power plant) and will be supplied for Thilawa future gas-fired TPP in Yangon Area.

According to EPD (Energy Planning Department), they judge the availability of domestic gas pipelines based on empirical rules without the gas flow analysis of gas pipelines system.



Domestic Pipeline

- MOGE has been laying the pipes throughout Myanmar to expand its national pipeline network.
- Various sizes from 6" to 24" of pipeline were constructed.
- Total length is about 2,278 miles.

Export Pipeline

		Offshore (miles)	On land (miles)
Yadana	(36”)	216	39
Yetagun	(24”)	126	43
Zawtika	(28”)	143	42
Shwe	(32”)	65	3
China-Myanmar (Gas)*	(40”)	Nil	495
China-Myanmar (Oil)*	(32”)	Nil	481

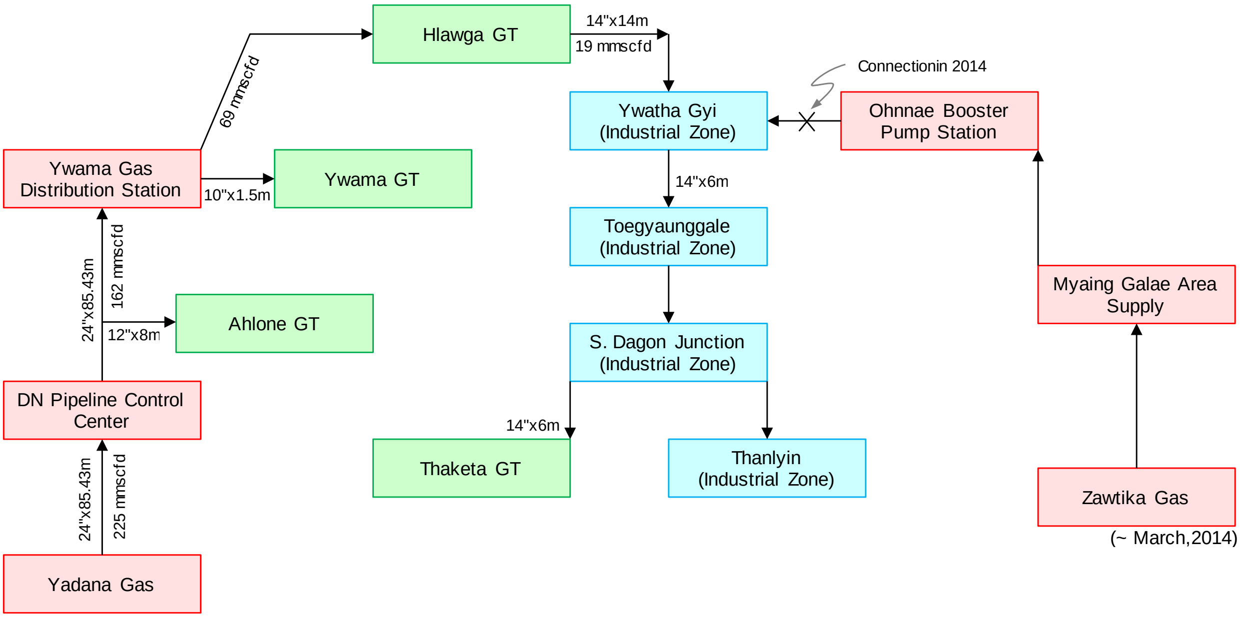
*Refer to Fig. 4.1-14.

Source: MOE (2012)

Fig. 4.1-13 Gas Pipelines in Myanmar

Source: MOE (2012)

Fig. 4.1-14 Gas/Oil Pipelines to China



Source: YESB (Yangon City Electricity Supply Board) Data

Fig. 4.1-15 Gas Pipelines in Yangon Area

4.1.4 LNG

(1) LNG Project by MOEP

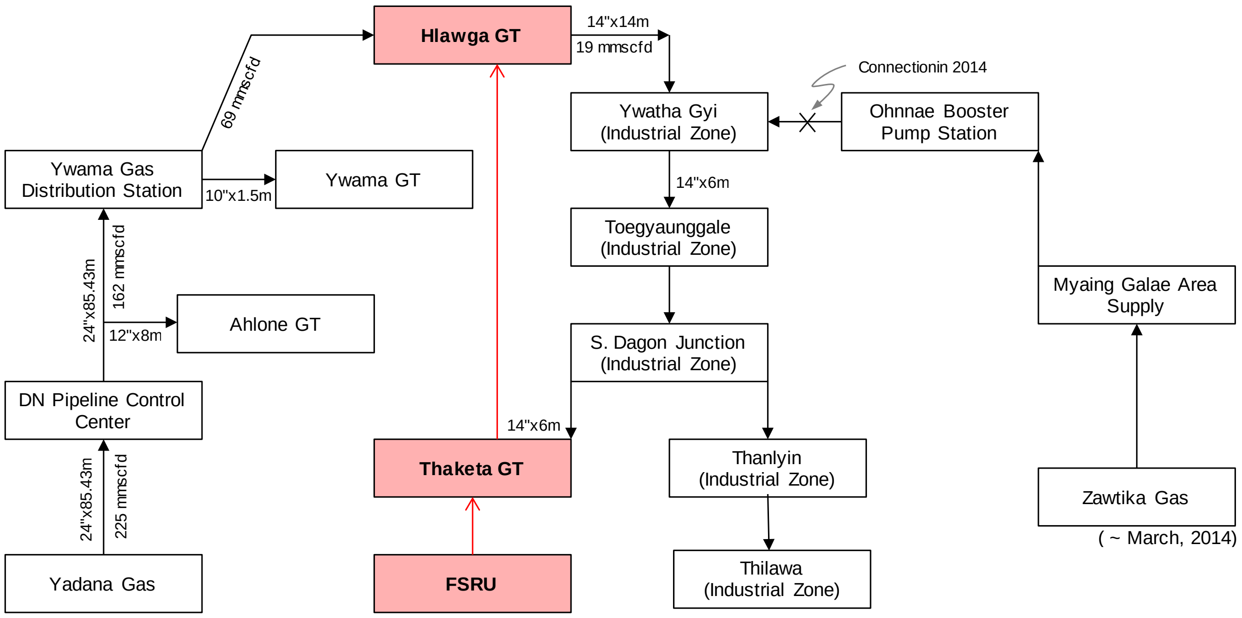
As explained in Section 4.1.2, (5) on gas supply shortage, MOEP called tender for LNG purchase and 14 bidders were selected as qualified bidders in August, 2013. YESB (Yangon City Electricity Supply Board) negotiated these 14 bidders and sent the evaluation reports on them to MOEP. MOEP submitted the reports to NEMC (National Energy Management Committee). However, NEMC has suspended the evaluation on the reports due to some issues[9].

According to YESB's tender specifications, 300 mmscfd of LNG should be supplied during 5 ~ 10 years' period. The contract is on a Lump-sum basis and the scope of the work includes LNG purchase, LNG transportation, FSRU (Floating Storage Regasification Units) lease and gas pipeline construction. One of the major issues of the LNG project is the selection of the location of FSRU in Myanmar.

Although MOEP has not completely given up the LNG project so far, liquid fuel as alternative of LNG might be required to be studied.

(2) Gas Pipelines for LNG

Fig. 4.1-16 shows LNG gas pipelines planned by MOEP. LNG vaporized at FSRU will be transported to Thaketa and to Hlawga gas fired power stations by new gas pipelines.



Source: YESB Data

Fig. 4.1-16 LNG Gas Pipelines

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[9] FSRU mooring location is too far from the Yangon area.

(3) Presentation on LNG Project by One Bidder

On 14th January 2014, one bidder made presentation to MOEP and MOE on LNG project in Myanmar. According to the information from MOEP, the contents are as follows;

1) FSRU is planned to be moored in Dawei because Dawei is SEZ (Special Economic Zone) and a deep water wharf will be constructed soon.
2) Considering the risk by the monsoon, there is alternative that is on-land gasification system with floating storage unit.
3) Expected construction period from the contract to LNG supply is 18-24 months if the existing Floating Storage and Regasfication Unit (FSRU) is applied.
4) There are several ways to transport LNG from Dawei to Yangon such as newly installed gas pipelines, small size LNG carriers, LNG tank lorries, etc.
5) No information on LNG price

(4) F/S (Feasibility Study) on LNG Receiving Facilities in Myanmar by METI (Ministry of Economy, Trade and Industry, Japan)

The project has completed at the end of March 2014. The main study results are as follows;

1) FSRU will moor in the sea 80 km south off the Yangon estuary where sea depth is around 15m and satisfies required sea depth of LNG carrier (min. 13m).

2) With regard to gas pipeline routes, although there are three candidates of landfall location, gas receiving terminal is located in South Dagon Junction. MOGE plans to extend gas pipeline from South Dagon Junction to Thilawa SEZ.

3) LNG will be purchased from LNG portfolio suppliers.

4) Specifications of facilities
    a) FSRU[10] storage capacity: 173,000 m^3
    b) Regasification capacity: 120 mmscfd × 4 units (1 unit is spare)
    c) Gas pipeline length: 80 km (offshore), 50 km (onshore)
    d) Size of gas pipeline: 24 inch
    e) Design of jetty: Cross jetty

5) Project Costs
    a) FSRU: 278 MUSD
    b) Jetty: 82 MUSD
    c) Offshore gas pipelines[11]: 154 MUSD
    d) Consulting fee: 15 MUSD
    e) Interest during construction, etc.: 69 MUSD
    f) Tax: 25.2 MUSD
    g) Total: 624 MUSD

6) Expected construction period from fundamental design to LNG supply is 53 months in which EPC (Engineering, Procurement, Construction) period is 33 months.

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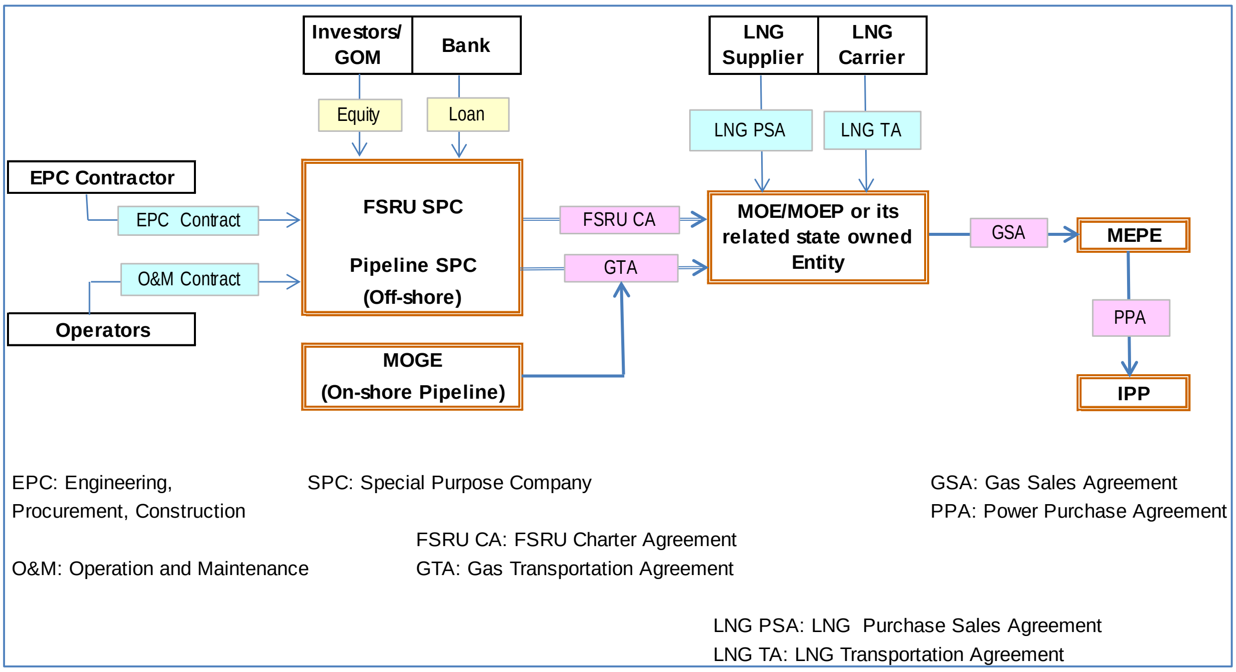
[10] Newly built FSRU
[11] On-shore gas pipeline will be constructed by MOGE and excluded from project costs

7) Project formation
The proposed project formation is shown in Fig. 4.1-17.



EPC: Engineering, Procurement, Construction

O&M: Operation and Maintenance

SPC: Special Purpose Company

FSRU CA: FSRU Charter Agreement

GTA: Gas Transportation Agreement

GSA: Gas Sales Agreement

PPA: Power Purchase Agreement

LNG PSA: LNG Purchase Sales Agreement

LNG TA: LNG Transportation Agreement

Source: METI F/S Report

Fig. 4.1-17 Proposed Project Formation

8) Financial analysis and economic analysis show good results with expected LNG price of 14 USD/MMbtu.

9) Expected electricity tariff with LNG

a) LNG cost per kWh:	11.3 cent/kWh
b) LNG facilities cost per kWh:	0.8 cent/kWh
c) Total per kWh:	12.1 cent/kWh

(5) LNG Project in Indonesia

In Indonesia, LNG project with FSRU started on July, 2012 (Fig. 4.1-18). PT. Pertamina (State Owned Oil/Gas Enterprise) and PGN (State Owned Gas Enterprise) set up joint company of PT Nusantara Regas. The project is to transfer LNG from Bontang LNG terminal operated by PT. Pertamina to gas-fired TPPs in North Jakarta. LNG after regasification is consumed in Tanjung Priok and Muara Karang gas fired power stations.

PT. Nusantara Regas made the following contracts;

1) LNG Transportation Contract:	Mitsui OSK Lines (December 2011)
2) FSRU Lease Contract:	Golar LNG Energy (October 2010)
3) GPSA:	PLN (State Owned Electricity Enterprise)

(1) LNG Transportation Agreement between PT. Nusantara Regas and Mitsui OSK Lines
(2) FSRU Lease Agreement between PT. Nusantara Regas and Golar LNG Energy
(3) Gas Purchase Sales Agreement between PT. Nusantara Regas and PLN

Source: prepared by JICA Study Team with newspapers

Fig. 4.1-18 LNG Project in Indonesia

4.1.5 Liquid Fuel

(1) Liquid Fuel in Myanmar

Realization of LNG purchase is not clear so far, and even if realized, it takes around 2 ~ 3 years at the soonest to supply LNG to gas fired power stations. Although there are several plans to uprate the existing GTs by means of rehabilitation and/or modification and/or replacement to GTCC (gas turbine combined cycle) without any increase of gas consumption, it takes 2 ~ 3 years' lead time to complete them.

Therefore, usage of liquid fuel such as light oil (HSD: High Speed Diesel Oil), crude oil and heavy fuel oil seems to be inevitable to solve the gas shortage in the very short run. GTs can usually use both gas and HSD, and some GEs (gas engine(s)) can use both gas and crude oil or heavy fuel oil.

In Myanmar, HSD and gasoline are transacted in the market. MPTA (Myanmar Petroleum Trade Association) purchase gasoline from overseas and sell it to retailors in Myanmar. On the other hand, Myanmar Petrochemical Products Enterprise purchase gasoline, HSD and jet fuel by following 2 routes and sell them to Ministries, Embassies and oil/gas companies that are partner with MOE (They do not sell them to other private companies) as follows:

1) MOGE (production of crude oil) → MPE (Myanmar Petrochemical Enterprise) (refinery of crude oil to gasoline, HSD, jet fuel and heavy oil) → MPPE (Myanmar Petroleum

Products Enterprise) (sales of gasoline, HSD and jet fuel[12])

2) Purchase from oversea

(2) Procedure to purchase Liquid Fuel in Myanmar

When IPP wants to purchase liquid fuel in future, methods to purchase liquid fuel seem to be as follows;

1) IPP directly purchases after getting import license from Ministry of Commerce. IPP should make the liquid fuel purchase contract with oversea liquid fuel distributers and prepare the oil jetty, oil unloader and oil storage tanks, etc., in the premises of the power plant.

2) IPP purchases HSD from MPPE with recommendation of MOEP.

3) With regard to jet fuel, MPPE will set up a JV (Joint Venture) with a private company in 2014. There is possibility to adopt the same scheme for HSD at the soonest in 2015. If the scheme is realized, the JV will installed HSD terminals. Therefore, IPP can purchase HSD from the JV by means of tank lorries or barges.

At present, item 1) seems to be most realistic.

(3) Prices of Liquid Fuel in Myanmar

The following table shows the information from EPD, MPTA and MPPE. Though there is difference between CIF (Cost, Insurance and Freight) and price at oil tank side, direct purchase from oversea seems to be cheaper than purchase from other sources.

Light oil (HSD)	EPD	:	Kyat 4,300/gallon (USD 154/barrel) as retail price
	MPTA (CIF)	:	USD 3.2/gallon (USD 112/barrel) Diesel oil: USD 3.0/gallon (USD 105/barrel), Gasoline: USD 3.9/gallon (USD 136.5/barrel)
	MPPE	:	USD 4.05/gallon (USD 142/barrel) for Embassy without tax USD 4.45/gallon (USD 156/barrel) for partner oil/gas companies with tax
Crude oil	EPD	:	Kyat 59,000/barrel (USD 60/barrel)
Heavy fuel oil[13]	EPD	:	Kyat 2,000/gallon (USD 71/barrel)

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[12] MPE sell heavy oil

[13] Heavy oil is more expensive than crude oil because price of crude oil is from MOGE to MPE and price of heavy oil is market price from MPE

(4) Availability of Adoption of Liquid Fuel in the Existing and Ongoing Gas-Fired TPPs

Dual firing (gas and liquid fuel) for newly installed gas-fired TPP from now on can enable for MOEP to specify it in the MOU (Memorandum of Understanding)/MOA (Memorandum of Agreement) or in the new tenders.

On the other hand, availability of adoption of liquid fuel in the existing and ongoing gas-fired TPPs is checked from the following viewpoints;

1) Are plants designed as dual firing?
2) Are liquid fuel firing facilities already installed in the power station?

Table 4.1-8 shows the results. As the results,

1) GTs are possible on dual firing, but GEs are impossible.
2) Although several power stations have the HSD fuel firing facilities, their tank capacities are around 24 hours GTs' operation.

Therefore, upgrading of the present facilities will be required for constant operation of some period. Especially for EGAT (Electricity Generating Authority of Thailand) (240MW) and Toyo-Thai (82MW), installations of the additional HSD fuel firing facilities seem to be inevitable.

Table 4.1-8 Availability of Adoption of Liquid Fuel in the Existing and Ongoing Gas-Fired TPPs

Location			COD	Output（MW）		Dual Firing	Liquid Fuel System	
				Existing	Ongoing			Tank Capacity
Local	Kyungchung	Existing	1974	54.30		○	×	
	Mann	Existing	1980	36.90		○	○	
	Shwedaung	Existing	1984	55.35		○	○	
	Mawlamyaing	Existing	1980	12.00		○	×	
	Myanaung	Existing	1975/1984	34.70		○	○	
	Thaton	Existing	1985/2001	50.95		○	○	
Yangon	Hlawga	Existing GT/ST	1996/1999	154.2		○	○	50,000 gal
		Zeya	2013.05(25MW) 2015-2016(25MW)	25.0	25.0	×	×	
	Ywama	Exsisting GT/ST	1980/2004	70.3		○	○	200,000 gal
		MSP	2013.07	50.0		×	×	
		EGAT	2014.02	240.0		○	△	
	Ahlone	Exsisting GT/ST	1995/1999	154.2		○	○	200,000 gal
		Toyo-Thai	2013.05	82.0		○	△	
			2015-2016		39.0	○	△	
	Thaketa	Exsisting GT/ST	1990/1997	92.0		○	○	200,000 gal
		CIC	2013.08	50.0		×	×	

☐ Existing 🟨 On-going

Possible	○	Installed	○
Impossible	×	Uninstalled	×

△: Additional Liquid Fuel System will be required

4.1.6 Coal

As shown above, there are constraints in the development through 2030 in the domestic energy of hydropower and gas. Thus, the outlook of coal supply which is the 3rd option in primary energy should be studied.

(1) Coal Reserves

As shown in Fig. 4.1-5 there are 25 coal basins, and major coal deposits in 6 areas at present (Fig. 4.1-19). Table 4.1-9 shows coal reserves of major coal deposits as of May 2012. Total coal reserves (Proven + Probable + Possible + Potential[14]) are estimated at 480 million ton, and this value is increased to 540 million ton according to the information from MOM (Ministry of Mines) on May 2013. Recoverable reserves usually estimated by 2P (Proven + Probable), are 230 million ton as of May 2012.

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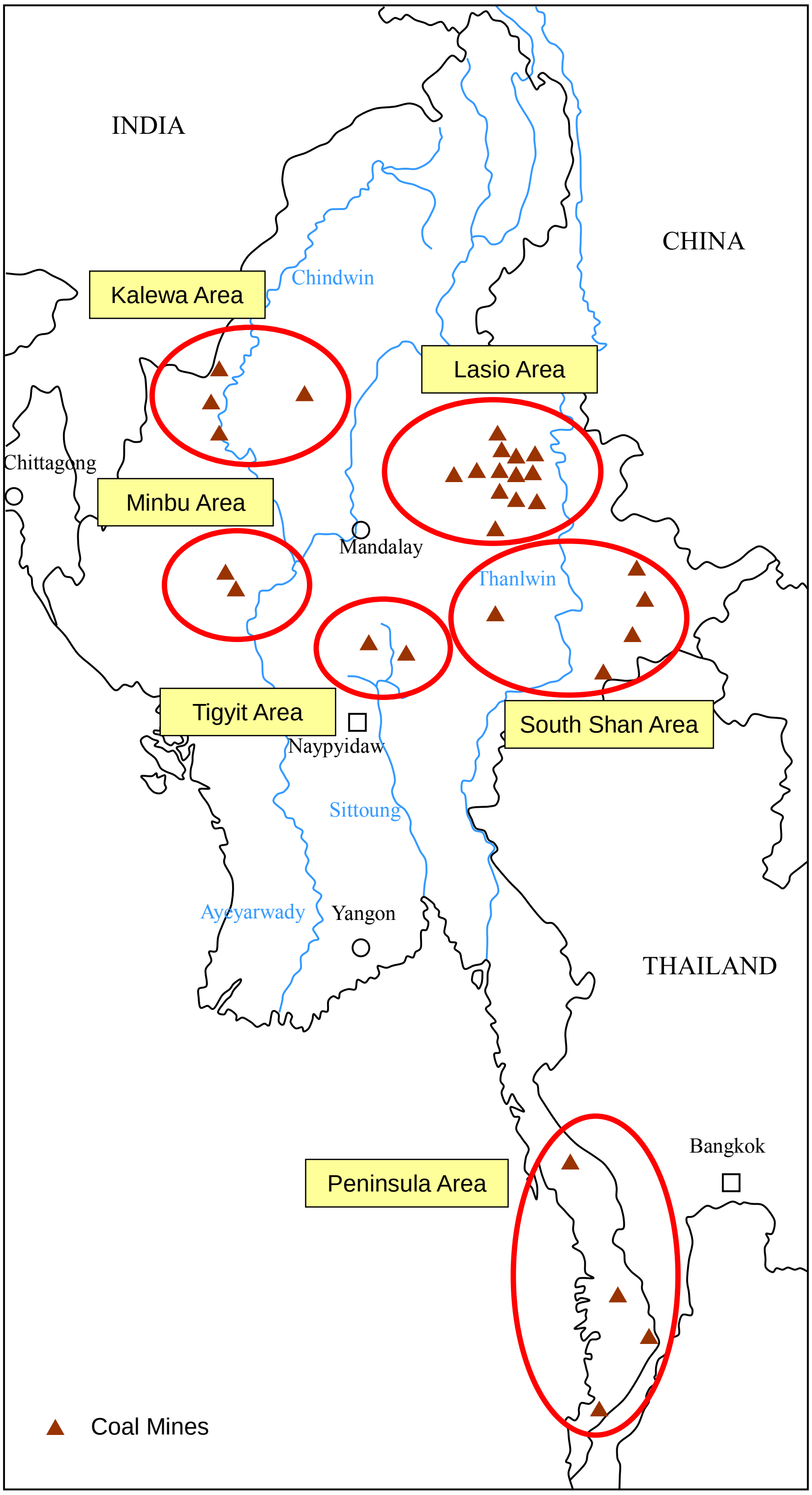
[14] Potential means that the production is not economical and/or technically difficult at present, but production may be possible in future. In that case, possibility of recovery is estimated at P1 (Proven).



Source: MOM and JCOAL (Japan Coal Energy Center) (2013)

Fig. 4.1-19 Coal Mines in Myanmar

Table 4.1-9 Coal Reserves in Myanmar

No.	Location	Township	State/Region	Reserves (Million ton)	Category	Coal Rank
1	Kalewa	Kalewa	Sagaing	4.615 17.831 65.335	P1 P2 P3	Sub-bituminous Ditto Ditto
2	Darthwekyauk	Tamu	Sagaing	33.000 5.000	P2 P4	Lignite ~ Sub-bituminous
3	Paluzawa	Mawlike	Sagaing	89.000	P4	Sub-bituminous
4	Mawleikgyi Ch.	Mawlike	Sagaing	0.810	P3	Sub-bituminous
5	Kyopin	Kawlin	Sagaing	2.230	P2	Lignite~Sub-bituminous
6	Lweji	Bamoh	Kachin	0.200	P3	Lignite
7	Kawmapyin	Tanintharyi	Tanintharyi	2.030	P2	Lignite ~ Sub-bituminous
8	Mawtaung	Tanintharyi	Tanintharyi	1.800 1.800 1.220	P2 P3 P4	Lignite~Sub-bituminous
9	Karathuri	Bokpyin	Tanintharyi	1.500	P4	Sub-bituminous
10	Banchaung	Dawe	Tanintharyi	1.175 18.000	P3 P4	Sub-bituminous
11	The Pyuchaung	Kyainseikkyi	Kayin	1.068	P4	Sub-bituminous
12	Wungyichaung	Seikphyu	Magwe	0.808	P2	Sub-bituminous
13	Tasu-Letpanhla	Pauk	Magwe	1.030	P2	Lignite
14	Kyesi-Mansan	Kyesi-Mansan	Shan (South)	18.110	P2	Sub-bituminous
15	Kholan	Namsam	Shan (South)	3.490	P2	Lignite
16	Tigyit	Pin Laung	Shan (South)	20.700	P2	Lignite ~ Sub-bituminous
17	Kyasakan-Minpalaung	Ywangan	Shan (South)	0.220	P3	Sub-bituminous
18	Mankyaung	Tanyang	Shan (North)	1.052	P3	Sub-bituminous
19	Manpan-Monma	Tanyang	Shan (North)	3.365 3.841	P3 P4	Sub-bituminous Sub-bituminous
20	Harput	Tanyang	Shan (North)	5.240 0.469 5.462	P2 P3 P4	Lignite ~ Sub-bituminous
21	Sale (Mansele)	Lasio	Shan (North)	0.149 1.213	P3 P4	Lignite ~ Sub-bituminous
22	Sanya	Lasio	Shan (North)	0.048 0.072 0.851	P2 P3 P4	Lignite
23	Sintaung	Lasio	Shan (North)	5.825 0.683	P2 P3	Lignite
24	Namma	Lasio	Shan (North)	2.800	P2	Sub-bituminous
25	Narkon	Lasio	Shan (North)	0.692 1.044 0.925	P2 P3 P4	Lignite
26	Narlan	Lasio	Shan (North)	1.574 0.200 0.826	P2 P3 P4	Lignite
27	Namlinhkan	Lasio	Shan (North)	0.048 0.339 0.549	P2 P3 P4	Lignite
28	Sanlaung	Thipaw	Shan (North)	1.870	P2	Lignite ~ Sub-bituminous
29	Mahkaw	Thipaw	Shan (North)	1.000 0.256	P2 P3	Lignite ~ Sub-bituminous
30	Wankyan (Namlap)	Kyaington	Shan (East)	16.660	P2	Lignite
31	Hoko	Kyaington	Shan (East)	1.190	P2	Lignite
32	Mainghkok	Maingsat	Shan (East)	117.700 3.680	P2 P3	Lignite ~ Sub-bituminous
33	Narparkaw	Maington	Shan (East)	10.930	P3	Lignite
34	Kywesin	Ingapu	Ayeyarwady	1.500	P4	Lignite ~ Sub-bituminous
Total				**483.025**		

Source: DGSE (Department of Geological Survey & Mineral Exploration) and JCOAL (2013)

(2) Coal Production System in Myanmar

No.3 Mining Enterprise takes responsibility of coal production in Myanmar. However, PSC with private firms is recently proceeding. 56 private firms have finished PSC as of January 2014, and produced coal under the supervision by No.3 Mining Enterprise.

On the other hand, DOM (Department of Mines) has concluded 90 PSC as of January 2014 with rather small scale coal mines.

(3) Coal Production

Table 4.1-10 shows yearly coal production records until 2012-2013, and Table 4.1-11 shows coal mine-wise coal production until 2013-2014. Coal production in 2006-2007 has recorded the highest, then dropped and recently increased again.

Coal productions from Kalewa, Namma mines have not been recorded since 2011-2012 due to privatization of these mines. Coal production from Maw Taung mine has not reported since 2009-2010 either because the mine now belongs to the military. Mine Khoke that has the maximum reserves in Myanmar will operate in 2014.

In Table 4.1-11, coal mines marked in red cell will supply domestic coal to Kalewa Coal-fired TPP (total output is 540MW) and those marked in blue cell will supply domestic coal to Keng Tong Coal-fired TPP (total output is 600MW). With regard to capability of domestic coal supply to the Coal-fired TPPs, JICA Study Team comments are shown in 4.2.2.

Although small amount of coal was used to be exported to Thailand and China, all coal is consumed in domestic cement industry and power industry, etc. at present.

Table 4.1-10 Yearly Coal Production in Myanmar

Year	Yearly Production (Thousand ton)
2005-2006	1,150
2006-2007	1,420
2007-2008	1,004
2008-2009	532
2009-2010	443
2010-2011	556
2011-2012	733
2012-2013	790

Source: No.3 Mining Enterprise

Table 4.1-11 Coalmine-wise Coal Production

(Unit: ton)

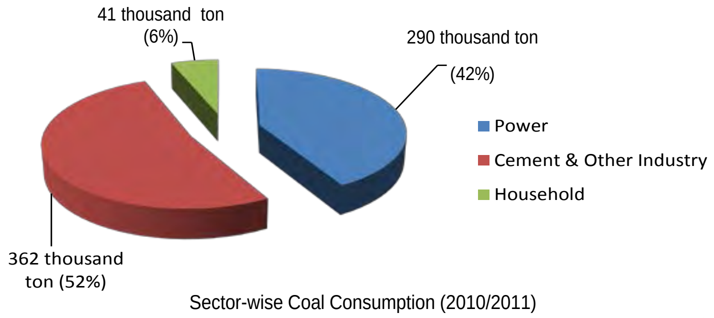
No.	Coal Mine	Company Name	1959-2001	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-2014	Total
1	Kalaywa	No.(3) Mining Enterprise	444,225	13,808	11,773	17,091	15,002	12,250	7,870	6,016	6,012	8,946	2,000				**544,993**
2	Namma	No.(3) Mining Enterprise	502,507	30,200	40,000	55,000	55,000	55,400	42,800	25,000	12,600	17,601	1,300				**837,408**
3	Lwejel	Arawaddy Myit Phya Co., Ltd.		7,000	3,200	1,700	2,400	700				30,000		4,500			**49,500**
4	Samlong (Large Scale)	Triple 'A' Cement International Co., Ltd.	101,173	44,731	60,800	111,000	119,400	67,800	100,000	72,000	60,000	48,000	46,000	92,884	85,965	26,524	**1,036,277**
5	Maw Taung	Myanma Economic Corporation	553,973	531,248	431,375	771,819	799,878	623,295	515,206	228,592	43,085						**4,498,471**
6	Ti-gyit	Edin Energy Natural Resources Development Co., Ltd.					58,095	324,906	553,089	466,136	244,136	206,549	290,097	338,120	302,598	11,637	**2,795,363**
7	Ma Khaw	UE Export Import Co., Ltd.					3,232	6,768	12,320	35,801	15,025	28,400	5,130	6,500	12,000	8,600	**133,776**
8	Paluzawa	Tun Thwin Mining Co., Ltd.						30,000	87,050	20,250	10,245	15,096	20,065	15,915	22,237	15,941	**236,799**
9	Samlong (Small Scale)	Triple 'A' Cement International Co., Ltd.					35,000	28,912	61,521	60,000	40,000	27,000	36,092	25,889	13,066	-	**327,480**
10	Na-Shan	Ming Htet Co., Ltd.							2,000	22,440	25,000	9,800	39,000	24,639	5,653	-	**128,532**
11	Mapan/Mongma	Ming Htet Co., Ltd.							31,500	35,000	37,000	15,100	39,000	54,286	31,737	10,045	**253,668**
12	Kongbaung/Nakon	Ngweyi Pale Mining Co., Ltd.							6,550	33,450	37,090	30,040	38,940	55,145	81,500	42,500	**325,215**
13	Kaung Pon Chaung	Ngweyi Pale Mining Co., Ltd.												300	6,950	3,758	**11,008**
14	Maipar	Ngweyi Pale Mining Co., Ltd.														1,400	**1,400**
15	Maw Leik Kyi Chaung	Geo Asia Industry and Mining Co., Ltd.									2,200	5,000	12,000	11,116	2,430	750	**33,496**
16	Dah Thway Kyauk	Yangon City Development Committee													6,500	-	**6,500**
17	Mine Khoke	Myanma Economic Corporation															
18	Ban Chaung	May Flower Mining Enterprise Ltd.(1+2+3)												20,000	33,700	8,100	**61,800**
19	Ban Chaung	May Flower Mining Enterprise Ltd. (4+5+6)														4,600	**4,600**
20	Kywe Tayar Taung	Myanmar Naing Mining Group Co., Ltd.															
21	Kyak Sakhan	Yangon City Development Committee													31,000	-	**31,000**
22	Kayauk Ohn Chaung	Myanma Economic Corporation										1,137	24,407	39,366	14,724	-	**79,634**
23	Dah Thway Kyauk & Pazun Seik	Dagon Mining Co., Ltd.												1,000	4,430	850	**6,280**
24	Nang Tang	Tun Kywel Paw Co., Ltd.												2,016	1,880	766	**4,662**
25	Kyun Pin Pyant	Tun Kyawe Paw Co., Ltd														335	**335**
26	Thantaung Kywin	Shwe Ohn Pwint Co., Ltd.												800	1,250	950	**3,000**
27	Paluzawa	Shwe Taung Mining Co., Ltd.													13,623	4,050	**17,673**
28	Dah Thway Kyauk	G4 Mining Co., Ltd.													500	550	**1,050**
29	Miinpalaung	G4 Mining Co., Ltd.													300		**300**
30	Wah-Ye Chaung	Max Myanmar Co., Ltd.												17,400	9,821	11,551	**38,772**
31	Three Small Scale	Dragon Cement Co., Ltd.											1,011.5	3,551.00	942		**5,505**
32	Pinlong	Mega Strength Co., Ltd.											278	71	73	113	**535**
33	Kyak Sakhan	Thukha Panthu Co., Ltd.											472		1,075	-	**1,547**
34	Sintaung	UE Export Import Co., Ltd.												12,500	13,000	9,600	**35,100**
35	Kyak Sakhan	Young Investment Group Industry Co., Ltd.															
36	Dah Thway Kyauk	Young Investment Group Industry Co., Ltd.															
37	Thit Chauk & Labin Chaung	Hoo International Industry Group Co., Ltd.													2,100	1,000	**3,100**
38	Harput	Ruby Garden Mining Co., Ltd.												2,420	27,680	17,475	**47,575**
39	Maw Ku	Geo Asia Industry and Mining Co., Ltd.												1,000	2,430	650	**4,080**
40	Hein Latt	Yuzana Cement Industrial Co., Ltd.															
41	Nan Pan Moon Chaung	Mandalay Distribution and Mining Co., Ltd.												900	20,400	3,200	**24,500**
42	Loon Taung	Myanmar Kauntoun Industry															
43	Kholan	Min Anawyahta Group Co., Ltd.															
44	Na-ngwe	Ngweyi Pale Mining Co., Ltd.												500	6,700	3,400	**10,600**
45	Mahu Taung	Shwe Innwa Mining & Industry Co., Ltd.												800	1,200	-	**2,000**
46	Pharse & Matpaing	Shan Yoma Goal & Product Co., Ltd.												900	3,900	1,500	**6,300**
47	Kyauk Sak	Thunder Lion Mining Co., Ltd.													3,000	3,100	**6,100**
48	Shwe Chaung	Lu Paung Sak Su Way Mining Co., Ltd.													800	915	**1,715**
49	Makar	Kanbawza Industry Group Co., Ltd.													21,000	27,613	**48,613**
50	Kantote	Pothar Mining Co.,Ltd													1,260	3,650	**4,910**
51	Shan Tut	YaungNi Mining Co.,Ltd													480	680	**1,160**
52	Kyat Sakhan	Thukha Panthu Co., Ltd.													2,300	2,550	**4,850**
53	Naungtaya/Tigyit	Big Power Co.,Ltd													110	335	**445**
54	Kantote	Soe Yadana Oo Co.,Ltd.													120	1,420	**1,540**
55	Thanpayar kaing	Myint Myat Chan Aye Mining Co.,Ltd.														3,650	**3,650**
56	NaungLai	Tiger Horn Co.,Ltd.														300	**300**
57	Ohmyaytwin	Zabuthit Mining Co.,Ltd.														800	**800**
58	Kantote	Ingyin Taung Co.,Ltd.														530	**530**
59	Ngaw Taung	Nyeinchan Seinphyarmyay Kabar Co.,Ltd.														300	**300**
60	Ohmyaytwin	Myanmar AhtutAhteik Mining Co.,Ltd.														120	**120**
61	Kaung Ai	Ahlinthit Year Mining Co.,Ltd.														750	**750**
62	Kone Paung	Shan Yoma Goal & Product Co., Ltd.														200	**200**
	Total		**1,601,878**	**626,987**	**547,148**	**956,610**	**1,088,007**	**1,150,031**	**1,419,906**	**1,004,685**	**532,393**	**442,669**	**555,793**	**732,518**	**790,434**	**236,758**	**11,685,817**

Note : 2013-2014 Production is up to December 2013. No.(1) & (2) is State-owned and already transferred to private. No. (5),(6) are permitted by Department of Mine.

Source: DGSE

(4) Sector-wise Coal Consumption

Fig. 4.1-20 shows sector-wise coal consumption in 2010-2011. Power sector occupies 42% of the consumption, which is due to Tigyit coal-fired power station (60MW × 2 Units). The output drops to around half of the design value, therefore, a rehabilitation is under planning.



Source: JCOAL (2013)

Fig. 4.1-20 Sector-wise Coal Consumption

(5) Coal Properties

Coal ranks of Myanmar are classified as sub-bituminous and lignite. They are not high quality coal, but suitable for fuel as coal-fired boilers because of low inclusion of ash and sulfur. On the other hand, as they have the propensity of spontaneous combustion due to high moisture content and of fragility, special attention is required for coal transportation and storage systems.

Table 4.1-12 shows coal properties of main coal mines that have total reserves of over 10 million tons. Coal produced in Lasio Region not shown in Table 4.1-12 due to relatively small reserves is hard with 20 ~ 27 of Hard Grove Index[15]. Therefore, the coal is not suitable for fuel as coal-fired boilers because of inferior grind ability of the mills.

Table 4.1-12 Coal Properties

Location				Proximate Analysis					
Region	County	State	Fixed Carbon (%)	Volatile Matter (%)	Moisture (%)	Ash (%)	Sulfur (%)	Heating Value	
								Btu/lb	kcal/kg
Kalewa	Kalewa	Sagaing	52.51	38.62	9.70	8.87		11,720	6,511
Darthwekyauk	Tamu	Sagaing	50.00			1.00	< 1	12,000	6,667
Paluzawa	Mawlike	Sagaing	41.47	45.32					
Kyesi-Mansan	Kyesi	Shan (South)	35.60	48.98	13.29	15.36	2,56	10,153	5,641
Tigyit	Pinlaung	Shan (South)	33.81	34.40	18.51	13.27		9,169	5,094
Wankyan	Kyaington	Shan (East)	23.00	23.00	40.00	8,50	0.4	5,890	3,272
Mainghkok	Maingsat	Shan (East)	45.00			1.86		10,185	5,658
Narparkaw	Maington	Shan (East)	25.93 ~ 28.07	26.31 ~ 31.89		14.83 ~ 15.39	0.96	7,720 ~ 8,370	4,289 ~ 4,650
Banchaung	Dawei	Tanintharyi	40.87	38.95	7.49	20.05	1.47	11,345	6,303

Source: DGSE and JCOAL (2013)

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[15] Hard Grove Index is measure for the grindability of coal. Usually more than 40 is required for pulverized coal-fired TPPs

(6) Coal Prices

Coal prices in Myanmar and Indonesia are summarized the following table based on information from HPGE (Hydropower Generation Enterprise) as of August 2013 and the report of JCOAL (Japan Coal Energy Center) (January 2013) and WCR (World Coal Report, March 2013). Coal prices are unified in USD at exchange rate of 1 USD=975 Kyats.

	Location	Heating Value (kcal/kg)	FOB (USD/ton)	Transportation (USD/ton)	CIF (USD/ton)	Remarks
JCOAL Report	Kalewa	6,111	41 ~ 51	17 ~ 22	58 ~ 73 at Mandalay	Transportation fees are different by dry and wet seasons
	Lasio 1	5,789	37 ~ 47	21	58 ~ 68 at Mandalay	
	Lasio 2	5,429	36	15	51 at Mandalay	
By HPGE	Tigyit	3,920			31	for Mine Mouth Power Station
WCR	Indonesia 1	6,500	90			late 2012
	Indonesia 2	3,400	30			late 2012

As there is no coal transportation experience from Indonesia to Myanmar, the coal transportation fee is estimated by that from Kalimantan to Southern Vietnam. The fee of the aforementioned route is USD 7 ~ 8.5/ton subject to 10-year's contract with Panamax (100,000 ton class) transportation.

There is no plan to install a coal terminal so far in Myanmar. Therefore, the cost for the offshore transshipment to be counted. With such price-up, it will cost around USD 20/ton to transport the coal, considering the distance difference between Myanmar and Southern Vietnam.

If JICA Study Team assumes at 20 USD/ton, CIF price of import coal for 6,500 Kcal/kg of heating value is almost twice as high as domestic coal. Therefore, it seems to be worth studying the construction of the mine-mouth coal-fired plants and/or coal-fired plants in Mandalay Area in future subject to the improvement of infrastructures on bulk coal transportation to Mandalay Area and construction of the transmission lines to the national grid.

(7) Tigyit Coal-Fired Power Station

Tigyit coal-fired power station that is located at 40 km south-south-east from Kalaw City in Shan State is the only coal-fired station in Myanmar at present.

The power units are of China-made, and planned outputs of the units are 60 MW × 2 (COD of No.1: December 24, 2004, COD of No.2: May 3, 2005). However, dependable outputs of both units are degraded to 30 MW respectively.

Coal is transported from 2 miles away from Tigyit Coal Mine by the belt conveyor with 1.5 miles length.

1) Maintenance Conditions

As spare parts have not been stored since COD, several problems are observed as follows;

a) No restoration of the broken soot bower
b) Leaked boiler tubes are plugged (usually replaced by a new tube)

c) Damaged bearings are repaired by local company (usually replaced by the spare parts)
d) Leaked pulverized coal pipes are repaired by build-up welding

2) Causes of Output Degradation

During 1st site visit to Myanmar, JICA Study Team heard that although calorific value of design coal is 10,100 Btu/lb, calorific value of actually used coal is 7,050 Btu/lb. Therefore, JICA Study Team suspected that this discrepancy might be the main cause of degradation. However, JICA Study Team is informed at Tigyit coal-fired power station of the following:

- During the design stage of the plant, MOEP informed the boiler manufacture that calorific value is 10,100 Btu/lb.
- The boiler manufacture investigated the coal quality by himself, and determined calorific value of 8,100 Btu/lb as the design coal. Therefore, the discrepancy with actually used coal is not significant.
- On top of that, the boiler manufacture considered calorific value of 7,200 Btu/lb as the worst coal.

Based on the new information, if the boilers were properly designed with the design coal and the worst coal by the boiler manufacture, calorific values of coal seem not to be a fatal cause of output degradation.

Causes of degradation are attributed to inadequate maintenance, and main factors seem to be as follows;

a) Deterioration of the condenser vacuum due to dysfunction of the condensers with bad cleanness and plug maintenance of condenser tubes,

b) Lack of air flow of the boiler due to increased draft by heavy ash deposit on the air-heaters surfaces, and

c) Dysfunction of boiler heat transfer surfaces due to broken soot blowers and plugged superheater tubes.

3) Environmental Conditions

As the power station was stopped by the restriction of power transmission capacity during site inspection, JICA Study Team could not investigate the operational conditions of the station. JICA Study Team gets the following information by hearings.

a) The FGD (Flue Gas Desulfurization) has not worked since COD because of large amount of ash-flow into FGD due to low efficiency of the EP (Electrostatic Precipitator).

b) The height of the stack was shortened from 150 m to 80 m to reduce the construction period.

c) An indoor type coal storage yard is installed to protect the neighboring households from coal dust.

d) There are no monitoring of NOx (Nitrogen Oxide), SOx (Sulfur Oxide) and dust from the stack.

e) There are no complaints from nearby residents on environmental issues.

4) Rehabilitation Plan

The rehabilitation plan was submitted to the Minister of MOEP, and is waiting for

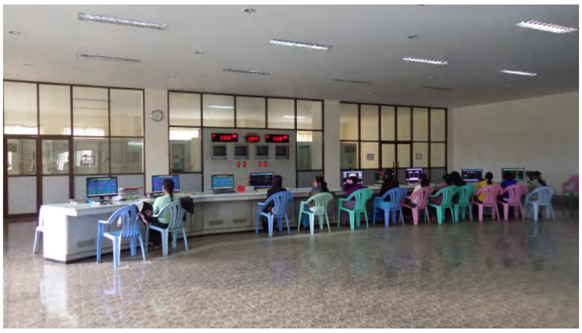
Parliament's approval. The bidders who have the interest in the work are to inspect the site and then submit their proposals on scopes, schedule and cost, etc. HPGE will evaluate the proposals and determine the successful bidder.

5) Pictures of Tigyit Coal-fired Power Station


(from right to left) Turbine House, Boiler, Stack

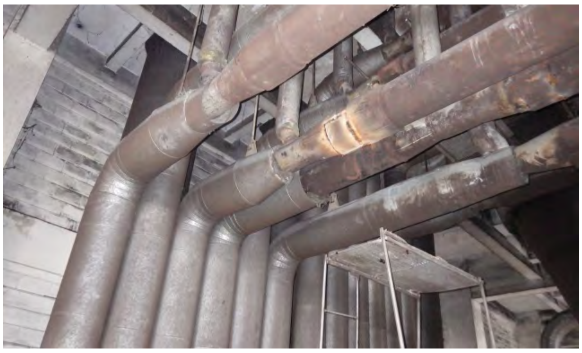

(from near side) Electrical precipitator, disabled FGD, Stack


(from the depth) Conveyor from Coal Mine, Indoor Type Coal Storage Yard, Conveyor to Boiler Bunker


Central Control Room

Overhauled Turbine

Unrestored broken Soot-blower



Pulverized Coal Pipes repaired by build-up welding

Turbine #2 Bearing House (frequent to vibration)

Damaged #2 Bearing

Condenser Water Box (difficult to open)

Indoor Type Coal Storage Yard

(8) Tigyit Coal Mine

1) Circumstances of the Coal Mine

The mine area is 2.68 km^2 (544 acre) and the overburden within the mine boundary is 115.859 million m^3. The average stripping ratio of the whole area is 5.65 m^3/ton. Soil stripping started in August 2004, and total stripped volume up to 2012-2013 is 27.6 million m^3.

Mine is open cast, and production capacity and service life are as follows;

a)	Annual production	:	750,000 ton
b)	Average daily production	:	2,000 ton
c)	Service life of mine	:	27 years

2) Coal Production Record

The coal production is recorded in Table 4.1-13.

Table 4.1-13 Annual Coal Production of Tigyit Coal Mine

Year	Target production (T) ton	Actual production (A) ton	(A)/(T) × 100 %
2005-2006	640,000	428,903	67
2006-2007	ditto	507,188	79
2007-2008	ditto	466,138	73
2008-2009	ditto	276,873	65
2009-2010	ditto	413,042	64
2010-2011	ditto	450,000	70
2011-2012	ditto	450,000	70
2012-2013	ditto	300,000	47
Total	**4,903,500**	**3,292,144**	**67**

Source: Tigyit Coal Mine

Coal produced by the coal mine is almost supplied to Tigyit coal-fired power station. Therefore, unachievable coal production is attributed to the low operating capacity factor of Tigyit coal-fired power station.

3) Pictures of Tigyit Coal Mine

Coal Mining Area (no work on site inspection day)

Overview from the dump area to the power station

Start point of the coal conveyor to the power station

4.1.7 Renewable Energy

(1) Overview

Rural electrification in Myanmar is about 33.4%[16] as of 2012-2013. To improve the rural electrification, expansions of on-grid and off-grid power sources are developed. Although diesel engines are main off-grid power sources so far, the renewable energy sources will be utilized as off-grid power sources from now on. Renewable energy is developed by the central government (such as MOI, MOST (Ministry of Science and Technology), MOAI (Ministry of Agriculture and Irrigation), MOECAF (Ministry of Environmental Conservation and Forestry), MOLFRD (Ministry of Livestock, Fisheries and Rural Development), MOEP, etc.), local governments and private firms.

The overall responsibility to promote the rural electrification is recently transferred from MOI to MOLFRD. Therefore, “Rural Energy Development Supporting Committee” chaired by the Minister of MOI is replaced by “Rural Region Electrification and Water Supply Committee” chaired by the Minister of MOLFRD.

MOST takes care of research and enlightenment of the renewable energy except for tidal energy

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[16] 28% in previous DRD (Department of Rural Development) data received in August 2013

investigated by MES (Myanmar Engineering Society). Table 4.1-14 shows the roles and responsibilities on renewable energy in association with rural electrification in Myanmar. Although diesel and GE are not renewable energy, they are added in the table as a role of rural electrification for reference.

Table 4.1-14 Roles & Responsibilities on Renewable Energy in Myanmar

Type of Energy	Research & Education	Production				
		Off-Grid			On-Grid	
		Central Government	Local Government	Private Company	Central Government	Private Company
Solar Power	MOST	MOI*², DRD*³	○	○	MOEP*³	○
Mini-Hydro	MOST	MOAI, MOI*², DRD*³, MOEP*¹	○	○	-	-
Wind Power	MOST	MOI*²	○	○	MOEP*³	○
Biogas (Cow dung)	MOST	MOST	○	-	-	-
Biofuel (Jetropha, etc.)	MOST	MOST	○	-	-	-
Biomass (Woodchip, Rice husk, Refuse, etc.)	MOST	MOST, MOI*², DRD*³	○	○	-	-
(Diesel/Gas Engine)	-	ESE[17]/MOI*²	○	○	MOEP	○
Geothermal Power	-	-	-	-	MOEP*³	○
Tidal Power	MES	Under study stage				

*¹ Transfer to Local Government, *²MOI sells equipment, *³Tendering for Investors

Source: prepared by JICA Study Team with hearings in Myanmar

Supplementary explanations of Table 4.1-14 are as follows;

1) Small scale hydro under 10 MW (mini-grid) is transferred from MOEP to local government early 2013. With regard to new mini-hydro power stations, MOEP provide technical assistant to local governments.

2) Solar power, mini-hydro and Biomass by DRD (Department of Rural Development) were partially transferred to local governments.

3) Mini-hydro in irrigation area is developed by MOAI, and mini-hydro other than irrigation area used to be developed by MOEP (from now on by local government).

4) MOI poses factories such as solar panel[18], turbine, generator, diesel engine, etc., and distributes the machines to end users of rural electrification.

5) Conditions of rural electrification by on-grid are as follows;
   - Villages to be located within 2 miles from the national grid.

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[17] The mini grid system constructed by ESE incurs so much fuel cost that ESE intends to operate and maintain the system without handing over the system to the local government.

[18] MOI imports CIGS thin film solar cell from USA and Invertors from Taiwan & China, then MOI assembles them in MOI factories. MOI produced Batteries at MOI factory in Padaung Township.

- Villages to set up the committee and submit the rural electrification plan and budget plan[19] to DRD
- If DRD approve the plans, DRD propose MOEP on it.
- If MOEP agree, transmission lines and distribution lines are constructed by MOEP.

(2) Rural Region Electrification and Water Supply Committee

The captioned committee was organized on September 9, 2013, and the first conference was held on September 19, 2013 under the presence of Vice President.

The organization is;

Chairman : Minister of MOLFRD

Members : Deputy Ministers of Ministry of Cooperative, MOAI, MOLFRD, MOECAF, MOEP, MOE, MOI and Ministry of Construction
Director Generals of Irrigation Department (MOAI) and MOLFRD
Chairmen of MES and Myanmar Renewable Energy Association

The work substances of the committee are as follows;

1) Collection of correct data and information about utilization of renewable energy resources such as small hydropower, solar power, wind power and biomass energy
2) To uplift the supply of electricity based on renewable energy for the off-grid villages
3) To draw the road map/blue print, business model and financial model
4) To invite local and international investment and aids for the development of renewable energy
5) To train rural residents to be energy related skill persons for sustainable use of renewable energy by their own effort
6) To distribute the knowledge of energy saving to the public
7) To support research and design development for renewable energy related projects
8) To supply clean drinking water
9) To construct ponds and reservoirs at less rainfall regions
10) To construct the coffer dam to prevent the flood at much rainfall regions, provide drainage systems and dredging system at silt up rivers/streams
11) To hold the Stakeholder Workshop occasionally participated by such entities as volunteers, NGOs (Non-Governmental Organization(s)), United Nations, resident organizations, International NGOs, technical experts and social organizations related to rural electrification and drinking water supply
12) To monitor and evaluate those works under current policies to achieve the goal

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[19] 50% of construction costs for grid connection are beard by the village and remaining 50% are supplied by DRD.

(3) Power Tariff and O&M (Operation and Maintenance) of Power System

Power tariffs and local residents’ burdens for O&M of the power systems are much different depending on the suppliers of the power systems.

1) Mini-hydro by MOEP

The tariff paid by local residents was the same as the tariff of on-grid. O&M was carried out by MOEP. Even after mini-hydro is transferred from MOEP to local governments, the scheme seems to be unchanged.

2) Mini-hydro by MOAI

Power tariff is free of charge, and MOAI carries out O&M. In the event of plant breakdown, MOAI dispatches mechanical/electrical engineers.

3) Biogas by MOST

Villages should share the following burdens;

a) A half of initial construction cost
b) O&M cost
c) Installation of electric distribution lines
d) Electrical charge of 20 Kyat/a fluorescent light, per night (4 hours operation)

4) Private Company

Power tariff is determined based on the project cost that must be agreed by local residents. The project company carries out O&M.

(4) Solar Power System

1) SHS (Solar Home System)

Typical specifications of SHS are shown in Table 4.1-15.

Table 4.1-15 SHS/Household

Solar panel	80 ~ 90 watt
Battery	12V/65Ah
Inverter	300 watt
Controller	10 watt
LED bulb	3 watt × 2
LED bulb	5 watt × 1

Source: DRD, May 2014

2) Solar Mini-Grid System

a) MOI

Currently, a total of 86,480W has been supplied by solar mini-grid system at 153 villages.

Table 4.1-16 Solar Mini-Grid System by MOI

No.	Location	No. of Village	Installed Capacity (W)	No.	Location	No. of Village	Installed Capacity (W)
1	Mon State	6	3,257	7	Magway Division	6	2,390
2	Rakhine State	2	1,715	8	Irrawaddy Division	24	5,710
3	Yangon Division	8	6,653	9	Tanintharyi Division	4	6,220
4	Mandalay Division	6	14,975	10	Narga	40	21,660
5	Pago Division	21	5,705	11	Naypyitaw	6	1,705
6	Sagaing Division	30	16,560	**Total**		**153**	**86,550**

Source: MOI, Dec. 2012

b) DRD

Actual experience of Solar Mini-System implanted by DRD in Mon state in 2013 is shown in Table 4.1-17.

Table 4.1-17 Solar Mini-Grid System by DRD

Solar panel	250 watt solar panel × 12 pieces = 3000 watt
Battery	12 V/200 Ah
LED for home	3 watt (5 hours use) × 200
LED for street post	5 watt × 40
User	100 household
Power/household	28 watt/household

Source: DRD, May 2014

c) MOST

Mandalay Technology University installed solar mini-grid systems under MOST at the following locations.

Table 4.1-18 Solar Mini-Grid System by MOST

Name	Location	Type	Start Date	Cost (USD)
3kW-GTI (Monocryatalline Solar Module)	Government Technical Institute (Putao), Kachin State	Stand-alone group Mounted	2008/04/01	40,000
3kW-GTHS (Amorphous Solar Modules)	Technical High School (Khamtee), Sagaing Region	Ditto	2009/07/18	33,700

Source: MOST, 2010

(5) Mini Hydro

1) MOI

Currently, a total of 475kW has been supplied by mini-hydro at 38 villages.

Table 4.1-19 Mini-hydro Project by MOI

No.	Location	No. of Village	Installed Capacity (kW)
1	Kachin State	*1*	*75*
2	Tanintharyi Division 75kW Francis Turbine (2 sets) 30kW Hydro Turbine (3 sets) 5kW Mini-hydro Turbine (32 sets)	*37*	*400*
Total		**38**	**475**

Source: MOI, December 2012

2) MOAI

In the summit held by MOAI on 2013, MOAI reported that a total of 3,320 kW had been supplied by mini-/micro-hydro[20] for 14,000 households.

Table 4.1-20 Mini-hydro Project by MOAI

No.	Location	No. of Installed Unit		No. of Household	Installed Capacity (kW)	W/Household
		Micro	Mini			
1	Naypyidaw	2		150	30	200
2	Yangon Region	2		100	8	80
3	Mandalay Region	23		3,350	302	90
4	Ayeyarwady Region	28	1	2,000	740	370
5	Sagaing Region	4	1	600	284	473
6	Bago Region	8	2	1,050	236	225
7	Magway	11	1	1,900	204	107
8	Tanintharyi Region	4		150	22	147
9	Southern Shan State	13	1	1,000	192	192
10	Northern Shan State		3	1,500	500	333
11	Kayah State	2		100	8	80
12	Mon State	2		150	9	60
13	Rakhine State		2	800	180	225
14	Chin Sate		1	1,100	600	545
15	Kayin State	1		50	5	100
Total		**100**	**12**	**14,000**	**3,320**	**Average: 215**

Source: MOAI, 2013

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[20] Micro: 5 kW ~ 100 kW, Mini: 100 kW ~ 1,000 kW

3) MOST

3 kW low head propeller turbine was constructed in 2009 at the central workshop (Kyause) and tested at Dan Taing Village hydropower site near Kyause. 7 kW head propeller turbine is constructed in 2009 at the central workshop (Kyause) and tested at Kulla Village hydropower site near Kyause.

Table 4.1-21 Mini Hydro Project by MOST

Output	Location	Type	Start Date
3 kW	Central Workshop (Kyause), MOST	Vertical type, 4 blades system of Propeller Turbine	2009/01/10
7 kW	Ditto	Ditto	

Source: MOST, June 2010

4) MOEP

Total of 33,327 kW was supplied by Mini-hydro installed by MOEP. These activities were transferred to local governments early 2013.

Table 4.1-22 Mini Hydro Project by MOST

Region/State	Number of Plants	Number of Machines	Installed capacity (kW)	Electrified Area	
				Towns	Villages
Kachin	3	8	6,460	6	
Kayah	1	2	118	1	
Kayin	1	2	62	1	
Chin	8	17	3,113	8	25
Sagaing	2	3	1,310	2	
Tanintharyi	2	6	392	1	4
Bago	1	2	2,000		1
Mandalay	2	4	4,450	1	3
Mon	1	3	192		1
Shan	11	24	15,230	10	10
Total	**32**	**71**	**33,327**	**30**	**44**

Source: MOEP, September 2013

(6) Biogas

MOST promote to introduce the biogas grid system. As of June of 2012, dome type biogas digester plants which capacity of gas are 25 ~ 100m^3 and of electricity are 5 ~ 25kW had been installed at 175 villages by MOST as summarized in Table 4.1-23.

Table 4.1-23 Biogas Project by MOST

Digester Size (m^3)	Location	Type	Date Started	Purpose/Objective	No. of Biogas Plant (No.)
50	Naypyidaw Division	Fixed Dome Type	2003	Electricity	6
10			2009	Electricity, Cooking and Lighting	5
8			2008	Cooking and Lighting	8
35			2012	Demonstration	1
15			2012	Demonstration	2
100	Mandalay Division		2008	Electricity	1
50			2002		102
35			2009		4
25			2009		2
8			2009	Cooking and Lighting	3
50	Sagaing		2004	Electricity	23
15			2010		1
10			2009	Cooking and Lighting	1
50	Magway		2004	Electricity	8
25			2009		1
50	Shan State (N)		2005		1
25	Shan State (E)		2009		1
10			2009		1
60	Shan Stage (S)		2010	Cooking	1
25			2009	Electricity	1
50	Kayah		2009		1
15	Kachin		2010		2
5			2010	Cooking and Lighting	1
10	Ayeyarwady		2009	Electricity	2
10	Mon		2012	Pumping	1
35	Yangon		2012	Electricity	1
35	Rakhine		2012	Electricity	1
8	Shan State (E)		2012	Cooking and Lighting	1
Total					**183**

Source: MOST, June 2012

MOST educates high school and university, and gives villagers the technical explanation to confirm if they have the will to introduce the system. The systems are successfully operated so far except one unfairness issue in collecting cow dung. This issue has been solved by means that cow owners provide the dung and villagers keeping no cow provide their workforces to prepare the fuel from the dung. By MOST's estimation, about 29 trees per one family per year can be protected from logging on average by the biogas system.

50% of the costs for all these projects were beard by the village and remaining 50% were temporary supplied by MOST. The remaining 50% are being repaid by the village to MOST with electricity tariff.

(7) Biomass

1) MOI

MOI installed 4 sets of biomass plants utilizing woodchip at 4 villages (Table 4.1-24).

In addition to aforementioned biomass project, Myanmar Rice Association set up the rice-husk electrification project in Ayeyarwady Area by NEDO's (New Energy and Industrial Technology Development Organization) fund. MOI supply GEs in the project.

Table 4.1-24 Biomass Project by MOI

No.	Location	No. of Village	Quantity of plant
1	Chin State[21]	3	3 sets (8 kW Gasifier)
2	Mandalay Division	1	1 set
Total		**4**	**4 sets**

Source: MOI, Dec. 2012

2) MOST

MOST is undertaking research and development of woodchip for application to down-draft gasifier and small scale fluidized bed gasifier to produce electricity for lighting of villages in the rural area.

As presented in Table 4.1-25, several woodchip down-draft gasifiers have been constructed as pilot plant as well as research purpose at MOST's own expense. However, these projects are now suspended due to offensive odor.

Table 4.1-25 Pilot Plants of Woodchip Down-draft Gasifier by MOST

Location	Capacity (kW)	Date started	Cost (US$)
Prawn Hatchery (Ge Wa, Taung Koat Township, Rakhine State)	30	2004	7,500
Technological University (Htarwel)	50	2009	9,400
Technological High School (Gantgaw)	50	2009	7,800
Mel Zel Village, Loikaw Township, Kayah State	50	2009	9,400
Technical High School (Putao)	50	2009	9,400
Technological University (Mawlamyaing)	50	2009	9,400
No(1) Motorcar Industry Department, Yangon, MOI (2)	50	2009	9,400
Gasifier Project, Renewable Energy Department, Technological University (Kyause)	50	2009	9,400

Source: MOST, 2010

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[21] 3 sets of gasifier were donated to MOI by Government of India. Construction costs for electricity distribution lines, etc. were beard by the village. A local private company operates the project and O&M costs are beard by the village.

(8) Wind Power

1) MOI

MOI installed one wind power plant so far.

Table 4.1-26 Wind Power by MOI

No.	Location	No. of Village	Installed Capacity
1	Irrawaddy Division	1	500 kVA

Source: MOI, Dec. 2012

2) MOST

Under the MOST, 3 wind power facilities were constructed and tested as shown in Table 4.1-27.

Table 4.1-27 Wind Power by MOST

Name	Location	Type	Date started	Cost (US$)
1.2 kW Wind Turbine	Momastery, Dattaw Mountain, Kyause Township, Mandalay Region	Radial-flux, Permanent Magnet Generator, Three Blades System	July 7, 2008	2,000
1.2 kW Wind Turbine	Government Technical High School (Ahmar), Ayeyarwady Region	Direct Driven, Horizontal Type and Three Blades System using Axial-Flux Permanent Magnet Generator	April 16, 2010	2,300
3 kW Wind Turbine	Wind Energy Project Group (Kyause), MOST	Direct Driven, Horizontal Type and Three Blades System of Wind Turbine, using Axial-flux Permanent Magnet Generator	January 10, 2009	3,000

Source: MOST, 2010

(9) Diesel Mini-Grid System

ESE (Electricity Supply Enterprise) has implemented the rural electrification by the diesel mini-grid systems so far as expressed in Table 4.1-28. Table 4.1-29 shows the detail data on recent rural electrification with the diesel mini-grid systems by ESE.

Table 4.1-28 Rural Electrification by Diesel Generators as of 2014

No.	Regions	No ; of electrified townships/ villages with diesel generator	No. of diesel generator	Capacity (kW)
1	Kachin	25	59	5,426.4
2	Kayah	17	27	958.4
3	Kayin	23	42	5,656.4
4	Chin	11	33	3,162.4
5	Sagaing	36	86	10,059
6	Tanintharyi	16	26	5,346.8
7	Bago(East)	3	17	1,012.4
8	Bago(West)	-	6	380.4
9	Magway	6	27	3,858.4
10	Mandalay	1	17	1,617.6
11	Mon	7	18	3,502.4
12	Rakhine	58	108	22,942
13	Yangon	-	-	-
14	Shan (Southern)	42	64	2,432
15	Shan (Northern)	21	42	4,324.24
16	Shan (East)	28	73	7,719
17	Ayeyarwady	8	27	1,773.8
18	Naypyitaw	-	22	6,472
Total		**302**	**694**	**86,643.6**

Source: ESE, May 2014

Table 4.1-29 Details of Diesel Mini-Grid System by ESE

Name of Town/Village	State	Output (kW)	Total No. of Households	No. of Users (Households)	W/ Household	Available Hours/Day
Kawaza	Mon	70	4,812	364	200	2 hours/day
Lamie	Ditto	470	18,580	396	1,200	2 hours/day
Katoe	Ditto	61	872	251	240	1.45 hours/day
Ye	Thanin	540	19,794	3,074	180	24 hours/day
Machanbaw	Kachin	128	488	219	580	2.15 hours/day
Naungmone	Ditto	63	299	136	460	3.2 hours/day
Saunparabon	Ditto	59	154	133	440	3 hours/day
Kaunglanpue	Ditto	7	144	41	170	2.5 hours/day
Pannandin	Ditto	7	267	40	180	3 hours/day
					Average 306 except Lamie	

Source: ESE, May 2014

Private companies are running rural electrification business by diesel generators with total amount of 46,106 kW so far. The power tariff is 370 ~ 500 Kyats/kWh, which is around 10 times as higher than the grid power tariff.

(10) Development of a Myanmar National Electrification Plan by WB (The World Bank)

With regard to “Development of A Myanmar National Electrification Plan Towards Universal Access 2015-2030”, WB reported the following three (3) projects as the draft final results at the Third Workshop in Naypyidaw on 8th August 2014.

1) National Geospatial, Least-Cost Electrification Rollout Plan

Proposed method is selection of the least cost rural electrification plan among grid, diesel mini-grid and off-grid (SHS) by inputting settlements as for power demand and grid lines including future plan in the map.

As the results, the recommended future electrification over the long term is that 99% of households in Myanmar have to be electrified by the grid connections.

But some remote area such as Chin, Shan, Kachin and Kayah will have high cost per connection. Therefore, grid connections will be reached in the latest phase (around 10 ~ 15 years later). To address this situation, pre-electrification options with lower service standards for basic needs are considered.

In conclusion, around 7.2 million households which equivalent to 99% of total households in Myanmar will be electrified by grid connections. To realize the plan, 2.5 ~ 3.0 GW of new generation capacity will be needed. Total cost is estimated USD 5.8 billion (average 800 USD/household)[22].

2) Universal Access Roadmap and an Investment Prospectus for 2015 ~ 2019

1.7 million households are expected to be electrified by grid connections for 2015 ~ 2019, and approximately 125,000 households can be electrified by mini-grid and off-grid both as permanent and pre-electrification.

To realize the plan, USD 650 million of loans and USD 24 million of technical assistance are required. Funding gap[23] depends on decisions about tariffs. Over a 40-year period, it is around USD 2.2 billion in case of current tariff, around USD 1.1 billion in case of cash neutral tariff of the existing system, and around 0.25 billion in case of maintaining a residential tariff equivalent to Vietnam respectively.

To close the funding gap, GoM will need to subsidize operating loss and pay debt service. Governmental support (subsidy) will increase year by year and finally reach around USD 528 million/year while current total governmental support to MOEP is USD 567 million/year.

3) Institutional Requirements for the National Electrification Plan Implementation

The project proposed institutional reform to meet Myanmar’s electrification change. The institutional reform will need to address barriers related to;

i) program-level management and coordination
ii) efficient operation of ESE and YESB under MOEP leadership, and ability to use private and community resources in sub-franchise areas
iii) accelerated implementation of mini-grid

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[22] Additional investments will be needed for generation & transmission
[23] Funding gap = (Revenue + Loan amount received) – (Capex + Opex + Loan repayment)

iv) sustainability and efficiency of individual household-level solutions
v) involving private sector efficiently

With regard to i), WB recommends establishing Executive Secretariat reporting to the office of the Vice President or President and to establish Independent Regulatory for tariff & standard setting in the medium term.

With regard to ii), WB recommends corporatizing YESB, developing investment program for YESB and being enable YESB to access financing for distribution expansion through Executive Secretariat. ESE should follow the same path as YESB

With regard to iii), WB recommends that mini-grid broadly follow the process for sub-franchising of ESE grid area and DRD combined responsibility for SHS and mini-grid system.

With regard to iv), WB recommends that DRD provide financial incentives, clear guidelines for entities and training support/incentives for technicians. WB also recommends DRD encourage scaling up of SHS and closely monitor program's progress.

With regard to v), WB recommends supporting private sector SHS provision.

(11) Investment Forum of Off-grid Renewable Energy by ADB

ADB (Asian Development Bank) held the Investor Forum on Off-grid Renewable Energy Opportunities at Naypyidaw on March 21-22, 2014.

1) Session 1: ADB Off-grid Renewable Energy Program in Myanmar

ADB presents the ongoing solar home system projects in Mandalay Region and Chin State with subsidies from GoM and Chin State. 40% of investment will be recovered by power tariff. The project will be completed on May 2014 as Phase I.

2) Session 2: Technology Applications for Lighting and Productive Uses

The session identifies suitable clean energy technology for lighting livelihood generation and appropriate business models through the examples in Bangladesh and Pakistan, etc.

3) Session 3: Best Practices for Scaling up Mini-Grid Systems

The session presents various technologies and modalities to develop suitable mini-grid systems through the examples in India, Laos and Africa, etc.

4) Session 4: Programmatic Approach for Energy Access – Lessons Learnt

Discussion on various programs, approaches and lessons learnt from successful initiatives through the examples in China and India.

(12) Renewable Energy for On-Grid

With regard to the solar power, wind power and geothermal power for on grid, MOEP makes MOU with private firms, and its details are described in Chapter 5.

4.2 OUTLOOK OF PRIMARY ENERGY TOWARD 2030

As the future plan of the HPPs (hydropower plants) is described in Chapter 5, outlooks toward 2030 for natural gas, coal and renewable energy[24] in Myanmar are examined in this Chapter. In this Draft Final Report (2), supply and demand balances (2013 ~ 2030) of natural gas and coal are prepared. Future gas-fired TPPs and future coal-fired TPPs that will be constructed during 2014 ~ 2030 are summarized in Table 4.2-1.

The table is mutually confirmed by MOEP and JICA Study Team in June 2014 (the table is same as Scenario 3 in Chapter 5).

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[24] mainly for rural electrification

Table 4.2-1 Construction Schedules on Gas-Fired TPPs and Coal-fired TPPs (~2030)

Project				Installed Capacity (MW)		COD	Available Capacity for Myanmar (MW)		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
									2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Thermal	Gas Turbine	Ywama	EGAT	240	GT	2013	240		240																	
		Kyaukphyu (New)	MOEP	50	GT	2016	50				50															
		Thilawa	Yangon	50		2015	50				50															
	(Sub Total)							*Cumulative*	*240*	*240*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*
	Combined Cycle	Ahlone	Toyo-Thai	84	GT	2013	84		84																	
			Toyo-Thai	37	ST	2014.9	37				37															
		Mawlamyaing	Myanmar Lighting	98	GTCC	2015	98			98																
			Myanmar Lighting	132	GTCC	2016	132					132														
		Hlawga	Hydrolancang (Cnina)	243		2021	243										243									
			Hydrolancang (Cnina)	243		2021	243											243								
		Thaketa	BKB (Korea)	167		2023	167												167							
			BKB (Korea)	336		2023	336													336						
			UREC (China)	100		2015	100				100															
			UREC (China) N1	400		2027	400															400				
		Kanpouk (New)	Dawei Power Utilities	200		2022	200											200								
			Dawei Power Utilities N2	300		2023	300																300			
		Myin Gyan (New)	Myn Gyan	250		2015.8	250				170	80														
		Hlaingtharyar (New)	Yangon	400		2025	400														400					
		Ayeyarwaddy (New)	Yangon	500		2024	500													500						
	(Sub Total)							*Cumulative*	*84*	*182*	*489*	*701*	*701*	*701*	*701*	*701*	*944*	*1387*	*1554*	*2390*	*2790*	*3190*	*3490*	*3490*	*3490*	*3490*
								Each year		*98*	*307*	*212*	*0*	*0*	*0*	*0*	*243*	*443*	*167*	*836*	*400*	*400*	*300*	*0*	*0*	*0*
	Gas Engine	Hlawga	Zeya	25	GE	2013.5	25		25																	
			Zeya	25	GE	2015	25				25															
		Ywama	MSP	50	GE	Commissioning 2013.7	50		50																	
		Thaketa	CIC	50	GE	Commissioning 2013.7	50		50																	
		Kyause (New)	Rental	82		2013	82		82		-82															
		Kyaukpyu (New)	Rental	4.4					3.3	1.1	-4.4															
		Kanpouk		20	GE	2015	20				20															
	(Sub Total)							*Cumulative*	*210.3*	*211.4*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*
				Sub Total	*4062*			*Cumulative*	*534.3*	*633.4*	*999*	*1211*	*1211*	*1211*	*1211*	*1211*	*1454*	*1897*	*2064*	*2900*	*3300*	*3700*	*4000*	*4000*	*4000*	*4000*
								Each year	*534.3*	*99.1*	*365.6*	*212*	*0*	*0*	*0*	*0*	*243*	*443*	*167*	*836*	*400*	*400*	*300*	*0*	*0*	*0*
	Coal-fired Future	Mon-Yee (Toyo-Thai)	Coal	1280		2018-2019	1280																			
		Yangon-Kunchangon (Virtue Land)	Coal	300		2016	300							300												
			Coal	990		2018	990														330	330	330			
			Coal	1980		2020	1980																	660	660	660
		Yangon-Htantapin (Htoo Group)	Coal	270		2018-2019	270																			
		Ngayukong (Ayarwaddy Division,Tata)	Coal	550		under discussion	550								275							275				
		Kalewa (Sagaing Division)	Coal	540		2017-2018	540						270								270					
		Boakpyin (Tanintharyi State)	Coal	500		2017-2018	250	Domestic 50%								250								250		
		Yangon-Kyauktan	Coal	1300		under discussion	1300										300			300			350		350	
		Keng Tong (Shan State)	Coal	600		under discussion	600														300				300	
		Thilawa (New)	Coal	360		2017	360						360													
		Ngaputaw	Coal	700		2021	700									350							350			
				Sub Total	*9370*		*9120*	*Cumulative*	*0*	*0*	*0*	*0*	*630*	*930*	*1205*	*1805*	*2105*	*2105*	*2105*	*2405*	*3305*	*3910*	*4940*	*5850*	*7160*	*7820*
								Each year	*0*	*0*	*0*	*0*	*630*	*300*	*275*	*600*	*300*	*0*	*0*	*300*	*900*	*605*	*1030*	*910*	*1310*	*660*

Source: prepared by JICA Study Team

4.2.1 Natural Gas

Necessary gas quantities are estimated by the following policy;

- Existing/ongoing gas-fired TPPs: registered values by MEPE[25] in Table 4.1-6.
- Future gas-fired TPPs: calculated values by JICA Study Team[26].

(1) Calculation Conditions of Necessary Gas Quantities for Future Gas Fired Plants

1) Output

To estimate the required gas quantities for gas fired TPPs, JICA Study Team assumes that outputs (installed capacities) in MEPE presentation are based on Myanmar atmosphere air conditions (i.e. air temperature is 30 °C).

2) Correction of Efficiency

With regard to efficiency, the efficiencies are estimated by Gas Turbine World 2013 Performance Specs 29th Edition. The efficiencies in Gas Turbine World are specified by ISO[27] bases. Therefore, the efficiencies are corrected by atmosphere air conditions of Myanmar. The efficiencies are also corrected by sea/river temperature, as well as expected partial load operation and deterioration of GT and GE with time. The results are shown in the right table;

Type	Correction
GT (Simple Cycle)	94%
GTCC	93%
GE	96%

In case of GTCC, the condenser of ST (steam turbine) is considered as the once-through type. Therefore, if the cooling tower system is applied, the efficiency will further drop.

3) Capacity Factor

JICA Study Team assumes that capacity factor is 75% in accordance with recent PPA (Power Purchase Agreement) of the gas-fired TPP.

4) Rehabilitation/Replacement of Existing Gas-Fired TPPs

As several existing gas-fired TPPs have operated more than 30 years, there are replacement plans to GTCC such as Thaton and uprated plan such as Thaketa. JICA Study Team assumes that these TPPs will consume same amount gas as that of existing power plants.

5) Lower Heating Value of Gas

JICA Study Team converts GCV informed by MOE to NCV (Net calorific value)[28] as shown in the right table. As JICA Study Team has information on GCV of the onshore gas and offshore gases except M-3, JICA Study Team assumes that the heating value of M-3 is the same as that of Zawtika. JICA Study Team adopts the average lower heating value for LNG.

Lower heating value of Yadana gas is much lower than

Gas Source	NCV	
	Btu/ft^3	Kcal/m^3
Onshore	965	8,581
Yadana	686	6,099
Shwe	938	8,337
Zawtika	897	7,971
M-3	Ditto	Ditto
LNG	1,040	9,250

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[25] Power Development Scheme of MEPE Presentation on July 2, 2013
[26] Necessary gas quantity for Thilawa is informed by JICA
[27] Atmosphere air temperature of ISO is 15°C
[28] Same meaning as LHV (lower heating value)

those of onshore gas, other offshore gases and LNG.

(2) Output and Efficiency of Future Gas-Fired TPPs

As GT/GTCC configurations of the future gas-fired TPPs are not exactly clear at this moment, JICA Study Team set the calculation conditions in Table 4.2-2 based on Gas Turbine World 2013 Performance Specs 29th Edition (ISO) and the correction factors described in 2).

UREC 2 (400 MW) and Dawei Power 2 (400 MW) with light orange cell in the table are added by JICA Study Team to address the power demand after 2016-2017. Other gas fired TPPs in the table are the same as those planned by MOEP.

As for the future gas-fired TPPs of Ayeyarwady/Yangon (500 MW), Hlaingtharyar (400 MW) and UREC 2 (400 MW), JICA Study Team recommend adopting GTCC with high efficiency GT (combustion temperature is more than 1,500°C) because MEPE can enjoy reducing the gas consumption by around 13% due to the increase of efficiency as shown in Table 4.2-2.

With regard to the system frequency stability of Myanmar in case of failure of 400 ~ 500 MW GTCC, as these gas fired TPPs are planned to be put into operation after 2024-2025, prospected peak load reaches around 7,000 MW. Therefore, the frequency drop by the loss of 400 ~ 500 MW is well within allowable range.

Table 4.2-2 Installed Capacity and Efficiency of Future Gas-Fired TPPs

Location.	Project	Machine Type	Installed Capacity (MW)	Gas Sources	Efficiency
Mawlamyaing	Myanmar Lighting	GTCC	98	Zawtika	46.5
	Ditto	GTCC	132	Ditto	47.3
Hlawga	Hydrolancang	GTCC	243	Unknown	48.7
	Ditto	GTCC	243		
Thaketa	BKB 1	GT	167	Unknown	31.6
	Ditto 2 (add-on)	GTCC	503		49.2
	UREC 1	GTCC	100	Zawtika	46.5
	UREC 2	GTCC	400	Unknown	54.4
Kyaukphyu	MOEP	GT	50 (25×2)	Shwe	31.7
	Rental GE	GE	4.4	Ditto	44.2
Kanpouk	GE	GE	20	Zawtika	44.2
	Dawei Power 1	GTCC	200	Unknown	50.0
	Dawei Power 2	GTCC	300		49.8
Mandalay	Myin Gyan	GTCC	250	Shwe	48.7
	Kyause (Rental GE)	GE	82	Ditto	44.2
Yangon	Hlaingtharyar	GTCC	400	Unknown	54.4
	Thilawa	GT	50	Zawtika	31.7
Ayeyarwady/Yangon		GTCC	500	Unknown	56.7

Source: prepared by JICA Study Team

(3) Required Gas Quantity

Table 4.2-3 shows required gas quantity for the existing, ongoing and future gas-fired TPPs.

Table 4.2-3 Estimated Required Gas Quantities

Location			COD	Output (MW)*^{1}	Required Gas (MMSCFD)	Required Gas (BBTUD)				Gas Source
						2013-2014	2014-2015	2015-2016	2016-2030	
Local	Kyungchung	Existing	1974	54.0	18	16.5	→	→	→	Onshore
	Mann	Existing (Spare)	1980	37.0	0	0	→	→	→	
	Shwedaung	Existing	1984	55.0	27	17.6	→	→	→	Yadana
	Mawlamyaing	Existing (Demolition)	1980	12.0	4	0	→	→	→	Zawtika
		Myanmar Lighting 1	2014.05	98.0	15		12.8	→	→	
		Myanmar Lighting 2	2016-17	132.0	20				17.3	
	Myanaung	Existing	1975/1984	34.7	17	11.1	→	→	→	Yadana
	Thaton	Existing	1985/2001	51/106	19	16.2	→	→	→	Zawtika
				Subtotal of Existing		61.2	74.8			
				Ditto + Others		62.0	86.1	74.0		
Yangon	Hlawga	Existing	1996/1999	154.0	39	25.4	→	→	→	Yadana
		Zeya	2013.05	25.0	8	5.2	→	→	→	
			2015-16	25.0	8			5.2	→	
		Hydrolancang (China)	2021-22	243.0	Unknown				30.8	Unknown
		Hydrolancang (China)	2022-23	243.0					30.8	
	Ywama	Existing	1980/2004	70.0	28	18.2	→	→	→	Yadana
		MSP	2014.03	50.0	16.6	10.8	→	→	→	
		EGAT	2014.04	240.0	80	52.0	→	→	→	
	Ahlone	Existing GT/ST	1995/1999	154.0	39	25.4	→	→	→	Yadana
		Toyo-Thai	2013.05(GT)	84.0	29.8	19.4	→	→	→	
			2015-16(ST)	37.0						
	Thaketa	Existing	1990/1997	92.0	22	18.7	→	→	→	Zawtika
		CIC	2013.08	50.0	11.5	9.8	→	→	→	
		BKB (Korea)	2023-24	167.0	Unknown				31.5	Unknown
			2024-25	336.0					31.5	
		UREC (China)	2015-16	100.0	15.6			13.2	→	Zawtika
			2026-27	400.0	Unknown				45.2	Unknown
				Subtotal of Existing		184.7	184.7	→	→	
Others (Future with 2 Existing)	Kyaukphyu	MOEP	2015-16	50.0	10.6			9.8	→	Shwe
		Renral GE		4.4	1	0.8	→	-0.8	0	
	Kanpouk	GE	2015-16	20.0	4			2.8	→	Zawtika
		Dawei Power Utilities	2022-23	200.0	Unknown				24.8	Unknown
			2027-28	300.0	Unknown				37.5	Unknown
	Mandalay	Myin Gyan	2015-16	250.0	35			31.5	→	Shwe
		Kyause (Rental GE)	2014.04	82.0	13		11.3	-11.3	0	
	Yangon	Hlaingtharyar	2025-26	400.0	Unknown				45.2	Unknown
		Tilawa*^{2}	2015-16	50.0	16*^{2}			10.4	→	Zawtika
		Ayeyarwady/Yangon	2024-25	500.0	Unknown				54	Unknown
Total				4702/4757	Unknown	246.7	270.8	331.6	**680.2**	(596.7) without JICA S/T

□ Existing 🟨 On-going 🟦 Future 🟧 Added by JICA Study Team

*^{1}Installed Capacity

*^{2}Information from JICA (16 MMSCFD seems to be Yadana gas)

Source: prepared by JICA Study Team

As shown in Table 4.2-3, gas sources of future gas fired TPPs planned to be operated after 2020-2021 are unknown. Therefore, required gas quantity (mmscfd) for several future gas fired TPPs marked in red cannot be estimated because of unknown gas properties.

Gas supply and demand balance based on gas calorific value basis

Gas supply and demand balance is usually prepared by gas volume basis (mmcfd or mmscfd), However, in case of Myanmar, gas sources after 2020-2021 are unknown[29]. As required gas volume cannot estimate without gas properties, it is impossible to prepare gas supply and demand balance until 2030 with gas volume basis.

To address this situation, JICA Study Team devises the method, which is gas supply and demand balance by calorific value basis (bbtud) instead of gas volume basis. The required gas calorific values (bbtud) can calculate without gas properties, therefore, it is possible to prepare gas supply and demand balance until 2030 without any information about gas sources after 2020-2021.

This method is also useful in case that gas heating values are quite different among gas sources.

In case of Myanmar, due to the foregoing two (2) reasons (unknown gas sources and different gas heating values among gas sources), gas supply and demand balance by calorific value basis (bbtud) is the best suitable method.

Required total gas quantities in 2030 are 679.4 bbtud with added projects by JICA Study Team and 596.7 bbtud without added projects by JICA Study Team respectively.

(4) Domestic Gas Supply Forecast

JICA Study Team received the domestic gas supply forecast from the existing and ongoing gas fields until 2030 from EPD. All gas volumes (mmcfd) in Table 4.2-4 are converted to gas calorific values (bbtud) to prepare the gas supply and demand forecast.

Table 4.2-4 Gas Supply Forecast (~2030)

(mmcfd)

	Proven + Probable Reserve	Commercial Operation Date	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31
Existing																				
(1) MOGE	2.5 TCF		65	65	65	65	65	65	65	65	65	92	94	95	97	99	101	102	104	105
(2) Yadana	6.942	1/7/1998	225	225	225	225	225	225	157	137	119	104	87	70	54	43	26			
(3) Yetagun	4.166	1/4/2000																		
Ongoing																				
(1) Zawtika	1.756		60	100	100	100	100	100	100	100	100	100	100	87	42	28	19	14	9	
(2) Shwe	5.353	15/7/2013	20	80	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
(3) M3	1.639								70	150	150	150	150	150	150	150	150	150	150	150
(4) LNG																				
New Gas Fields																				
(1) 2022-2031																				
Supply Total			370	470	490	490	490	490	492	552	534	546	531	502	443	420	396	366	363	355
Supply Total for Electricity			258																	

Source: EPD (2013)

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[29] Main candidate of gas sources after 2020 is gas from new gas fields, however, if new gas is delay or not enough, there is a possibility of LNG.

(5) Gas Supply and Demand Balance

With regard to gas supply, JICA Study Team assumes as follows;

- Gas supply from new gas fields starts in 2020-2021[30]
- Gas shortage until 2019-2020 is solved by imported fuel oil or LNG.
- LNG can be supplied from 2016-2017.
- Fuel oil can be supplied from 2014-2015
- Average lower heating value of LNG is 9,250 kcal/m^3 (1,040 Btu.ft^3)
- Average lower heating value of HSD is 8,624 kcal/l
- The efficiencies of GE and GT during fuel oil firing are reduced by about 5% respectively compared with those during gas firing. Therefore, required fuel oil quantities are calculated with such consideration.

Table 4.2-5 shows gas supply and demand balance until 2030.

Table 4.2-5 Gas Supply and Demand Balance (~ 2030)

bbtud

		2P*/MW	COD	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31
Supply	Existing																				
	(1) MOGE	2.5 TCF		63	63	63	63	63	63	63	63	63	89	91	92	94	96	97	98	100	101
	(2) Yadana	6.9TCF	1/7/1998	154	154	154	154	154	154	108	94	82	71	60	48	37	29	18			
	(3) Yetagun	4.2TCF	1/4/2000																		
	Ongoing																				
	(1) Zawitika	1.8TCF		54	90	90	90	90	90	90	90	90	90	90	78	38	25	17	13	8	
	(2) Shwe	5.4TCF	15/7/2013	19	75	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
	(3) M-3	1.6TCF								63	135	135	135	135	135	135	135	135	135	135	135
	Supply Total			290	382	401	401	401	401	418	476	464	479	470	447	398	379	361	340	337	330
	Supply Total for Electricity			201	248.3	260.7	260.7	260.7	260.7	271.7	309.4	301.6	311.4	305.5	290.6	258.7	246.4	234.7	221	219.1	214.5
	Required Calorie (bbtud)				22	70	87	87	87	76											
	LNG (mmcfd)^{*2}						84	84	84	73											
	HSD (mmld)*^{3}				0.7	2.1	2.7	2.7	2.7	2.3											
	New Gas Fields (bbtud)										60	119	189	247	401	520	609	684	705	708	715
	New Gas Fields (mmcfd)*^{4}										66	133	211	275	448	580	678	763	786	790	797
Demand	Existing Plants																				
	(1) Yangon Area	919^{*5}	1980 ~ 2014	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7	184.7
	(2) Other than Yangon Region	385^{*5}	1974 ~ 2014	62	85.3	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2	73.2
	Ongoing																				
	(1) Hlawaga GE (MCP)	25	2015 ~ 2016			5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	(2) Toyo-Thai (ST)	37																			
	New Gas Fired Plants																				
	(1) 2014 ~ 2016 Myanmar Light 2, UREC 1, Kyaukpyu, Kanpouk, Myin Gyan, Tilawa	602	2014 ~ 2016			67.7	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
	(2) 2021 ~ 2030 Hydorance, BKB, UREC 2, Dawei 1, Dawei 2, Hlaingtharyar, Ayeyarwady	2,789	2020 ~ 2021									30.8	86.4	117.9	203.4	248.6	293.8	331.3	331.3	331.3	331.3
	Total Power Generation	4,757																			
	Demand Total			247	270	331	348	348	348	348	348	379	435	466	552	597	642	679	679	679	679
Balance				-46	-22	-70	-87	-87	-87	-76	-39	-77	-123	-161	-261	-338	-396	-445	-458	-460	-465
Total Balance with LNG and New Gas				-46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*2P: Gas reserves on 2P (Proven + Probable) basis
*^{2}Incase of LNG=1,040 Btu/f^3
*^{3}In case of HSD (LHV = 8,624 kcal/l)
*^{4}In case of LHV = 897 Btu/f^3
^{*5}Installed Capacity

Source: prepared by JICA Study Team

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[30] In EPD presentation material (September 2013) "Ensuring Domestic Supply of Natural Gas for Sustainable Power Generation in Myanmar" described that Offshore Block M-3: Earliest First Gas on 2018, Offshore Areas: Develop earliest on 2019. On the other hand, JICA Study Team have officially received Table 4.2-4 in which M-3 starts 2019-2020. Considering 2 pieces of information, JICA Study Team adjusts new gas from 2020-2021 at the earliest.

Explanations of Table 4.2-5:

a) Gas supply quantities made by EPD are converted from gas volume base (mmcfd) to gas calorific value base (bbtud).

b) Total supply to power sector in 2013-2014 is followed by that of Table 4.1-6 prepared by MEPE. After 2014-2015, total supply is assumed as power sector = domestic gas supply by MOE × 0.65.

c) To address the gas shortage during 2014 ~ 2019, LNG and/or fuel oil has to be purchased. Required maximum quantity of LNG only for the power sector is 84 mmcfd (marked in green), and that of fuel oil only as HSD for the power sector is 2.7 mmld (marked in green). In case of mixed use of LNG and HSD, these maximum values are reduced in accordance with mixed percentage.

d) Gas shortage during 2020 ~ 2030 will be solved by gas from new gas fields (marked in blue). Maximum required gas quantity from new gas fields including other sectors' requirements is estimated 715 bbtud (797 mmcfd based on Zawtika's calorific value). On the other hand, maximum required gas quantity from new gas fields for the power sector is 465 bbtud (518 mmcfd based on Zawtika's calorific value). This gas quantity is expected to be possible because gas from new gas fields is due only for domestic use.

To solve gas shortage until 2019, the following actions are necessary.

1) LNG

- Resume the contract negotiation with bidders on LNG purchase by MEPE.

2) Fuel Oil

- As explained Section 4.1.4, existing and ongoing GTs can use HSD. Therefore, upgrading of the present HSD facilities and/or installation of the additional HSD fuel firing facilities for GTs are implemented, if necessary to soonest use of HSD .
- Designation of dual firing type GE/GECC (gas engine combined cycle)/GT/GTCC in the biddings for new gas-fired TPPs to use fuel oil such as HSD, heavy fuel oil and crude oil during gas shortage period[31].

Fig. 4.2-1 shows the summary of gas/liquid fuel supply and demand plan until 2030 for the power sector.

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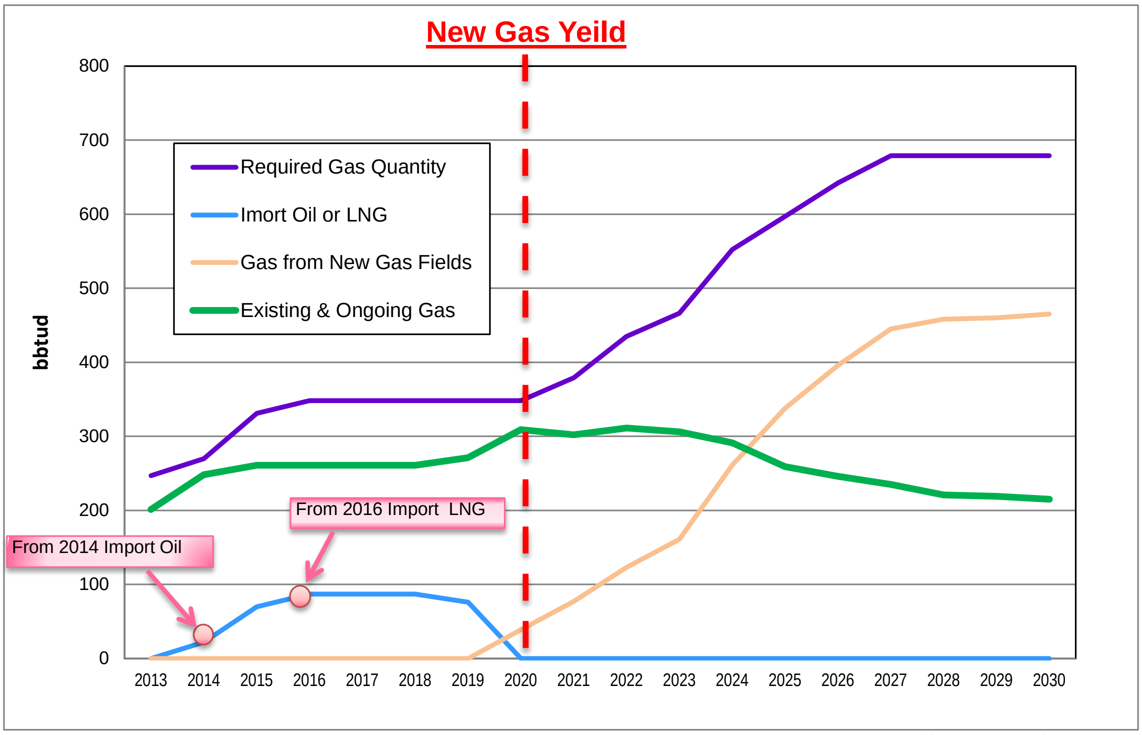
[31] As explained in 4.1.4, some GE can use both gas and heavy fuel oil/crude oil.



Source: prepared by JICA Study Team

Fig. 4.2-1 Gas/Liquid Fuel Supply Plan (~ 2030)

4.2.2 Coal

With regard to required coal quantity for the coal-fired TPPs, the outputs and efficiencies are corrected by means of similar methods to those for the future gas-fired TPPs.

(1) Existing Coal-fired TPP

The Tigyit coal-fired TPP (60 MW × 2 units) operated by HPGE is the only coal-fired TPP in Myanmar at present. Although the output of the plant is currently less than 50%, JICA Study Team assumes the calculation conditions to prepare the coal supply and demand balance (~ 2030) are as follows in consideration of planned rehabilitation:

a) Capacity factor is 70%
b) The design plant efficiency is 31%.
c) HHV (Higher Heating Value) is assumed as 7,050 Btu/lb (3,900 Kcal/kg) by the hearing from HPGE.

Under the foregoing assumptions, the required coal quantity after rehabilitation is estimated at 524×10^3 ton/year.

(2) Future Coal-fired TPPs

Required coal quantities for the future coal-fired TPPs are calculated under the following conditions;

1) Output

JICA Study Team considers the outputs (installed capacities) described in DHPP (Department of Hydropower Planning) presentation material is gross output (generator side).

2) Efficiency

The efficiency is divided into five (5) categories based on outputs.

Category	Gross Plant Efficiency (%)	Adopted efficiency (%)
Subcritical Plant (≦60MW)	33	33
Subcritical Plant (60 ~ 150MW)	37	37
Subcritical Plant (≧150MW)	37 ~ 39	38
SC (Super Critical) Plant	40 ~ 41	40.5
USC (Ultra Super Critical) Plant	42 ~ 43	42.5

Efficiency is based on HHV and Gross (generator side)

Type	Correction
Coal-fired TPP	95%

The efficiency is corrected according to sea/river water temperature in Myanmar, partial load operation and deterioration by aging. The results are shown in the right table. The condenser of ST is considered as the once-through type. Therefore, if the cooling tower system is applied, the efficiency further drops.

Subcritical plants are considered for the future IPP projects in Myanmar. However, In light of worldwide trend to mitigate the environmental burden by coal-fired plants, JICA Study Team recommends that MOEP make efforts to adopt USC plant as much as possible irrespective of MOEP's project or IPP. In this context, JICA Study Team explains the concrete procedure to introduce USC plant in Myanmar in Section 4.3.2.

In case of adoption of USC plant, USC plant is usually planned in the way that its capacity is more than 600 MW. The peak load of Myanmar will reach more than 6,000 MW in 2023-2024. Therefore, USC plant should be put into operation after 2023-2024 to keep system stability in case of failure of 600 MW capacity.

3) Capacity factor

Capacity factor is assumed as 70%.

4) HHVs of Coal

HHVs of domestic coals and Indonesian coals are shown below;

Kind of Coal	Heating Value (Kcal/kg)	Used Heating Value (Kcal/kg)
Domestic Coal	3,000 ~ 6,500	5,000
Indonesian Coal	4,500 ~ 5,500[32]	5,000

HHV, as received base

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[32] In Section 4.1.5 (6), JICA Study Team explains that typical heating values of exported coal from Indonesia are 6,500 and 3,400 Kcal/kg. However, by our previous study on planned IPP project in Myanmar, IPP will import rather low heating value coal from Indonesia to lower the coal price.

HHV of 5,000 Kcal/kg is used for both domestic coal and Indonesian coal to calculate the required coal quantity.

(3) Efficiency and Required Coal Quantity of Future Coal-fired TPPs

Table 4.2-6 shows the estimated coal efficiencies and required coal quantities.

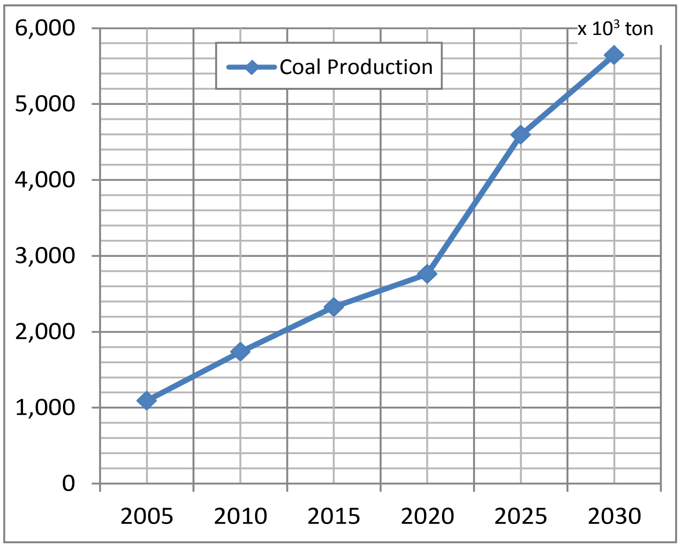
Table 4.2-6 Estimated Efficiency and Required Coal Quantities of Future Coal-fired TPPs

Location.	Project	Machine Type	Installed Capacity (MW)	COD	Estimate Values	
					Efficiency (%)[33]	Required Annual Coal Quantity (10^3 ton)
Yangon	Kunchangon	Subcritical	150×2, 330×3, 660×3	2018-2030	36.1	876, 964×3, 1,928×3
	Thilawa	Ditto	180×2	2017-2018	36.1	526×2
	Kyauktan	Ditto	300×2, 350×2	2021-2029	36.1	876×2, 1,023×2
Tanintharyi	Boakpyin	Ditto	250×2	2020-2028	36.1	730×2
Ayeyarwady	Ngayukong	Ditto	275×2	2019-2026	36.1	780×2
	Ngaputaw	Ditto	350×2	2020-2027	36.1	1,023×2
Sagaing	Kalewa	Ditto	135×4	2017-2025	35.2	405×4
Shan	Keng Tong	Ditto	300×2	2025-2029	36.1	876×2

Source: prepared by JICA Study Team

(4) Production Plan of Domestic Coal until 2030

MOM plans to increase the domestic coal production by about 16% annually to reach more than about 5,000 × 10^3 ton on 2030 as shown in Fig. 4.2-2[34].



Source: No.3 Mining Enterprise and JCOAL (2013)

Fig. 4.2-2 Annual Coal Production Forecast (~ 2030)

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[33] Efficiency is based on gross and HHV.

[34] As explained in 4.1.5 (2), DOM produces coal with PSC of private companies. JICA Study Team asked DOM their coal production plan. They answered as follows; 1) No coal production plan so far, 2) As mines controlled by DOM are relatively small, coal production plan by No.3 Mining Enterprise can be taken as that of MOM.

(5) Coal Supply and Demand Balance (~ 2030)

Table 4.2-7 shows the coal supply demand balance (~ 2030).

Table 4.2-7 Coal Supply and Demand Balance (~ 2030)

		2P*/MW	COD**	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31
Supply	(1) Domestic Coal	231,000		2,100	2,200	2,326	2,400	2,500	2,600	2,700	2,761	3,100	3,480	3,900	4,220	4,593	4,820	5,000	5,220	5,420	5,654
	Supply for Electricity			1,260	1,320	1,396	1,440	1,500	1,560	1,620	1,657	1,860	2,088	2,340	2,532	2,756	2,892	3,000	3,132	3,252	3,392
	(2) Import Coal							886	1,702	2,422	4,138	4,811	4,583	4,331	5,015	7,441	9,058	11,960	14,486	18,193	19,981
Demand	Existing Plants																				
	(1) Tygit	120	2004.12	300	300	300	524	524	524	524	524	524	524	524	524	524	524	524	524	524	524
	New Plants																				
	(1) 2017-2018	630						1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862
	(2) 2018-2019	300							876	876	876	876	876	876	876	876	876	876	876	876	876
	(3) 2019-2020	270								780	780	780	780	780	780	780	780	780	780	780	780
	(4) 2020-2021	600									1,753	1,753	1,753	1,753	1,753	1,753	1,753	1,753	1,753	1,753	1,753
	(5) 2021 ~ 2022	300										876	876	876	876	876	876	876	876	876	876
	(6) 2022 ~ 2023	0																			
	(7) 2023 ~ 2024	0																			
	(8) 2024 ~ 2025	300													876	876	876	876	876	876	876
	(9) 2025 ~ 2026	900														2,650	2,650	2,650	2,650	2,650	2,650
	(10) 2026 ~ 2076	600															1,753	1,753	1,753	1,753	1,753
	(11) 2027 ~ 2028	1,030																3,010	3,010	3,010	3,010
	(12) 2028 ~ 2029	910																	2,658	2,658	2,658
	(13) 2029 ~ 2030	1,310																		3,827	3,827
	(14) 2030~ 2031	660																			1,928
	Total Power Generation	7,930																			
	Demand Total			300	300	300	524	2386	3262	4042	5,795	6,671	6,671	6,671	7,547	10,197	11,950	14,960	17,618	21,445	23,373
Balance				0	0	0	0	-886	-1,702	-2,422	-4,138	-4,811	-4,583	-4,331	-5,015	-7,441	-9,058	-11,960	-14,486	-18,193	-19,981
Total Balance with Import Coal				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2P*: Coal reserves on 2P (Proven + Probable) basis COD**: Commercial Operation Date 13-14 means 2013-2014

Reference: Total Capacity of New Coal Fired Power Plant by Domestic Coal (MW)	387	456.91	535	621	687	763	810	847	891.94	932.98	980.99

Source: prepared by JICA Study Team

Conditions and assumptions of the table prepared are as follows;

a) HHV for Tigyit is 3,900 Kcal/kg, and HHV for domestic coal other than Tigyit and Indonesian coal is 5,000 Kcal/kg.

b) Before CODs of the future coal-fired TPPs, required coal quantity for Tigyit coal-fired TPPs is fully supplied by domestic coal. JICA Study Team assumes Tigyit coal-fired TPPs are rehabilitated on 2016-2017. Therefore, 300,000 ton/year is supplied until 2015-2016 and 524,000 ton/year is supplied after 2016-2017.

c) After CODs of the future coal-fired TPPs, JICA Study Team assumes that domestic coal is supplied for the power sector up to 60%.

d) Shortage of domestic coal will be solved by imported coal from Indonesia, Australia and South Africa, etc.

Conclusions of Table 4.2-7 is as follows;

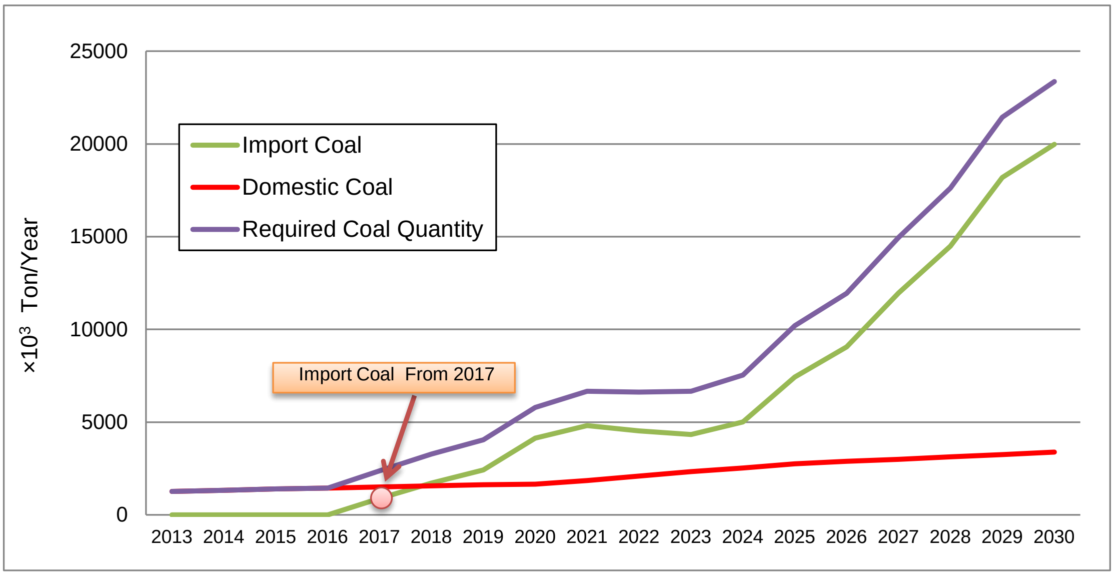
i) Before CODs of the future coal-fired TPPs, there is no coal shortage.

ii) After CODs of the future coal-fired TPPs, coal shortage marked in red in the tables is envisaged.

iii) To solve the coal shortage, maximum 20 million tons coal need to be imported annually (marked in blue in the tables).

iv) If 60% of the domestic coal is supplied for the power sector, maximum capacities of the future coal-fired TPPs by the domestic coal is estimated at 980 MW (marked in green in the tables).

Fig. 4.2-3 shows the graphic view of Table 4.2-7.



Source: prepared by JICA Study Team

Fig. 4.2-3 Coal Supply Plan

(6) Categorization of Future Coal-fired TPPs in Myanmar

Future coal-fired TPPs are divided into three (3) groups as follows;

Group No.	Site	Plants	Coal Source	Coal Transportation
1	Near Power Demand	Kyauktan, Thilawa, Kunchangon, Ngapudaw, etc.	Import	• Direct Trans. from Overseas • Via Future Coal Terminal • Off-shore Transshipment
2	Deep Sea Port	Boakpyin, Ngayukong, etc.	Import	Direct Trans. from Overseas
3	Mine-mouth	Keng Tong, Kalewa, etc.	Domestic	Coal Conveyors

Source: prepared by JICA Study Team

Group No.2 seems to be no problem in terms of the coal transportation because these coal-fired TPPs face deep sea. Imported coal can directly transported to the power station by bulk coal carrier such as Panamax and /or Cape Size from overseas after construction of the coal jetty or wharf.

(7) Considerations for Group No.1

Future coal-fired TPPs in Group No.1 except Ngapudaw[35] face the Yangon River. At the installation of these coal-fired TPPs, some difficulty is envisaged because of relatively shallow Yangon River.

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[35] This coal-fired TPP faces the Pathein River. The depth of the river is unknown.

1) From river mouth to Thilawa SEZ of the Yangon River

The river depth allows 25,000 ~ 30,000 ton class coal carrier to directly transport coal from overseas subject to waiting for high tide, although coal transportation efficiency is inferior to bulk coal carriers such as Panamax and /or Cape Size.

2) Area of the Yangon Port

Coal seems to be transported to Myanmar by bulk coal carriers such as Panamax and /or Cape Size from overseas, and then there are two methods to carry coal to the power station;

a) Coal is transshipped offshore from bulk carriers to barges (7,000 ~ 8,000 ton class) or 15,000 ton class coal carriers subject to waiting for high tide.

b) If the coal terminal is constructed in Dawei or Kalegauk area in future, coal is transported to the Yangon Port area by the foregoing barges and/or small size coal carriers through the coal terminal.

With regard to b), although many future coal-fired TPPs are planned to be constructed in Myanmar by IPP, it is not clear who will prepare the coal terminal that has enough capacity to handle the coal for these IPPs project. The most prospective method on coal transportation with IPPs for the time being is by off-shore transshipment from the bulk coal carrier to barges. This method is not the best option in terms of environment and cost-efficiency.

For the coal terminal that will be utilized by multiple IPPs, it is realistic that GoM takes initiative in developing the coal terminal. However, it is not deniable that the common coal terminal that other IPPs can use is developed by the IPP together with construction of coal-fired TPPs.

(8) Considerations for Group No.3

1) Coal Producers

In general, the coal producers in Myanmar operate small-scale mines, and have not enough capacity to supply bulk coal to planned future coal-fired TPPs. However, fortunately in Kalewa region, there is a coal mine group. IPP can contract CSA (Coal Sells Agreement) with the group to receive bulk coal.

On the other hand, there is no coal mine group in Shan state that will supply coal to Keng Tong coal-fired TPP so far. No.3 Mining Enterprise advises that if setup of such group is required, consultation with Tun Thwin Mining Co. Ltd. who is the representative of Myanmar coal mines seems to be necessary.

2) Increase of Domestic Coal Production

COD of Kalewa (1st stage) is scheduled in 2017-2018. Therefore, JICA Study Team highly recommends that MOEP explain the plan on the future mine-mouth coal-fired TPP to the coal mine group and ask them to increase the coal production to meet the necessary coal quantity that is around 810×10^3 ton/year.

On the other hand, COD of Keng Tong (1st stage)[36] is scheduled in 2025-2026. Although there is some lead time, JICA Study Team also recommends that MOEP makes effort to set

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[36] JICA Study Team confirm MOEP on coal supply prospect for Keng Tong. They reply that they asked China IPP, but haven’t got any answer.

up the coal mine group in Shan state, and ask them to increase the coal production in advance.

In this context, No.3 Mining Enterprise comments that technical transfer of the latest mine technology and investment from development countries are inevitable to increase coal production in Myanmar.

4.2.3 Renewable Energy

With regard to rural electrification by renewable energy, DRD revised the road map from rural electrification plan up to 2030-2031 (JICA Study Team received August 2013) to Five-Year rural electrification plan up to 2015-2016 (Original received in November 2013 and revised received in January 2014) as shown Table 4.2-8.

According to the plan, rural electrification ratio of 33.4% in 2012-2013 will soar up to 65.4% in 2015-2016 by means of extension of on-grid power sources and enhancement of off-grid power sources by renewable energy.

Table 4.2-8 Rural Electrification Plan up to 2015-2016

No.	Activities	Villages	Electrification Rate
1	30-year plan from 2001-2002 to 2030-2031	64,917	
2	Implemented Villages up to 2010-2011 (on/off Grid)	16,153	
3	Implemented Villages up to 2012-2013 (on/off Grid)	21,675	33.4%
4	Remaining Villages	43,242	
5	Five-Year Plan (short list) from 2011-2012 to 2015-2016	1,792	
6	Implementing Villages in 2013-2014	766[37]	
7	Implementation Plan in 2014-2015	10,000	
8	Implementation Plan in 2015-2016	10,000	
9	Implementation Plan up to 2015-2016 (on/off Grid)	42,441	64.5%
10	Remaining Villages	22,476	

Source: DRD as of January 2014

DRD also prepares the detail Five-Year Plan that forecasts the state/division-wise annual number of rural electrification villages, adopting technology and required cost in details.
Table 4.2-9 shows the detail Five-Year Plan.

The definition of electrified village in Myanmar is explained in the following box.

Definition of Electrified Village in Myanmar

1) **Definition by DRD**
   (a) More than 50% of households in the village are electrified, and
   (b) More than 100 households are electrified in the village (If total number of households is less than 100, all households should be electrified)
2) **Actual experience of rural electrification with bio-gas mini-grid system by MOST**
   The rural electrification with bio-gas mini-grid system requests the consensus of all households in the village. Therefore, it means 100% households are electrified.

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[37] Although this figure was 766+1,800=2,566 as of November 2013, 1,800 were not realized.

Table 4.2-9 Detailed Five-Year Plan

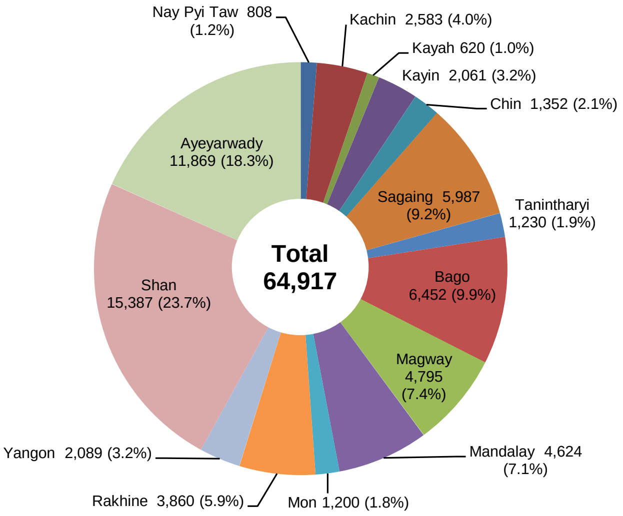
Million Kyat

Sr. No.	States/ Regions	Total Township	Total Villages	Implemented up to 2012-2013	Remaining Villages	2013-2014 FY			2014-2015 FY							2015-2016 FY							No. of villages to be implemented up to 2015-2016 FY
						On-going	Expenditure	Remaining Villages	Budget Plan		(10000) villages Project		Total Plan		Remaining Villages	Budget Plan		(10000) villages Project		Total Plan		Remaining Villages	
									No. of villages	Estimate	No. of villages	Estimate	No. of villages	Estimate		No. of villages	Estimate	No. of villages	Estimate	No. of villages	Estimate		
1	Nay Pyi Taw	8	808	477	331			331	21	525.490	103	3,749.000	124	4,274.490	207	20	618.220	54	1,689.980	74	2,308.200	133	675
2	Kachin	18	2,583	355	2,228	26	331.400	2,202	79	1,619.600	346	12,124.000	425	13,743.600	1,777	33	620.000	332	11,703.400	365	12,323.400	1,412	1,171
3	Kayah	7	620	108	512	3	88.000	509	25	290.200	81	2,920.600	106	3,210.800	403	24	430.000	90	3,223.600	114	3,653.600	289	331
4	Kayin	7	2,061	255	1,806	10	207.600	1,796	59	983.600	275	9,636.000	334	10,619.600	1,462	17	450.000	258	9,075.200	275	9,525.200	1,187	874
5	Chin	9	1,352	294	1,058	61	127.800	997	25	741.200	180	6,307.000	205	7,048.200	792	32	370.000	186	6,517.200	218	6,887.200	574	778
6	Sagaing	37	5,987	3,815	2,172	247	6,245.880	1,925	199	3,926.800	907	36,140.000	1,106	40,066.800	819	96	1,170.000	723	24,310.900	819	25,480.900	-	5,987
7	Tanintharyi	10	1,230	696	534	8	221.400	526	64	1,103.770	163	5,691.800	227	6,795.570	299	38	750.000	102	4,169.800	140	4,919.800	159	1,071
8	Bago	28	6,452	1,090	5,362	13	254.400	5,349	103	4,970.760	861	30,417.800	964	35,388.560	4,385	22	750.000	780	27,743.800	802	28,493.800	3,583	2,869
9	Magway	25	4,795	2,514	2,281	15	253.600	2,266	76	2,899.860	688	23,965.800	764	26,865.660	1,502	19	730.000	1,483	48,565.600	1,502	49,295.600	-	4,795
10	Mandalay	28	4,624	2,563	2,061	28	862.100	2,033	90	2,905.040	744	27,990.700	834	30,895.740	1,199	24	750.000	1,175	39,251.300	1,199	40,001.300	-	4,624
11	Mon	10	1,200	573	627	3	52.200	624	16	738.200	164	5,746.600	180	6,484.800	444	16	450.000	151	5,536.400	167	5,986.400	277	923
12	Rakhine	17	3,860	1,016	2,844	11	194.000	2,833	69	2,077.200	517	18,098.000	586	20,175.200	2,247	12	430.000	1,093	38,567.600	1,105	38,997.600	1,142	2,718
13	Yangon	45	2,089	455	1,634	46	805.793	1,588	37	1,673.900	278	9,753.400	315	11,427.300	1,273	19	710.000	262	9,250.400	281	9,960.400	992	1,097
14	Shan	55	15,387	1,848	13,539	274	2,697.230	13,265	423	6,236.729	1,809	65,576.471	2,232	71,813.200	11,033	310	4,170.000	1,421	64,449.800	1,731	68,619.800	9,302	6,085
15	Ayeyarwady	26	11,869	5,616	6,253	21	292.000	6,232	176	6,398.425	1,422	49,916.000	1,598	56,314.425	4,634	36	760.000	1,172	41,589.200	1,208	42,349.200	3,426	8,443
Total		330	64,917	21,675	43,242	766	12,633.403	42,476	1,462	37,090.774	8,538	308,033.171	10,000	345,123.945	32,476	718	13,158.220	9,282	335,644.180	10,000	348,802.400	22,476	42,441

Source: DRD as of January 2014

(1) Number of Villages

Total number of villages in Myanmar is 64,917, and Fig. 4.2-4 shows area-wise number of villages. Shan and Ayeyarwady make up almost half of total number.



Unit: Village

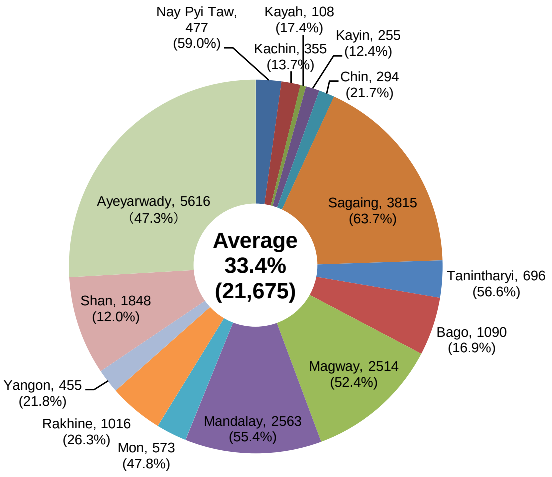
Source: DRD as of January 2014

Fig. 4.2-4 Area-wise Number of Villages

(2) Past Record until 2012-2013

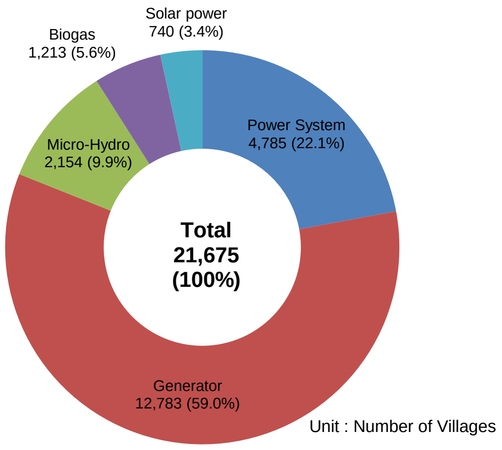
21,675 villages were electrified until 2012-2013. Nationwide average rural electrification is 33.4%, and Fig. 4.2-5 shows area-wise rural electrification percentages.

Fig. 4.2-6 shows power sources until 2012-2013. Main power source was generators (most of them are diesel engines). The percentage of renewable energy will rise from now on. Fig. 4.2-10 in (5) "Prospective Power Sources in Future" shows prospective power sources for rural electrification in future.



21,675: Actual Number of Electrification Villages until 2012-2013

Fig. 4.2-5 Past Record until 2012-2013

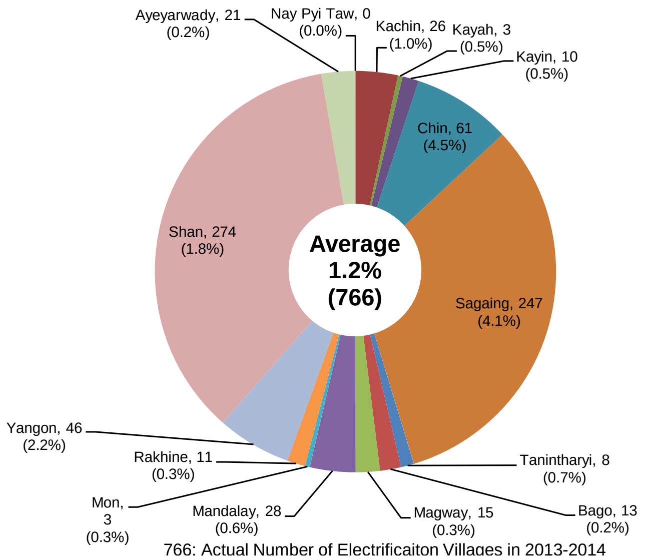


Source: DRD as of January 2014

Fig. 4.2-6 Power Sources until 2012-2013

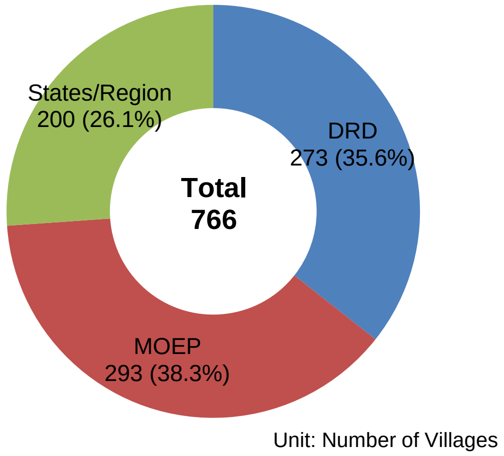
(3) Record in 2013-2014

Although 2013-2014 is not over as of January 2014, according to DRD, final number of the villages is 766. Increment of nationwide average rural electrification is only 1.2% in 2013-2014.



766: Actual Number of Electrificaiton Villages in 2013-2014

Fig. 4.2-7 Record in 2013-2014



Source: DRD as of January 2014

Fig. 4.2-8 Sector-wise in 2013-2014

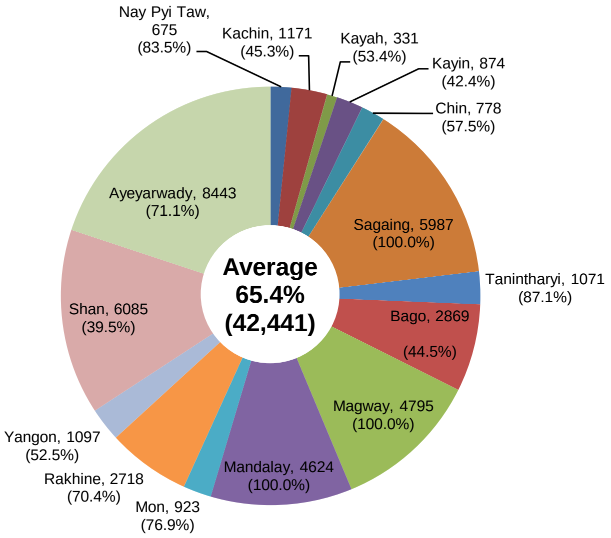
Fig. 4.2-7 shows area-wise rural electrification in 2013-2014. There is subtle trend to equalize the percentage of area.

Fig. 4.2-8 shows the contribution of sectors on rural electrification in 2013-2014. MOEP (by on-grid), DRD (by renewable energy) and state/region made almost same contributions.

(4) Forecast on Rural Electrification until 2015-2016

DRD plans to electrify 10,000 villages in 2014-2015 and 2015-2016 respectively, and attains total 42,441 villages' electrification (65.4% of nationwide average electrification) until 2015-2016.

Fig. 4.2-9 shows the forecast on area-wise rural electrocution until 2015-2016. 100% rural electrification will be carried out in Sagaing, Magway and Mandalay, and even in Shan expected as the least electrification state, the electrocution will reach around 40%.



42,441: Expected Number of Electrification Villages until 2015-2016

Source: DRD as of January 2014

Fig. 4.2-9 Forecast on Rural Electrification until 2015-2016

(5) Prospective Power Sources in Future

Fig. 4.2-10 shows prospective power sources for rural electrification in Myanmar. Generators made 303 villages electrified from 2012-2013 to 2013-2014, but it is anticipated that only 2 villages will be electrified by generators from 2013-2014 to 2014-2015.

The increment of rural electrification by generators will drop from now on. However, the percentage of rural electrification by generators will still occupy major sources for the time being.

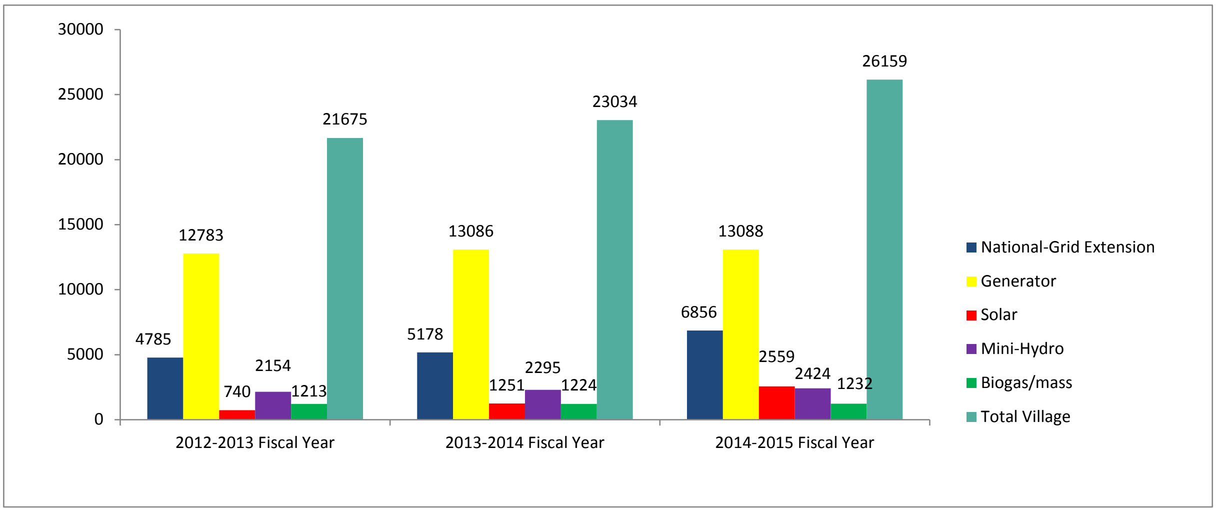


Fig. 4.2-10 Prospective Power Sources in Future

(6) Required Cost to Achieve Five-Year Plan

Table 4.2-10 shows the actual costs and estimations by DRD to achieve Five-Year Plan.

Table 4.2-10 Required Cost for Five-Year Plan

Fiscal Year		2013－2014	2014－2015	2015－2016
Budget	Million Kyat	－	37,091	13,158
	Million USD	－	37.8	13.4
Investment, Donation, etc.,	Million Kyat	－	308,033	335,644
	Million USD	－	314.3	342.5
Total	Million Kyat	12,633	345,124	348,802
	Million USD	12.9	352.1	355.9

Source: DRD as of January 2014

(7) Progress of Budget Allocation for Five-Year Plan as of May 2014.

DRD explained as follows;

1) In 2014-2015, budget for 3,145 villages is fixed, and remaining 6,855 villages need investment and donation. The breakdown of 3,145 villages is shown in Table 4.2-11.

Table 4.2-11 Progress of Budget Allocation as of May 2014

Item	Number of Villages	%
Budgeted by DRD	1,491	47
Budgeted by MOEP (Grid extension)	1,634	52
Budgeted by MOI with ADB	20	1

Source: DRD as of May 2014

2) In 2015-2016, budget for 718 villages is in prospect, but investment and donation for 9,282 villages is out of prospect.

4.3 CONCLUSIONS AND RECOMMENDATIONS FOR PRIMARY ENERGY

4.3.1 Natural Gas

(1) Conclusions

1) Gas shortage is foreseen during 2014 ~ 2019. To address the gas shortage, LNG and/or fuel oil (HSD) has to be purchased. Required maximum quantity of LNG only is 84 mmcfd, and that of HSD only is 2.7 mmld. In case of mixed use of LNG and HSD, these maximum values are reduced in accordance with mixed percentage.

2) Gas shortage during 2020 ~ 2030 will be solved by gas from new gas fields (marked in blue). Maximum required gas quantity from new gas fields including other sectors' requirements is estimated 715 bbtud (797 mmcfd based on Zawtika's calorific value). On the other hand, maximum required gas quantity from new gas fields for the power sector is 465 bbtud (518 mmcfd based on Zawtika's calorific value). This gas quantity is expected to be possible because gas from new gas fields is due only for domestic use.

3) In the GSA of Shwe gas, "Take or Pay" contract is adopted. MOE will make "Take or Pay" contract in GSA for future new gas from now on that will supply 100% for domestic consumers. According to the "Take or Pay" clause of GSA, in case that gas consumption is less than 50% of DCQ, MOEP must pay for gas quantity equivalent to 50% of DCQ.

(2) Recommendations

1) With regard to expected gas shortage in the very short run (1 ~ 2 years), JICA Study Team primarily recommends MOE try to repurchase the export gas from Thailand and China again.

   If the negotiation on gas repurchase is difficult or takes long time, as the second best solution, JICA Study Team recommends MOEP consider the liquid fuel (HSD) firing in the existing and ongoing GTs/GTCCs where gas shortage is forecasted in the very short run

   The reasons are as follows.

   a) Realization of LNG purchase is not clear so far, and even if realized, it takes 2 ~ 3 years at the soonest to supply LNG to the gas-fired power stations.
   b) Although there are several plans to upgrade the existing GTs and GTCCs by means of rehabilitation and/or modification and/or replacement without any increase of gas consumption, it also takes 2 ~ 3 years' lead time to complete.

2) As several existing gas fired power stations are deteriorated by 30 ~ 40 years' operation, JICA Study Team recommends MOEP rehabilitate and modify them such as Thaketa or replace them with new GTCC such as Thaton to increase the reliability and capacity of them without any increase of gas consumption.

3) As gas shortage is expected in the future, JICA Study Team recommends MOEP consider designating the dual firing[38] for the future gas firing plants (GE, GECC, GT, GTCC) in the new tenders.

4) As for the future gas-fired TPPs of Ayeyarwady/Yangon (500 MW), Hlaingtharyar (400 MW) and UREC 2 (400 MW), JICA Study Team recommend adopting GTCC with high

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[38] for GE, GECC: Gas and heavy fuel oil/ crude oil, for GT, GTCC: Gas and HSD

efficiency GT (combustion temperature is more than 1,500°C) because MEPE can enjoy reducing the gas consumption by around 13% due to the increase of efficiency.

With regard to the system frequency stability of Myanmar in case of failure of 400 ~ 500 MW GTCC, as these gas-fired TPPs are planned to be put into operation after 2024-2025, prospected peak load reaches around 7,000 MW. Therefore, the frequency drop by the loss of 400 ~ 500 MW is well within allowable range.

5) "Take or Pay" contract is adopted in the GSA of Shwe gas. As the outputs of hydropower power stations increases considerably during wet season, the load factors of gas-fired TPPs of this season accordingly decrease.

   It is recommended that to avoid the "Take or Pay" contract, gas-fired TPPs that use Yadana gas and Zawtika gas reduce the load factors or stop the operations in order to maintain the load factors of gas-fired TPPs that use Shwe gas.

6) As the capacities of the existing gas pipelines are almost full, JICA Study Team recommends MOE study the construction of new gas pipelines in parallel with development of the new gas fields.

4.3.2 Coal

(1) Conclusions

1) To realize the operation of all the future coal-fired TPP until 2030, maximum 20 million tons' coal needs to be imported annually.

2) Boakpyin (500 MW) and Ngayukong (550 MW) coal-fired TPPs that face to deep sea seem to be no problem. Imported coal can directly transported to the power station by bulk coal carrier such as Panamax and /or Cape Size from overseas after construction of the coal jetty or wharf.

3) With regard to Kyauktan (1,300 MW), Thilawa (360 MW) and Kunchangon (3,270 MW) coal-fired TPPs that will be constructed along the Yangon River, bulk coal transportation and coal unloading methods shall be considered.

   Especially in the Yangon Port area, either offshore coal transshipment or construction of the coal terminal will be required.

4) Kalewa (540 MW) and Keng Tong (600 MW) that are planned as the mine-mouth coal-fired TPPs have two (2) issues to be solved before implementations of the projects.

   a) Coal mine group
      As there is the coal mine group in Kalewa region, IPPs can contract CSA with the group to enable the bulk coal purchase. On the other hand, no coal mine group in Shan state that supply coal to Keng Tong coal-fired TPPs exists. As Keng Tong coal-fired TPPs will consume bulk coal, private coal mine companies cannot deal with required large amount of coal independently. The coal mine group must be set up before implementations of Keng Tong coal-fired TPP projects.

   b) Increase of domestic coal production
      Present coal productions in Kalewa region and Shan state are far away from required coal quantities to supply coal for Kalewa and Keng Tong coal-fired TPPs, therefore,

the increase of coal production is an imperative demand. In this context, No.3 Mining Enterprise comments that technical transfer of the latest mine technology and investment from developing countries are inevitable to increase coal production in Myanmar.

(2) Recommendations

1) JICA Study Team recommends that the GoM takes initiative in developing the coal terminal in order to facilitate the bulk coal import to future coal-fired TPPs, especially in Yangon area considering the development by several IPP projects. However, it is not deniable that the common coal terminal that other IPPs can use is developed by the IPP together with construction of coal-fired TPPs.

2) COD of Kalewa (1st stage) is scheduled in 2017-2018. Therefore, JICA Study Team highly recommends that MOEP explain the plan on the future mine-mouth coal-fired TPP to the coal mine group in advance and ask them to increase the coal production to meet the necessary coal quantity.

   On the other hand, COD of Keng Tong (1st stage) is scheduled in 2025-2026. Although there is some lead time, JICA Study Team also recommends that MOEP makes effort to set up the coal mine group in Shan state, and ask them to increase the coal production.

3) Utilization of best available technologies for the introduction of coal thermal plants considering the mitigation for environmental impacts.

4.3.3 Renewable Energy

(1) Conclusions

1) The overall responsibility to promote the rural electrification is recently transferred from MOI to MOLFRD.

2) The roles and responsibilities on rural electrification and promotion of renewable energy in Myanmar are summarized in Table 4.1-14.

3) If the Five-Year Plan (2011-2012 ~ 2015-2016) prepared by DRD is realized, rural electrification ratio of 33.4% in 2012-2013 will soar up to 65.4% in 2015-2016 by means of extension of on-grid power sources and enhancement of off-grid/mini-grid power sources by mainly renewable energy.

(2) Recommendations

1) As the Five-Year Plan by DRD is challenging project especially on budget, it is recommended that the GoM well coordinates donors and investors to collect the necessary fund.

2) JICA Study Team also recommends that the GoM reflects the study results by WB and ADB on the Five-Year Plan and a future plan as much as possible with regard to the feasible rural electrification system, programmatic sector-wide approach and planning of the financial model on long term rural electrification plan in Myanmar.

CHAPTER 5

POWER GENERATION DEVELOPMENT PLAN

CHAPTER 5 POWER GENERATION DEVELOPMENT PLAN

5.1 SITUATION OF POWER GENERATION IN MYANMAR

5.1.1 Investigation Outline

For power generation development in Myanmar, planning, designing, construction, and O&M (Operation and Maintenance) have been implemented by DHPP (Department of Hydropower Planning), DHPI (Department of Hydropower Implementation), HPGE (Hydropower Generation Enterprise), DEP (Department of Electric Power) and TPD (Thermal Power Department) of MEPE (Myanma Electric Power Enterprise) under the MOEP (Ministry of Electric Power).

For planning of PGDP (Power Generation Development Plan), lists of existing HPPs (hydropower plant(s)) (as of July 2013) and lists of future HPPs have been collected by JICA (Japan International Cooperation Agency) Study Team. Concerning future planning, 68 new HPPs are planned with a total installed capacity of 45.5 GW. MOEP's and MOAI's (Ministry of Agriculture and Irrigation) projects, including ongoing construction sites, are only 13 plants with an installed capacity of 2.6 GW (5.7% of 45.5 GW total). The rest of 94.3% is planned development under local/IPP (Independent Power Producer) schemes by private companies in Myanmar or JV (Joint Venture)/IPP schemes with companies in neighboring countries.

DHPP is in charge of planning HPPs and coal-fired TPPs (thermal power plant), with DEP in charge of planning other TPPs such as gas-fired. In the PGDP by MOEP in June 2013, solar power generation totaling 50 MW is planned for between 2013 and 2014.

Data on the existing HPPs and TPPs were collected from HPGE and TPD. In addition, JICA Study Team visited four gas-fired TPPs (Ywama, Hlawga, Ahlone and Thaketa) in Yangon to acknowledge the current situations of the existing plants and progress of ongoing projects.

Data collection also included the O&M records of the existing HPPs through July 2013 as well as the construction costs of future projects. In addition, the existing TPPs' O&M records (e.g., generated energy, heat efficiency, schedule of periodical maintenance, forced outage rates) and ongoing TPP's data (e.g., heat efficiency, construction costs) were also collected.

5.1.2 Situation of Existing Power Plants

(1) Outline of Power Sources

The total installed capacity of existing power plants in Myanmar is 3,896.05 MW, according to the June 2013 PDP (Power Development Plan) in Myanmar (June 2013)[1]: hydropower generation (2,780 MW), gas-fired power generation (996.05 MW), and coal-fired power generation (120 MW). The location of existing power plants is shown in Fig. 5.1-1 and the installed capacity of each existing power plant is shown in Table 5.1-1.

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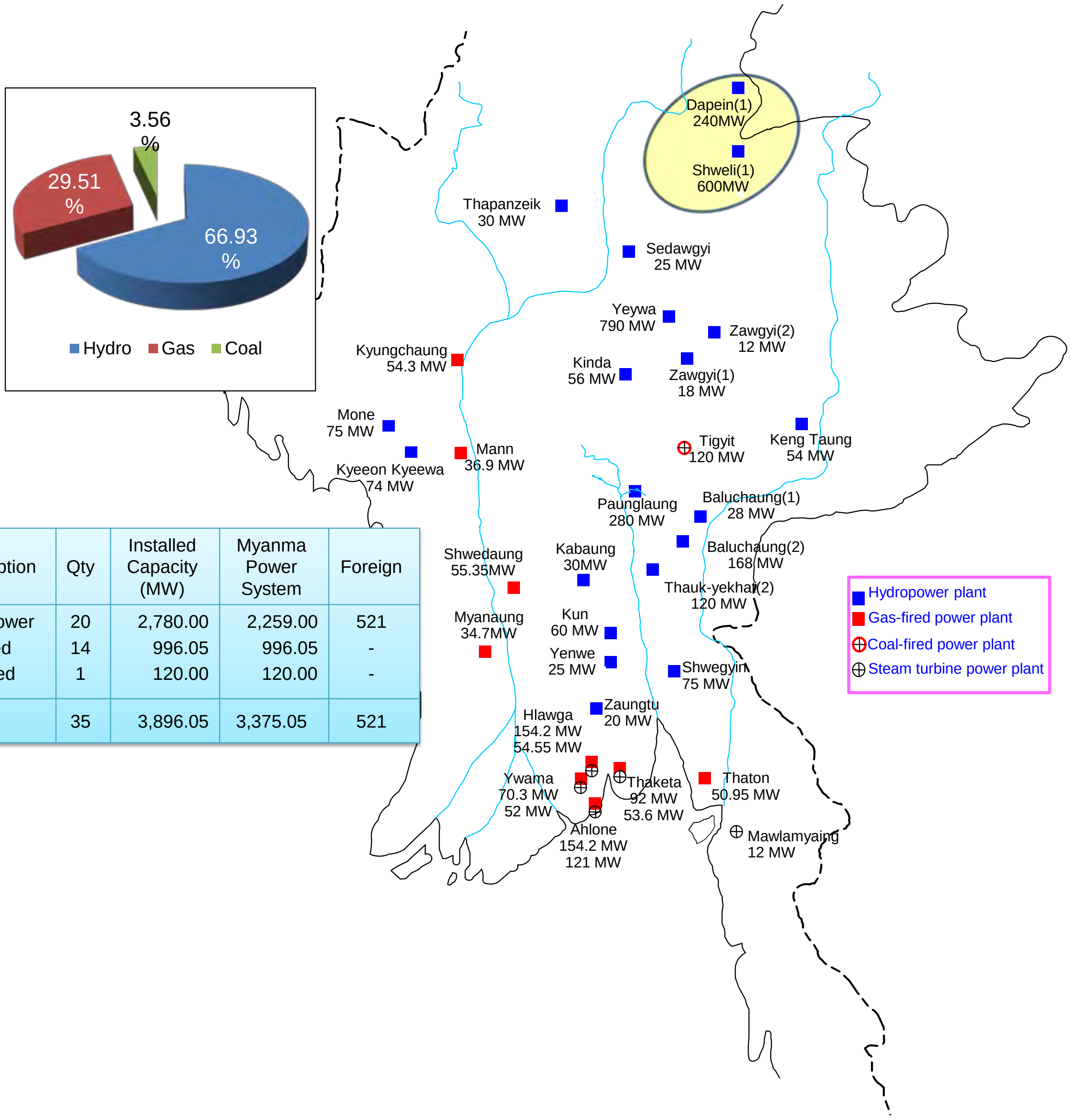
[1] PDP in Myanmar by MOEP (June, 2013)



Sr	Description	Qty	Installed Capacity (MW)	Myanma Power System	Foreign
1	Hydropower	20	2,780.00	2,259.00	521
2	Gas-fired	14	996.05	996.05	-
3	Coal-fired	1	120.00	120.00	-
	Total	35	3,896.05	3,375.05	521

Source: MOEP (2013)

Fig. 5.1-1 Location of Existing Power Plants

Table 5.1-1 Power Plants in Myanmar (as of December 2012)

	Hydropower	Output (MW)
1	Baluchaung-1	28
2	Baluchaung-2	168
3	Yeywa	790
4	Kinda	56
5	Sedawgyi	25
6	Zawgyi-1	18
7	Zawgyi-2	12
8	Thapanseik	30
9	Mone	75
10	Paunglaung	280
11	Kabaung	30
12	Yenwe	25
13	Zaung Tu	20
14	Shweli-1	600 (300)
15	Keng Tong	54
16	Shwegyin	75
17	Kun	60
18	Kyee On Kyee Wa	74
19	Dapein-1	240(221)
20	Thauk Ye Khat-2	120
	Subtotal	**2,780 (521)**

	Gas-fired	Output (MW)
1	Kyungchaung	54.3
2	Mann	36.9
3	Shwedaung	55.35
4	Mawlamyaing	12
5	Myanaung	34.7
6	Hlawga	154.2+54.55*=208.75
7	Ywama	70.3+52*=122.3
8	Ahlone	154.2+121*=275.2
9	Thaketa	92+53.6*=145.6
10	Thaton	50.95
	Subtotal	**996.05**

	Coal-fired	Output (MW)
1	Tigyit	120

Existing Power System Total
= 3,896.05 (521) MW

* by IPP(Total 281.15MW)

Notes: Figures in ( ) exports to China by JV Project.
Pre-commissioning plants are not included.

Source: MOEP (2013)

The following is supplementary information obtained by JICA Study Team through interviews with MOEP staff.

- The Hlawga gas-fired TPP (54.55MW) in Yangon Region (GE (gas engine) of 26MW (1MW × 26 units)) Phase 1 was commissioned July 2013 by an IPP. The rest of capacity (Phase 2) has yet to start construction.

- The Ywama gas-fired TPP in Yangon Region (GE of 52MW (4MW × 13 units)) was commissioned August 2013 by an IPP.

- The Ahlone gas-fired TPP (121MW) in Yangon Region (GTCC (gas turbine combined cycle) 82MW (41MW × 2 units)) Phase 1 began operation in June 2013 by an IPP. A ST (steam turbine) of 39MW (39MW × 1 unit) as Phase 2 will begin operation from September 2014.

- The Thaketa gas-fired TPP in Yangon Region (GE of 53.6MW (3.352MW × 16 units)) was commissioned July 2013 by an IPP. In addition, a rehabilitation project is planned under an ODA (Official Development Assistance) Yen loan scheme to improve the output from 64MW, which was the actual operational output in 2012, to 86MW.

- As of September 2013, HPPs' installed capacity is 2,780MW (20 plants), gas-fired TPPs' installed capacity is 796.9MW (10 plants, including four gas-fired TPPs' IPPs of 54.55 + 52 + 121 + 53.6 MW in Yangon Region, and the 82MW Ahlone Station IPP Phase 1, and coal-fired TPPs' installed capacity is 120MW. As a result, total installed capacity is 3,696.9MW (31 plants).

(2) HPPs

During the second site investigation, the existing HPPs' installed capacity and operational situations obtained from HPGE are shown in Table 5.1-2. The simulation of the existing HPPs is based on this data; for each, available capacity is almost equal to rated capacity.

Concerning expansion or rehabilitation projects of the existing HPPs, only Baluchaung-2 HPP is planned with JICA grant cooperation (to replace the turbines and generators).

(3) Gas-fired TPPs

The existing gas-fired TPPs' installed capacity and operational records are shown in Table 5.1-3. Ahlone plant's IPP is not included in the table because phase 2 of the IPP is still under construction. In this list, while the total installed capacity is 714.9MW, total current generation output is only 366MW. The amount is half of the total installed capacity because of a gas supply shortage, a decrease of heat quantity of offshore gas, and aging/deterioration of the facilities.

(4) Coal-fired TPPs

The operation data of Tigyit coal-fired TPPs (60MW × 2 units, completed in 2004) was collected from HPGE. The installed capacity is 120MW, but current generation is only 30MW. This is due to insufficient maintenance causing turbine vacuum deterioration and draft increase of the ventilation system, etc. (refer to Section 4.1.6 "Coal").

Table 5.1-2 Existing HPP List

Sr.	Location	Name of Hydroelectric Power Station	Operation Year	Installed Capacity (MW)	Units MW x unit	Annual Energy Generation (GWh)	Power Generation (GWh) in 2011												Power Generation (GWh) in 2012												Power Generationn (GWh) in 2013							Power Generation in 2012			Capacity Factor (%) 4/2012-3/2013
							1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	Operation Hours	Forced Outage (hours)	Planned Outage (hours)	
1	Kayah State	Baluchaung-2	1960 / 1974	168	28 x 6	1,190	39.1	57.4	71.8	82.4	82.2	84.0	66.2	43.4	61.1	66.2	69.0	83.0	93.4	90.8	105.7	97.5	109.1	101.6	88.0	57.0	64.8	70.5	95.1	105.9	106.7	96.3	105.3	103.8	103.5	101.1	99.7	8,104	10	645	74.60
2	Mandalay Division	Kinda	1985	56	28 x 2	165	0.7	7.6	13.2	13.0	7.8	-	-	3.6	11.6	13.1	16.3	1.3	0.3	8.0	21.1	21.2	20.0	17.7	15.8	15.5	12.6	14.3	12.8	2.4	-	4.6	11.1	10.1	-	-	-	4,168	10	4,577	30.18
3	Mandalay Division	Sedawgyi	1989	25	12.5 x 2	134	8.0	5.7	7.9	9.0	11.9	14.1	16.4	16.4	8.6	7.7	12.6	11.6	8.9	4.9	9.3	11.8	7.8	5.2	1.8	4.9	8.7	10.8	8.2	4.9	3.8	3.5	7.8	9.0	7.1	7.7	4.9	6,919	77	17	36.18
4	Kayah State	Baluchaung-1	1989.06 (1992)	28	14 x 2	200	5.2	9.7	12.5	14.8	14.1	14.5	11.0	6.4	7.1	10.1	12.4	14.4	17.1	16.5	19.3	17.9	19.8	18.4	16.4	9.9	9.4	11.0	17.6	19.7	19.7	17.8	19.4	19.2	19.2	18.7	18.5	7,680	1,055	24	80.26
5	Shan State	Zawgyi-1	1995.07	18	6 x 3	35	3.5	3.6	3.5	3.9	5.6	5.5	7.7	10.8	10.6	8.6	8.1	6.5	5.4	5.0	3.5	2.9	4.9	6.0	6.8	10.1	10.3	9.4	8.0	6.9	4.8	4.0	3.9	3.4	3.8	5.6	5.5	5,857	640	454	49.48
6	Shan State	Zawgyi-2	1998.01	12	6 x 2	30	1.3	2.5	4.6	5.2	3.9	3.5	3.3	2.8	1.6	3.7	3.6	4.6	3.0	3.0	6.8	6.6	7.1	8.2	7.8	8.0	4.3	6.8	6.5	1.4	1.3	3.0	6.4	6.2	4.1	4.5	0.2	6,513	2,650	-	64.19
7	Bago	Zaung Tu	2000.03	20	10 x 2	76	1.3	1.0	1.0	4.5	4.2	8.1	10.5	11.6	10.2	10.7	1.6	0.7	0.6	0.7	0.6	0.6	1.6	3.8	9.4	11.4	10.6	2.3	0.8	1.4	1.0	0.9	1.5	1.3	0.7	5.7	9.9	3,034	4	3	25.85
8	Sagaing	Thapanseik	2002.05	30	10 x 3	117.2	0	10.6	18.6	14.3	11.7	14.7	18.7	17.6	17.7	16.8	11.8	0.9	0.1	2.3	17.3	12.5	17.8	17.8	14.9	11.2	7.9	12.6	10.1	0.2	0.2	1.9	5.5	5.1	4.1	4.5	7.5	5,380	47	28	42.88
9	Magwe	Mone	2004	75	25 x 3	330	12.5	8.3	10.9	13.4	10	17.9	34.1	36.5	37.1	39.2	25.4	30.8	16.6	7.8	11.0	6.9	5.7	8.7	41.8	36.0	35.7	33.8	11.3	11.5	14.7	15.7	14.7	10.0	4.0	9.9	17.5	5,021	66	3,569	36.01
10	Mandalay Division	Paunglaung	2005.03	280	70 x 4	911	29	17.4	22.9	48.5	42.7	38.2	61.2	62.6	66.1	85.6	65.2	65.9	45.2	42.6	36.7	25.8	22.2	32.0	62.9	83.7	60.5	52.7	64.9	54.2	41.0	36.6	25.9	39.8	30.4	33.4	35.3	2,645	26	17	22.92
11	Bago	Yenwe	2007	25	12.5 x 2	123	8	7.3	8.3	11.2	10.2	11.5	6	1.1	2.7	10.1	7.7	11.6	11.8	11.4	8.3	10.4	10.3	9.9	10.8	11.1	9.1	0.7	0.9	2.6	6.4	8.2	10.5	11.7	11.9	12.2	10.8	5,553	22	13	41.57
12	Bago	Kabaung	2008	30	15 x 2	120	12.2	7.5	10.9	11.9	8	7.1	4.6	1.3	4.9	6.7	8.7	8	9.8	11.0	19.1	18.5	15.9	12.0	8.3	0.5	0.2	0.7	0.9	3.2	6.9	6.6	6.8	8.9	12.5	14.2	8.0	3,661	9	4	30.63
13	Shan State	Keng Tong	2008	54	18 x 3	377.6	21.9	23.4	24.3	18.9	18.8	22.8	12.8	15.8	22.8	23.6	25.0	25.9	26.0	24.3	22.8	26.1	27.6	25.2	31.8	24.6	24.0	25.6	31.5	35.6	31.4	26.8	25.6	22.9	24.0	26.8	34.3	6,711	139	152	70.99
14	Shan State	Shweli-1	2008	600	100 x 6	4022	50	48	36	40	43	41	45	44	34	29	53	50	49	51	44	37	39	45	46	31	41	46	64	50	44	37	32	39	46	49	55	7037	-	480	9.69
15	Mandalay Division	Yeywa	2010	790	197.5 x 4	3,550	271.5	204.1	190.9	155.3	155.5	173.7	225.1	281.2	256.2	309.2	279.5	331.6	236.0	230.7	176.3	95.7	90.0	90.9	153.2	310.2	314.2	298.3	232.7	198.0	168.4	154.6	165.9	160.8	103.9	127.7	155.2	4,223	17	16	32.83
16	Kachin	Dapein-1	2011.02	240	60 x 4	1,065	2.0	1.9	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1.8	2.3	2.3	-	-	-	0
17	Bago	Shwegyin	2011	75	18.75 x 4	262	11.5	11.5	16.5	24	21	21.6	40.5	50.6	37.7	31.7	9.6	13.3	9.8	13.3	32.1	16.9	11.2	7.9	15.9	19.5	17.8	13.2	8.7	10.7	17.5	19.7	18.9	22.1	15.6	11.1	18.5	2,784	287	30	27.08
18	Magway	Kyee On Kyee Wa	2012	74	37 x 2	370															5.4	13.5	13.0	9.2	19.2	18.2	10.5	14.7	4.4	3.0	16.3	15.5	18.4	13.5	10.2	14.8	16.8	3,818	25	8	24.06
19	Bago	Kun	2012	60	20 x 3	190												5.6	10.4	6.7	32.4	40.2	40.9	30.9	20.6	2.6	5.0	12.6	5.0	14.3	19.2	24.2	32.1	37.8	35.1	24.0	10.6	4,372	14	-	47.14
	Subtotal			*2,660*		*13,267.8*																																			
20		Thauk Ye Khat		120	40 x 3	604																										14.0	27.8	33.0	23.4	13.4	22.4	351	-	-	

Source: "Strategies for Sustainable Hydropower Development in Myanmar, 29 January 2013", DHPP,MOEP and MOEP
"Maynmar Energy Sector Initial Assessment, Table A5.1", October 2012, ADB

Table 5.1-3 Existing TPP List

	Region/State	Station	Installed Capacity (MW)	Type	COD	Current Generation (MW)	Capacity Factor (%)	Efficiency (%)	Remark
Gas Thermal Power Existing	Yangon	Hlawga GTCC	33.3	GT	1996.01	88	55	19.18	
			33.3	GT					
			33.3	GT					
			54.3	ST	1999.04				
	Yangon	Ywama GT	18.45	GT	1980	50	40	19.72	
			18.45	GT					
			24	GT	2004				NEDO
			9.4	ST	2004				NEDO
	Yangon	Ahlone GTCC	33.3	GT	1995.04	76	52	22.3	
			33.3	GT					
			33.3	GT					
			54.3	ST	1997.02				
	Yangon	Tharkayta GTCC	19	GT	1990.03	57	59	16.52	
			19	GT					
			19	GT					
			35	ST	1997.02				
	Mon	Thaton GT	18.45	GT	1985	35	61	18.98	
			16.25	GT	2001				
			16.25	GT					
	Magwe	Kyunchaung GT	18.1	GT	1974	24.5	32	21.45	
			18.1	GT					
			18.1	GT					
	Mon	Mawlamyaing GT	6	GT	1980	3	28	17.02	
			6	GT					
	Ayanwaddy	Myanaung GT	16.25	GT	1975&84	12	27	21.08	
			18.45	GT					
	Bago	Shwedaung GT	18.45	GT	1984	20.5	36	15.61	
			18.45	GT					
			18.45	GT					
	Magwe	Mann GT (Production stop in 2005)	18.45	GT	1980	0			
			18.45	GT					
			Sub Total	714.9		366			

Source: HPGE

Reference 1 : Power System Development Scheme of MEPE 2.7.2013
Reference 2 : PDP in Myanmar 6, 2013
Reference 3 : Efficiency is calculated from actual value of power generation by MEPE
Reference 4: Pre-commissioning plants are not included

5.1.3 Situation of Ongoing and Future Power Plants

Based on the PDP in Myanmar, short term plans (2013 ~ 2016), middle term plans (2017 ~ 2021) and long term plans (2022 ~ 2026 and 2027 ~ 2031) are shown in Table 5.1-4 to Table 5.1-7. The power generation capacity ratio of each term is shown in Fig. 5.1-2 to Fig. 5.1-5.

These figures indicate that gas and coal-fired TPPs are mainly developed for short term due to their advantages of short construction period, and HPPs are mainly developed for the middle and long term to reap the merits in power generation costs and so on.

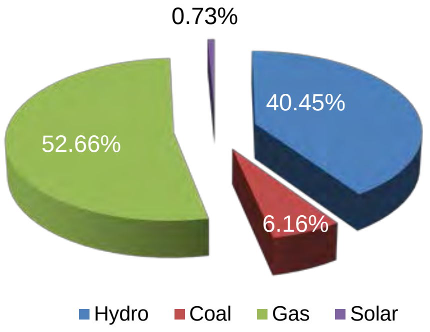
(1) 2013 ~ 2016 (Short Term) Development Plan

Table 5.1-4 Power Plant Projects to be Completed from 2013 to 2016

Sr. No.	Project Name	Type	Installed Capacity	2013-2014	2014-2015	2015-2016
1	Phyu	Hydro	40	40	-	-
2	Nancho	Hydro	40	40	-	-
3	Upper Paunglaung	Hydro	140	-	140	-
4	Baluchaung-3	Hydro	52	52	-	-
5	Upper Baluchaung	Hydro	29	-	29	-
6	Chipwinge	Hydro	99	99	-	-
7	Dapein-1	Hydro	101	-	-	101
8	Minbuu	Solar	50	50	-	-
9	Hlawga	Gas	54.55	54.55	-	-
10	Hlawga	Gas	486	-	243	243
11	Ywama	Gas	52	52	-	-
12	Ywama	Gas	240	240	-	-
13	Thaketa	Gas	53.6	53.6	-	-
14	Thaketa	Gas	503	-	167	336
15	Thaketa	Gas	513	-	127	386
16	Ahlone	Gas	121	82	39	-
17	Mawlamyaing	Gas	230	-	100	130
18	Kyaukphyu	Gas	100	-	100	-
19	Kanpouk	Gas	525	-	175	350
20	Yangon-Kunchangon	Coal	300	-	-	300
Total			**3,729.15**	**763.15**	**1,120**	**1,846**

Source: MOEP (2013)

Sr No.	Type of Energy	Installed capacity to be completed in year 2015-16 (MW)	Installed Capacity (MW)
1	Hydro	501	2,760
2	Coal	300	420
3	Gas	2,878.15	3,593.05
4	Solar	50	50
	Total	**3,729.15**	**6,823.05**



Source: MOEP (2013)

Fig. 5.1-2 Power Source Ratio in 2016

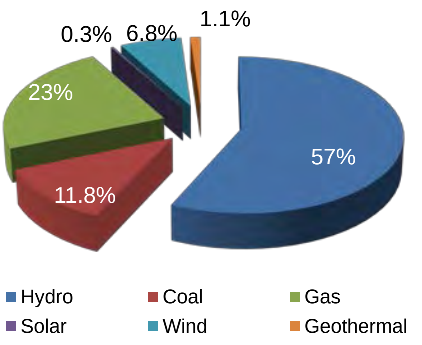
(2) 2017 ~ 2021 (Middle Term) Development Plan

Table 5.1-5 Power Plant Projects to be Completed from 2017 to 2021

Sr. No.	Project Name	Type	Installed Capacity	Installed Capacity for Myanmar
1	Upper Yeywa (MOEP)	Hydro	280	280
2	Shweli-3 (MOEP)	Hydro	1,050	1,050
3	Bawgata (MOEP)	Hydro	160	160
4	Upper Bu (MOEP)	Hydro	150	150
5	Middle Paunglaung (MOEP)	Hydro	100	100
6	Thahtay (MOEP)	Hydro	111	111
7	Upper Keng Tong (MOEP)	Hydro	51	51
8	Chibwe	Hydro	3,400	1,700
9	Laza	Hydro	1,900	950
10	Upper Thanlwin (Kunlong)	Hydro	1,400	700
11	Gawlan	Hydro	100	50
12	Wxhonhgze	Hydro	60	30
13	Lawngdin	Hydro	435	217.5
14	Hkan Kwan	Hydro	140	70
15	Tongxingqiao	Hydro	320	160
16	Hutgyi	Hydro	1,360	680
17	Shweli-2	Hydro	520	260
18	Saindin	Hydro	76.5	38.25
19	Dapein-2	Hydro	168	84
20	Manipur	Hydro	380	190
21	Belin	Hydro	280	280
22	Ngotchaung	Hydro	16.6	16.6
23	Yangon - Htantapin	Coal	270	270
24	Yangon- Thilawa	Coal	650	650
25	Boakpyin	Coal	500	250
26	Ngayukong	Coal	500	500
27	Ayeyarwady/Yangon	Gas	500	500
28	Tanintharyi, Mon, Kayin	Wind	1,000	300
29	Shan, Kayah	Wind	1,930	579
30	Chin, Rakhine, Ayeyarwady, Yangon	Wind	1,102	330
31	Sagaing, Magway, Mandalay, Shan, Tanintharyi	Geothermal	200	200
Total			**19,110.1**	**10,907.35**

Source: MOEP (2013)

Sr No.	Type of Energy	Installed capacity to be completed in year 2020-21 (MW)	Installed Capacity (MW)
1	Hydro	73,28.35	10,088.35
2	Coal	1,670	2,090
3	Gas	500	4,093.05
4	Solar	-	50
5	Wind	1,209	1,209
6	Geothermal	200	200
	Total	**10,907.35**	**17,730.04**



Source: MOEP (2013)

Fig. 5.1-3 Power Source Ratio in 2021

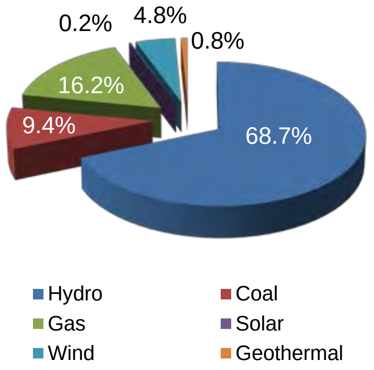
(3) 2022 ~ 2026, 2027 ~ 2031(Long Term) Development Plan

Table 5.1-6 Power Plant Projects to be Completed from 2022 to 2026

Sr. No.	Project Name	Type	Installed Capacity	Installed Capacity for Myanmar
1	Ywathit-Thanlwin	Hydro	4,000	2,000
2	Wutsok	Hydro	1,800	900
3	Kaunglanhpu	Hydro	2,700	1,350
4	Yenan	Hydro	1,200	600
5	Pisa	Hydro	2,000	1,000
6	Laymyro	Hydro	600	300
7	Laymyro-2	Hydro	90	45
8	Natabat-Kayah	Hydro	180	90
9	Naung Pha	Hydro	1,000	500
10	Mantaung	Hydro	200	100
11	Keng Tong	Hydro	96	48
12	Wan Ta Pin	Hydro	25	12.5
13	So Lue	Hydro	165	82.5
14	Mong Wa	Hydro	50	25
15	Keng Yang	Hydro	28	14
16	He Kou	Hydro	88	44
17	Nam Kha	Hydro	200	100
18	Natabat-Kachin	Hydro	200	100
19	Kalewa	Coal	600	300
Total			**15,222**	**7,611**

Source: MOEP (2013)

Sr No.	Type of Energy	Installed capacity to be completed in year 2025-26 (MW)	Installed Capacity (MW)
1	Hydro	7,311	17,399.35
2	Coal	300	2,390
3	Gas	-	4,093.05
4	Solar	-	50
5	Wind	-	1,209
6	Geothermal	-	200
	Total	**7,611**	**25,341.4**



Source: MOEP (2013)

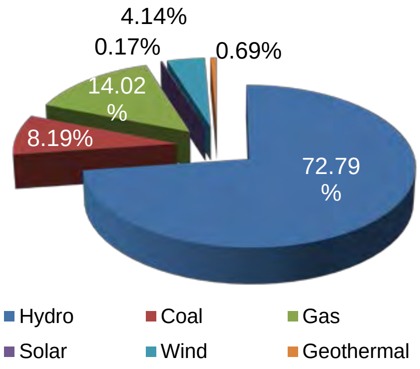
Fig. 5.1-4 Power Source Ratio in 2026

Table 5.1-7 Power Plant Projects to be Completed from 2027 to 2031

Sr. No.	Project Name	Type	Installed Capacity	Installed Capacity for Myanmar
1	Htu Kyan	Hydro	105	52.5
2	Hanna	Hydro	45	22.5
3	Thakya	Hydro	150	75
4	Palaung	Hydro	105	52.5
5	Bawlake	Hydro	180	90
6	Upper Thanlwin - Mongton	Hydro	7,110	3,555
Total			**7,695**	**3,847.5**

Source: MOEP (2013)

Sr No.	Type of Energy	Installed capacity to be completed in year 2030-31 (MW)	Installed Capacity (MW)
1	Hydro	3,847.5	21,246.85
2	Coal	-	2,390
3	Gas	-	4,093.05
4	Solar	-	50
5	Wind	-	1,209
6	Geothermal	-	200
	Total	**3,847.5**	**29,188.9**



Source: MOEP (2013)

Fig. 5.1-5 Power Source Ratio in 2031

1) HPP

A list of the future HPPs are shown in Table 5.1-8 (based on “Strategies for Sustainable Hydropower Development in Myanmar (January 2013))”.

Modifications from “Strategies for Sustainable Hydropower Development in Myanmar” were confirmed through interviews with DHPP in November 2013, with revisions to Table 5.1-8 shown below.

[Canceled]

✔Belin	(Local/IPP)	280 MW
✔Mawlike	(JV/IPP)	520 MW
	Total	**800 MW**

Also, some HPPs listed in Table 5.1-8 are not listed in the PDP in Myanmar.

The summary of power generation plants list which integrates MOEP’s documents (collected from each department) for hydropower, TPPs and renewable energy plants was prepared by JICA Study Team. Although some discrepancies were modified, this list was generally compiled based on MOEP’s master plan[1]. It is shown in Table 5.1-11.

A list of MOEP’s own power plants was obtained through interviews with DHPP and is shown in the table below.

Power Plant (MOEP)	Finance Resource
Phyu Chaung	Local Currency
Nancho	Local Currency
Upper Paunglaung	Local Currency
Ann	Local Currency
Thahtay	Local + Foreign Loan (China)
Upper Keng Tong	Local + Foreign Loan (China)
Upper Yeywa	Local + Foreign Loan (China)
Shweli-3	JV/IPP + Foreign Loan
Bawgata	Local Preliminary Works
Upper Bu	MOAI
Middle Paunglaung	Proposal Stage

2) Gas TPPs

A list of future gas-fired TPPs (as of November 2013) is shown in Table 5.1-9 based on the PDP in Myanmar and “Power System Development Scheme of MEPE” (2nd July 2013).

Modifications to the existing information were undertaken through interviews with TPD and are shown below and in Table 5.1-9.

[Capacity changes]

✔Kyaukphyu (GT), 100MW to 50MW (to be commissioned in 2014)

[Additional information]

✔Myin Gyan (New GTCC), 225 ~ 250MW (assumption).
(To be commissioned in August 2015.) [Bid Announced: 18/09/2013]

✔Kyause (GE, rental) 80 ~ 100MW (assumption).
(To be commissioned in February 2014.) [Bid Announced: 18/09/2013]

✔Hlaingtharyar (new gas-fired TPP), 500MW. (To be commissioned in 2016.)

✔Thaton (rehabilitation of existing plant), 50.95MW to 106MW.
(To be commissioned in 2016.)

In addition, a new GT project (50MW) is planned via JICA loan cooperation in Thilawa Region (to be commissioned in 2016).

Table 5.1-8 New HPPs (as of June 2013)

Sr.	Name of Project	Installed capacity (MW)	Expected Generation Energy (GWh)	Location Region/State	Unit Construction Cost (US$/kW)	Date of MOU Signing	Current Situation *1)	Weighted Progress *2)	Expecting COD	Implementing Agency
1	Chipwinge	99	599	Kachin St	1,946	28.12.2006		100%	2012/13	JV/IPP
2	Phyu Chaung	40	120	Bago Re			UC	67.69%	2013/14	MOEP
3	Nancho	40	152	Mandalay Re			UC	94.67%	2013/14	MOEP
4	Thauk Te Khat-2	120	605	Bago Re	2,175	2.5.2008		100%	2012/13	Local/IPP
5	Baluhaung-3	52	334	Kayar St	3,610	2.5.2008	UC	79.82%	2013/14	Local/IPP
6	Upper Baluchaung	29	120	Bago Re	1,410	5.11.2009	UC	37.34%	2014/15	Local/IPP
7	Upper Paunglaung	140	454	Bago Re			UC	76.81%	2014/15	MOEP
	Sub-Total	***520***	***2,384***							
1	Ann	10	44	Rakhine St			SP	18.7%	-	MOEP
2	Thahtay	111	386	Rakhine St			UC	26.13%	2018/19	MOEP
3	Upper Keng Tong	51	267	Shan St(S)			UC	15.43%	2018/19	MOEP
4	Upper Yeywa	280	1,330	Shan St(N)			UC	17.49%	2019/20	MOEP
5	Shweli-3	1,050	3,500	Shan St(N)			UC	5.99%	2020/21	MOEP
6	Bawgata	160	500	Bago Re				Pre.Works	2020/21	MOEP
	Sub-Total	***1,662***	***6,027***							
1	Shwezaye	660		Sagaing	2,846	16.9.2010	SP	Investigation	-	JV/IPP
2	Tanintharyi	600		Taninthayi	1,908	9.10.2008	SP	Investigation	-	JV/IPP
3	Tamanthi	1,200		Sagaing	2,371	16.9.2010	SP	Investigation	-	JV/IPP
4	Mawlike	520		Sagaing		27.5.2010	SP	Investigation	-	JV/IPP
5	Hutgyi	1,360		Kayin	1,679	30.5.2005	F/S	Investigation	-	JV/IPP
6	Manipur	380		Sagaing	-	29.8.2012	F/S	On-going	-	JV/IPP
7	Chipwi	3,400		Kachin	1,278	28.12.2006	F/S	Investigation	-	JV/IPP
8	Laza	1,900		Kachin	1,451	-	I	Investigation	-	JV/IPP
9	Dapein-2	168		Kachin	1,000	25.9.2008	I	Investigation	-	JV/IPP
10	Gawlan	100		Kachin	-	26.2.2009	I	Investigation	-	JV/IPP
11	Wu Zhongze	60		Kachin	-	-	I	Investigation	-	JV/IPP
12	Lawngdin	435		Kachin	-	-	I	Investigation	-	JV/IPP
13	Hkan Kawn	140		Kachin	-	-	I	Investigation	-	JV/IPP
14	Tongxingqiao	320		Kachin	964	-	F/S	Investigation	-	JV/IPP
15	Upper Thanliwn (Kunlong)	1,400		Shan (N)	980	5.4.2007	F/S	Investigation	-	JV/IPP
16	Shweli-2	520		Shan (N)	1120	12.11.2009	F/S	Investigation	-	JV/IPP
17	Myitsone	6,000		Kachin	1330	28.12.2006	SP	Investigation	-	JV/IPP
18	Sinedin	76.5		Rakhaing		5.11.2009	F/S	Investigation	-	JV/IPP
19	Upper Bu	150		Magway				On-going	-	MOEP
20	Belin	280		Mon	-	24.11.2010	SP	Investigation	-	Local/IPP
21	Middle Paunglaung	100		Mandalay				Investigation		MOEP
	Sub-Total	***18,969.5***								
1	Ywathit (Thanlwin)	4,000		Kayan	1217	7.1.2010	F/S	Investigation	-	JV/IPP
2	Wutsok	1,800		Kachin	1263	28.12.2006	I	Investigation	-	JV/IPP
3	Kaunglanhpu	2,700		Kachin	1142	-	I	Investigation	-	JV/IPP
4	Renam (Yenam)	1,200		Kachin	1286	-	I	Investigation	-	JV/IPP
5	Hpizaw (Pisa)	2,000		Kachin	1,268	-	I	Investigation	-	JV/IPP
6	Naopha	1,000		Shan (N)		20.12.2009	F/S	Investigation	-	JV/IPP
7	Mantong	200		Shan (N)		-	F/S	Investigation	-	JV/IPP
8	Lemro (Laymyo)	600		Rakhine	2533	7.1.2010	I	Investigation	-	JV/IPP
9	Lemro-2 (Laymyo-2)	90		Rankhine		-	I	Investigation	-	JV/IPP
	Namlwe	**452**								
10	Keng Tong	96		Shan (S)		25.9.2007	F/S	Investigation	-	JV/IPP
11	Wan Ta Pin	25		Shan (S)		-	F/S	Investigation	-	JV/IPP
12	So Lue	165		Shan (S)		-	F/S	Investigation	-	JV/IPP
13	Mong Wa	50		Shan (S)		-	-	Investigation	-	JV/IPP
14	Keng Yang	28		Shan (S)		-	F/S	Investigation	-	JV/IPP
15	He Kou	88		Shan (S)		-	F/S	Investigation	-	JV/IPP
16	Nam Kha	200		Shan (S)		-	F/S	Investigation	-	JV/IPP
17	Nam Tamhpak (Kachin)	200		Kachin		20.1.2011	F/S	Investigation	-	JV/IPP
18	Nam Tamhpak (Kayah)	180		Kayah		7.1.2010	I	Investigation	-	JV/IPP
	Sub-Total	***14,622***								
1	Upper Thanliwn (Mongton)	7,110		Shan (E)	977	10.11.2010	I	Investigation	-	JV/IPP
	Nam Pawn	**585**								
2	Htu Kyan (Tuzxing ?)	105		Shan(S)/Kayah		7.1.2010	I	Investigation	-	JV/IPP
3	Hseng Na	45		Shan(S)/Kayah		-	I	Investigation	-	JV/IPP
4	Tha Hkwa	150		Shan(S)/Kayah		-	I	Investigation	-	JV/IPP
5	Palaung	105		Shan(S)/Kayah		-	I	Investigation	-	JV/IPP
6	Bawlake	180		Shan(S)/Kayah		-	I	Investigation	-	JV/IPP
	Sub-Total	***7,695***								

Note: *1) UC = Under Construction, D/D = Detailed Design Stage, F/S = Feasibility Study Stage, SP: Suspended more than three (3) years, I = Investigation Stage

*2) Weighted progress up to 31st June 2013.

Source: "Strategies for Sustainable Hydropower Development in Myanmar, 29 January 2013", DHPP, MOEP

Table 5.1-9 New Gas-fired TPPs based on the PDP in Myanmar (as of November 2013)

Station	Installed Capacity (MW)	Type	Time for Commissioning	Current Generation (MW)	Current Situation	Remark
Hlawga	26	GE	2013.05	18		1MW×26units
	28.55	GE	2014.02		FS	54.55-26=28.55
	243		2014.11		I	
	243		2015.05		I	
Ywama	52	GE	Commissioning 2013.07	0		4MW×13units
	240	GT	2014.02		UC	
Ahlone	82	GT	2013.06	72		
	39	ST	2014.09		UC	
		GE?	2014?		I	50MW?
Thaketa	53.6	GE	Commissioning 2013.07	0		3.352MW×16units
	167		2015.02		FS	
	336		2016.01		FS	
	127		2014.12		FS	
	386		2016.03		FS	
Mawlamyaing	100	GTCC	2015		FS	43.5(GT) + 21.6(GT) + 34.9(ST)
	130	GTCC	2016		FS	43.5(GT)´2 + 43(ST)
Kyaukphyu (New)/ Rakhine State	50	GT	2014.12		FS	2013.9 ~ 2014.12 3.3MW (Rental)
Kanpouk (New)	175		2015.03		I	
	350		2016.02		I	
Myin Gyan	225 ~ 250 (assumption)	GTCC	2015.08			Bid Announce: 18/09/2013
Kyause	80 ~ 100 (assumption)	GE, rental	2014.02			Bid Announce: 18/09/2013
Hlaingtharyar	500		2016			
	Sub Total	*2878.15*		*90*		*~ 2016*
Ayeyarwady/ Yangon	500	GT	2021	500	I	~ 2031

Note: *1) UC= Under Construction, F/S = Feasibility Study Stage, I = Investigation Stage

Source: MOEP and MEPE (2013)

3) Coal-fired TPPs

In the PDP in Myanmar, six new coal-fired TPPs are planned (Table 5.1-10).

Whenever a report is submitted by IPP, the basic specifications for power plants, such as output and location, are changed. HPGE thus experiences difficulty in collecting information regarding IPP power plants.

Currently, 12 new coal-fired TPPs, which include six of the plants mentioned above, are planned according to interviews with HPGE. Most of them are planned to be developed by IPPs. However, Kaw Thaung coal-fired TPP (8MW), constructed in a previously non-electrified area, is already operational. Therefore, 11 new coal-fired TPPs are in fact planned.

IPP companies will procure coal-fired TPPs for these new plants by themselves. For example, Kunchangon coal-fired TPP is planning to import coal from Indonesia.

Table 5.1-10 New Coal-fired TPPs based on the PDP in Myanmar

	Project Name	Installed Capacity (MW)	Installed Capacity for Myanmar (MW)	Time for Commissioning	Current Situation
1)	Yangon-Kunchangon	300	300	2015/2016	FS
2)	Yangon-Htantapin	270	270	2017/2021	I
3)	Yangon-Thilawa	650	650	2017/2021	I
4)	Boakpyin	500	250	2017/2021	I
5)	Ngayukong	500	500	2017/2021	FS
6)	Kalewa	600	300	2022/2026	I

Note: *1) F/S = Feasibility Study Stage, I = Investigation Stage

Source: MOEP (2013)

4) Renewable Energy Power Plants

In the PDP in Myanmar, the following renewable energy power plants are planned.

Project Name	Type	Installed Capacity (MW)	Installed Capacity for Myanmar (MW)	Time for Commissioning
Minbuu	Solar	50	50	2013/2014
Tanintharyi, Mon, Kayin	Wind	1000	300	2017/2021
Shan, Kayah	Wind	1930	579	2017/2021
Chin, Rakhine, Ayeyarwady, Yangon	Wind	1102	330	2017/2021
Sagaing, Magway, Mandalay, Shan, Tanintharyi	Geothermal	200	200	2017/2021

For renewable energy projects by IPPs, including solar and wind power, DEP is in charge of project evaluation. However, as MOEP does not have enough engineers versed in these alternative energies, it is difficult to evaluate the reports submitted by the IPP companies.

Minbuu solar power plant (50MW) is planned to be operational from December 2014, but an MOU (Memorandum of Understanding) has yet to be concluded.

Another new solar power plant (500MW) is planned in Mandalay; although this project is proposed by an US-based company, details of its configuration, including sites, are not clear.

5) Conclusion

A list of all power plants based on obtained documents and information is presented in Table 5.1-11. This list includes existing, ongoing and future power plants (hydropower, gas and coal-fired power, and renewable energy).

Additionally, the power supply capacities are also described in Table 5.1-11 through 2030. Although the power generation situation in Myanmar is currently in flux, this table is adjusted to correspond to the PDP in Myanmar as of June 2013.

Table 5.1-11 Total Power Generation Supply Plan based on the PDP in Myanmar (1/3)

			Installed Capacity (MW)			Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Hydro Power Existing	Kayah State	Baluchaung-2	168			156.5	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168	168
	Mandalay Div.	Kinda	56			51	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
	Mandalay Div.	Sedawgyi	25			24.1	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Kayah State	Baluchaung-1	28			28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
	Shan State	Zawgyi-1	18			18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	Shan State	Zawgyi-2	12			12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Bago	Zaungtu	20			19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	Sagaing	Thapanseik	30			29.3	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Magway	Mone	75			74.15	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Mandalay Div.	Paunglaung	280			282	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280	280
	Bago	Yenwe	25			27.32	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Bago	Kabaung	30			29.71	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Shan State	Keng Tong	54			37.72	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
	Shan State	Shweli-1	600			155	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Mandalay Div.	Yeywa	790			732	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790
	Kachin	Dapein-1	240			5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
	Bago	Shwegyin	75			75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
	Magway	Kyee On Kyee Wa	74			74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
	Bago	Kun	60			21.08	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Bago	Thauk Ye Khat (2)	120			120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
			Subtotal	*2780*		*1970.88*																			
Thermal Power Existing	Yangon	Hlawga GTCC	33.3	GT		88	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			33.3	GT			33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			33.3	GT			33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			54.3	ST			54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3
		Ywama GT	18.45	GT		50	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			18.45	GT			18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			24	GT	NEDO		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
			9.4	ST	NEDO		9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
		Ahlone GTCC	33.3	GT		76	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			33.3	GT			33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			33.3	GT			33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
			54.3	ST			54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3	54.3
		Tharkayta GTCC	19	GT		57	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
			19	GT			19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
			19	GT			19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
			35	ST			35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Mon	Thaton GT	18.45	GT		35	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			16.25	GT			16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
			16.25	GT			16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
	Magway	Kyunchaung GT	18.1	GT		24.5	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
			18.1	GT			18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
			18.1	GT			18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1	18.1
	Mon	Mawlamyaing GT	6	GT		3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
			6	GT			6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Ayeyarwady	Myanaung GT	16.25	GT		12	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
			18.45	GT			18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
	Bago	Shwedaung GT	18.45	GT		20.5	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			18.45	GT			18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			18.45	GT			18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
	Magway	Mann GT (Production stop in 2005)	18.45	GT		0	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			18.45	GT			18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45	18.45
			Subtotal	*714.9*		*366*																			
	Shan	Tigyit Coal-fired	60			87.1	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
			60				60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
			Subtotal	*120*																					

Table 5.1-11 Total Power Generation Supply Plan based on the PDP in Myanmar (2/3)

		Installed Capacity (MW)			Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Hydro Power On-going or Future	Chipwinge	99		2013			99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
	Phyu Chaung	40		2014			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Nancho	40		2014			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Baluhaung-3	52		2014			52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
	Upper Baluchaung	29		2015				29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
	Upper Paunglaung	140		2015				140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
	Tapain	101		2016					101	101	101	101	101	101	101	101	101	101	101	101	101	101	101	101
	Ann	10																						
	Thahtay	111		2019								111	111	111	111	111	111	111	111	111	111	111	111	111
	Upper Keng Tong	51		2019								51	51	51	51	51	51	51	51	51	51	51	51	51
	Upper Yeywa	280		2020									280	280	280	280	280	280	280	280	280	280	280	280
	Shweli-3	1050		2021										1050	1050	1050	1050	1050	1050	1050	1050	1050	1050	1050
	Bawgata	160		2021										160	160	160	160	160	160	160	160	160	160	160
	Upper Bu	150		2021										150	150	150	150	150	150	150	150	150	150	150
	Middle Paunglaung	100		2021										100	100	100	100	100	100	100	100	100	100	100
	Shwezaye	660																						
	Tanintharyi	600																						
	Tamanthi	1200																						
	Mawlaik	520																						
	Hutgyi	1360		2021	680									680	680	680	680	680	680	680	680	680	680	680
	Manipur	380		2021	190									190	190	190	190	190	190	190	190	190	190	190
	Chipwi	3400		2021	1700									1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
	Laza	1900		2021	950									950	950	950	950	950	950	950	950	950	950	950
	Dapein-2	168		2021	84									84	84	84	84	84	84	84	84	84	84	84
	Gawlan	100		2021	50									50	50	50	50	50	50	50	50	50	50	50
	Wu Zhongze	60		2021	30									30	30	30	30	30	30	30	30	30	30	30
	Lawngdin	435		2021	217.5									217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5	217.5
	Hkan Kawn	140		2021	70									70	70	70	70	70	70	70	70	70	70	70
	Tongxinqiao	320		2021	160									160	160	160	160	160	160	160	160	160	160	160
	Upper Thanliwn (Kunlong)	1400		2021	700									700	700	700	700	700	700	700	700	700	700	700
	Shwel-2	520		2021	260									260	260	260	260	260	260	260	260	260	260	260
	Myitsone	6000																						
	Sinedin	76.5		2021	38.25									38.25	38.25	38.25	38.25	38.25	38.25	38.25	38.25	38.25	38.25	38.25
	Belin	280		2021										280	280	280	280	280	280	280	280	280	280	280
	Ywathit (Thanlwin)	4000		2026	2000														2000	2000	2000	2000	2000	2000
	Wutsok	1800		2026	900														900	900	900	900	900	900
	Kaunglanhpu	2700		2026	1350														1350	1350	1350	1350	1350	1350
	Renam (Yenam)	1200		2026	600														600	600	600	600	600	600
	Hpizaw (Pisa)	2000		2026	1000														1000	1000	1000	1000	1000	1000
	Naopha	1000		2026	500														500	500	500	500	500	500
	Mantong	200		2026	100														100	100	100	100	100	100
	Lemro (Laymyo)	600		2026	300														300	300	300	300	300	300
	Lemro-2 (Laymyo-2)	90		2026	45														45	45	45	45	45	45
	Namlwe																							
	Keng Tong	96		2026	48														48	48	48	48	48	48
	Wan Ta Pin	25		2026	12.5														12.5	12.5	12.5	12.5	12.5	12.5
	Solue	165		2026	82.5														82.5	82.5	82.5	82.5	82.5	82.5
	Mong Wa	50		2026	25														25	25	25	25	25	25
	Keng Yang	28		2026	14														14	14	14	14	14	14
	He Kou	88		2026	44														44	44	44	44	44	44
	Nam Kha	200		2026	100														100	100	100	100	100	100
	Nam Tamhpak (kachin)	200		2026	100														100	100	100	100	100	100
	Nam Tamhpak (kayah)	180		2026	90														90	90	90	90	90	90
	Upper Thanliwn (Mongton)	7110		2031	3555																			3555
	Nam Pawn																							
	Htu Kyan (Tuzxing ?)	105		2031	52.5																			52.5
	Hseng Na	45		2031	22.5																			22.5
	Tha Hkwa	150		2031	75																			75
	Palaung	105		2031	52.5																			52.5
	Bawlake	180		2031	90																			90
	Ngotchaung	16.6		2021										16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
		Subtotal	*44266*																					

Table 5.1-11 Total Power Generation Supply Plan based on the PDP in Myanmar (3/3)

			Installed Capacity (MW)			Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Thermal Power On-going or Future	Mawlamyaing	GTCC	100		2015				100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
		GTCC	130		2016					130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130
	Hlawga	GE	26		2013.5	18	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
		GE	28.55		2014.2		28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55	28.55
			243		2014.11				243	243	243	243	243	243	243	243	243	243	243	243	243	243	243	243	243
			243		2015.5					243	243	243	243	243	243	243	243	243	243	243	243	243	243	243	243
	Ywama	GE	52		Commissioning 2013.7	0	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52
		GT	240		2014.2			240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240
	Ahlone	GT	82		2013.6	72	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
		ST	39		2014.9		27		27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
		GE?			2014?																				
	Thaketa	GE	53.6		Commissioning 2013.7	0	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6
			167		2015.2				167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167
			336		2016.1					336	336	336	336	336	336	336	336	336	336	336	336	336	336	336	336
			127		2014.12				127	127	127	127	127	127	127	127	127	127	127	127	127	127	127	127	127
			386		2016.3					386	386	386	386	386	386	386	386	386	386	386	386	386	386	386	386
	Kyaukphyu (New)	GT	100		2014.12				100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
			175		2015.3				175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175
			350		2016.2					350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
			Subtotal	*2878.2*																					
	Ayeyarwady/Yangon	Gas	500		2021	500									500	500	500	500	500	500	500	500	500	500	500
	Yangon-Kunchangon (Virtue Land)	Coal	300		2016	300				300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
	Yangon-Htantapin	Coal	270		2021	270									270	270	270	270	270	270	270	270	270	270	270
	Yangon-Thilawa	Coal	650		2021	650									650	650	650	650	650	650	650	650	650	650	650
	Boakpyin	Coal	500		2021	250									250	250	250	250	250	250	250	250	250	250	250
	Ngayukong	Coal	500		2021	500									500	500	500	500	500	500	500	500	500	500	500
	Kalewa	Coal	600		2026	300														300	300	300	300	300	300
			Subtotal	*3320*																					
Renewable		Minbuu (PV)	50		2014	50		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
		Wind	1209		2021										1209	1209	1209	1209	1209	1209	1209	1209	1209	1209	1209
		Geothermal	200		2021										200	200	200	200	200	200	200	200	200	200	200
			Subtotal	*1459*																					
			Total	**55538**			7400.1	7896.1	9006.1	10854	10856	10858	11022	11304	21771	21773	21775	21777	21779	29392	29394	29396	29398	29400	33250
								496	1110	1848	2	2	164	282	10467	2	2	2	2	7613	2	2	2	2	3849.5
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031

5.1.4 Gas-fired TPP Investigation

During the second site investigation, JICA Study Team visited four gas-fired TPPs in Yangon Region (Ywama, Hlawga, Ahlone and Thaketa) from 20th - 21st August 2013. During the fourth site investigation, JICA Study Team visited Paunglaung hydropower station on 13th November 2013 and Tigyit coal-fired TPP from 21st - 22nd November 2013. Information on the existing, ongoing and new plants was collected through these site visits. The result of the site visit to Tigyit coal-fired TPP is highlighted in Chapter 4.

(1) Outline

Even though commissioning has been carried out for ongoing gas-fired TPPs located in four TPPs of Yangon Region, PPAs (Power Purchase Agreement) with MOEP have yet to be finalized for commercial operation. The largest capacity plant under construction is a 240MW class GT plant in Ywama TPP, commissioning in 2014. The completed project image is shown below.

On the other hand, IPPs from Korea and China are planning to construct 500MW GTCC plants located beside the Thaketa TPP. The Korean IPP has already obtained an MOU with MOEP and built a construction office; its completed project image is shown below.

Ywama 240MW GT

Thaketa 500MW GTCC

(2) Ywama Thermal Plant

1) Operational situation of existing station

(a) Cleaning of ST's condenser tube supply is carried out manually for ten days every two months. For the measurement, JICA Study Team recommended an online cleaning system (ball cleaning).

(b) Offshore gas is currently used for generation. While onshore gas heating value is 900 btu/cf [lower heating value], offshore gas heating value is 720 btu/cf. Therefore, generator output is decreased.

(c) The current output of GT installed through MOEP's own finance is 32MW (16MW × 2) against the rated output of 36.9MW. As for GTCC granted by NEDO (New Energy and Industrial Technology Development Organization in Japan), current output is 25MW against the rated output of 33.4MW.

(d) Interval [equivalent operation hours] and period for maintenance of GT are as follows:

Combustor inspection : 7 - 10 days per 8,000 hours

Hot gas parts inspection	:	20 days per 16,000-24,000 hours
Major overhaul	:	1 month per 24,000-32,000 hours

(e) The number of staff at the Ywama station is 104, including 21 engineers.

2) New plants' situation

(a) 52MW GE plants by IPP

- Installed capacity: 4MW × 13 units (German)
- Commissioning from August 2013
- PPA has yet to be contracted

52MW GE Plant

(b) 240MW GT plants by IPP

- Installed capacity: 120MW × 2 units
  Unit 1 commissioning: November 2013,
  Commercial operation: January 2014
  Unit 2 commissioning: December 2013,
  Commercial operation: February 2014

At present, the plant land is partially developed with houses and a 230kV switchgear station under construction. The generated power will be sent to Hlaingtharyar substation, and the 230kV transmission line is under construction. According to MOEP, 30 personnel from the IPP will be dispatched to the station as trainers for one year after completion of construction.

240MW GT Construction Site

MOGE (Myanma Oil and Gas Enterprise) will supply gas to MOEP at 5 USD/Btu; MOEP will provide gas to the IPP free of charge.

(3) Hlawga Thermal Station

1) Operational situation of existing station

(a) This plant is stopped only for condenser cleaning, unlike at the Ywama station. The cleaning is carried out during the ST inspection five days per year.

(b) GT was designed for onshore gas use, but currently uses lower heating value offshore gas as Yadana. As a result, current output is decreased to 26.27MW against 33.3MW of installed capacity.

The company selected by an international tender is now reforming the combustor for GT3 with MOEP budgeting. The other two units will be reformed in a year; output is guaranteed at 30MW for one year after reforming.

(c) GT maintenance interval

Kind of maintenance	Equivalent operation hours	Maintenance days
Combustor I	8,000 hrs	7 days
Combustor II	16,000 hrs	7 days
Hot gas parts	24,000 hrs	40 days
Major overhaul	32,000 ~ 40,000 hrs	45 days

(d) Numbers of trips
The number of trips is two times per month on average. GT's trip time is about one hour and ST's is about four hours. The main cause is out of range of frequency.

(e) The number of staff in the station is 120, including 20 engineers.

2) Ongoing IPP situation

Next to the Hlawga station, a GE plant is under construction by a IPP. 26MW as Phase 1 [1MW × 26 units, including 1 reserve unit] has been commissioned. However, they are still on standby as a PPA has yet to be contracted. In Phase 2, it is planned to decrease maintenance time by adapting a larger capacity unit.

GE IPP Project

GE House

GE (1MW)

(4) Ahlone Thermal Station

1) Operational situation of existing station

(a) GTs are under construction for improvement. At present, GT 2 is under suspension for construction. Improvement works are also under implementation for GT 1 and GT 3 (scheduled for completion November 2013). After the upgrades, the generator output will be 30MW by enlarging the nozzle diameter to match with offshore gas, which has low heat efficiency. The budget of this upgrade is from MOEP.

(b) The maintenance interval and period is similar to Hlawga station.

121MW GTCC Plant

(c) The number of staff in the station is 120, including 34 engineers.

2) Ongoing IPP situation

(a) 121MW GTCC plant by IPP

- Commissioning: GT 1 April 2013; GT 2 June 2013; ST September 2014 (expected).
- Although PPAs have yet to be contracted, power selling has started.

(b) 50MW GE plant by IPP (planning only)

- Installed capacity : 50MW (1MW × 50 units)

(5) Thaketa Thermal Station

1) Operation situation of existing station

(a) Operation is suspended once every two months for cleaning of condensers (same as at the Ywama station) as the underground water used for cooling contains iron and other contaminants. This takes two to three days of around-the-clock maintenance.

(b) Rehabilitation is planned via a Yen loan scheme. Actual output as of 2012 is 64MW; this will be increased to 86MW after rehabilitation.

(c) GT's maintenance interval and period are the same as at the Hlawga station.

(d) GT's heat rate is 16,660.813 btu/kWh.

(e) The generator's trip record (first half of 2013) obtained at the station is shown in Table 5.1-12. Gas line shutdowns and system breakdowns have occurred due to gas supply interruptions and system outages.

2) Ongoing IPP situation

Next to the Thaketa station, GE plants by IPP have been commissioned. The installed capacity is 53.6MW (3.352MW × 16 units including one unit as a standby).

As a PPA has yet to be finalized, commercial operation have not started.

3) Future IPPs

(a) 503MW by IPP (Korea)
A MOU and MOA (Memorandum of Agreement) have been approved. It is planned to be constructed on MOEP land. A land lease agreement has been approved by MOEP. A construction office has been built at the entrance to the construction site and 1-2 civil engineers are stationed there.

(b) 513MW by IPP (China)
MOU and MOA approval have yet to be confirmed. It is planned to be constructed jointly on MOEP and a developer's land in Yangon. A land lease agreement has yet to be approved.

(c) Diesel generator [1MW × 9 units] is installed with Japanese Grant-Aid support at the site adjacent to the Korean IPP. Commencement of operation is planned for 2014.

Table 5.1-12 Thaketa GT & ST Trip Record

MONTH	Machine	Stop Duration	Remarks
(1/2013)	STG	28/12/2012(22:10) 09/01/2013(19:00)	Servo Error
(2/2013)	GT (1)	23/02/2013(00:00) 26/02/2013(04:35)	Gas Line Maintenance
	GT (2)	20/02/2013(00:35) 26/02/2013(16:43)	Power Supply Trouble & Gas Line Shutdown
	GT(3)	23/02/2013(00:00) 26/02/2013(05:00)	Gas Line Shutdown
	STG	04/02/2013(18:15) 10/02/2013(12:30)	Generator Bearing Temperature High
	STG	10/02/2013(20:25) 11/02/2013(01:05)	Generator Winding Temperature High & Vacuum Pressure Low
	STG	11/02/2013(15:45) 11/02/2013(19:20)	Generator Winding Temperature High & Vacuum Pressure Low
	STG	16/02/2013(06:05) 16/02/2013(09:30)	Voltage Surge
(3/2013)	STG	23/02/2013(23:50) 05/03/2013(04:30)	Gas Shutdown, Condenser, Generator, Lube Oil Cooler Tube Cleaning
	GT (2)	09/03/2013(05:32) 09/03/2013(14:55)	66kV Feeder Heavy Fault Overspeed Trip
	GT(3)	09/03/2013(05:32) 09/03/2013(07:07)	66kV Feeder Heavy Fault Overspeed Trip
(4/2013)	GT (1)	05/04/2013(00:16) 12/04/2013(06:41)	Gas Line Shutdown
	GT (2)	05/04/2013(00:15) 12/04/2013(13:14)	Gas Line Shutdown
	GT(3)	05/04/2013(00:14) 12/04/2013(07:30)	Gas Line Shutdown
	STG	05/04/2013(00:15) 12/04/2013(11:30)	Gas Line Shutdown & Generator Cooler, Lube Oil Cooler
	STG	16/04/2013(07:53) 16/04/2013(20:15)	Ejector Check Valve Inspection & Cleaning
(5/2013)	GT(2)	16/05/2013(06:15) 16/05/2013(12:17)	Power Supply Trouble
	STG	04/05/2013(21:06) 05/05/2013(12:35)	Gland Steam Valve Cleaning, Batching Plate Replacement
	STG	10/05/2013(20:35) 11/05/2013(17:35)	CV 4605 Cleaning, Gland Steam Nozzle and Ejector Cleaning
	STG	12/05/2013(18:25) 13/05/2013(12:35)	Condenser Vacuum Line Maintenance, Ejector Check Valve
(6/2013)	GT (2)	03/06/2013(10:05) 03/06/2013(20:10)	66kV Feeder Heavy Fault, Power Supply Trouble
	STG	03/06/2013(10:05) 03/06/2013(14:15)	System Breakdown
	STG	04/06/2013(13:08) 04/06/2013(18:00)	System Breakdown
	STG	09/06/2013(13:05) 09/06/2013(19:30)	Vacuum Pressure High

Source: Thaketa Gas TPP

(6) Paunglaung Hydropower Station

The information below was obtained from a site visit on November 13, 2013.

- At the Paunglaung station (280MW (70MW × 4 units), in operation since March 2005, only two or three units can be operated at simultaneously due to a bottleneck of transmission line capacity in the line between Taungoo and Thephyu (towards Yangon). When JICA Study Team visited, only three units (output 160MW) were operating and surplus water was being discharged from the spillway. During the rainy season, the maximum output is 280MW. In the dry season, output decreases to 50MW.
- For maintenance, operation of each unit is suspended for one to one and a half months during the rainy season. However, according to the station, during this most recent rainy season, suspension of each unit was not carried out based on orders from the load dispatching center.
- Daily operation consists of two shifts of four groups as follows:
  05:00 - (3 units) – 10:00 - (2 units) – 16:00 - (3 units) – 24:00 - (stop)
- Paunglaung and Yeywa reservoir type stations are operated to cope with a daily peak load. Shweli and Baluchaung-2 stations are operated to cope with a base load.
- The number of station staff is 87, including 69 engineers. The dam is managed by MOAI.

Generator room

Control room

Rockfill dam

Spill out from spillway

5.2 BASIC CONDITIONS FOR FORMULATION OF THE PGDP

In this Section, basic conditions for the optimal PGDP has been proposed based on the current situation of power generation in Myanmar.

5.2.1 Planning Methodology for the Short Term

The PDP in Myanmar presents that new gas thermal plants (mainly by IPP projects) are crucial for power supply in the short term (by 2016) because of their relatively short construction periods. As the PDP in Myanmar serves as the base for this study, the plan has been reviewed with a variety of power supplies and delays in construction in mind.

For short term planning, in order to mitigate a power supply shortage, current issues have been extracted and prioritized. Middle and long term plans have also been recommended in view of economic performance and reliability.

As mentioned in Section 5.2.1, available power supply capacity has been reviewed and, based on this review, an optimal power generation planning program has been utilized.

5.2.2 Planning Methodology for the Middle and Long Term

The PDP in Myanmar prepared prior to this study shows various power generation plants listed for middle term planning (by 2020) and long term planning (by 2030). JICA Study Team has studied the list in terms of economy and reliability, based on the following three scenarios.

Scenario 1	Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)
Scenario 2	Least Cost Scenario
Scenario 3	Power Resources Balance Scenario

In Scenario 1, the utilization of domestic power resources will be maximized based on the PDP in Myanmar. For example, hydropower including large scale ones and gas-fired plants are fully developed, with the power supply deficit compensated by coal-fired TPPs.

In Scenario 2, the overall generation cost will be minimized. Therefore, compared with the above scenario, power supply from coal-fired TPPs will increase and that from gas-fired plants will decrease in order to minimize costs.

In Scenario 3, the best mix of power resources is proposed considering feasibility of project implementation and the primary energy forecast as shown in Chapter 4. In this Scenario, HPPs with higher priority will be selected, namely realistic hydropower project plans with short lead time to completion and with a short distance to demand centers. Gas-fired plants will be fully developed as long as adequate gas supplies can be expected. However, the capacity of domestic energy resources such as hydropower, gas and renewable energy is insufficient for future demand and comprises some risks in the power supply. Coal-fired TPPs will have be developed to compensate for them. This is most effective when balancing power resources in the viewpoint of energy security.

The study was conducted using the optimal power generation development program, which can analyze the cost and power supply reliability of each scenario.

Throughout the study, JICA Study Team proposed best-mixed power generation development from the viewpoints of economy and reliability for the middle and long terms.

5.2.3 Issues of Power Generation Development in Myanmar

In the PDP in Myanmar, the growth rates for demand and the reserve ratio are set at 13% and 30%, respectively; this is considered sufficient power supply planning for the demand forecast (for example, the reserve capacity reaches over 10,000MW against the demand in 2021 and 2025).

In planning the PGDP, the adequacy of the plan has been checked against whether power supply shortages can occur if some variables of power supply and demand are changed. In this respect, JICA Study Team considered major variables such as the available power supply capacity of hydropower projects during the dry season and the power supply capacity of domestic IPP projects. Generally, in Myanmar power supply of hydropower stations will decrease by 50% of the installed capacity during the dry season. Regarding JV/IPP projects, although it depends on the PPA contracts between MOEP and developers, domestic power supply would be expected to be 10% to 50% of the total installed capacity. Table 5.2-1 to Table 5.2-4 present the power supply and demand conditions studied under variables mentioned above. Demand forecast and candidate hydropower projects mentioned in the PDP in Myanmar are applied in this case. Table 5.2-1 is a summary and Table 5.2-2 to Table 5.2-4 contains the breakdowns.

Table 5.2-1 shows that a power supply shortage could occur in 2025-2026 if the IPP domestic supply ratio is assumed to be 10%. In 2030-2031, a shortage may occur if the IPP domestic supply ratio is both 50% and 10%.

Therefore, even if sufficient power supply is planned in the PDP in Myanmar, power shortages could occur based on the abovementioned conditions.

Table 5.2-1 Power Supply and Demand Balance Variables

(Unit : MW)

Year	Consumption		Supply							
			IPP ratio : 50%				IPP ratio : 10%			
	Base	Reserve 30%	Rainy	Differences between reserve and supply	Dry	Differences between reserve and supply	Rainy	Differences between reserve and supply	Dry	Differences between reserve and supply
2015-16	3,077	4,000	6,823	2,823	5,995	1,995	-	-	-	-
2020-21	5,686	7,392	17,730	10,338	13,238	5,846	13,427	6,035	10,986	3,594
2025-26	10,400	13,521	25,341	11,820	17,194	3,673	14,949	1,428	11,777	-1,744
2030-31	19,216	24,981	29,189	4,208	19,887	-5,094	16,834	-8,147	13,097	-11,884

Source: Prepared by JICA Study Team

Table 5.2-2 Power Supply between 2017 and 2021 Variables

2017 - 2021		Installed Capacity	IPP supply ratio of 50%		IPP supply ratio 10%	
				Dry : (×0.5)		Dry : (×0.5)
1	Upper Yeywa (MOEP)	280	280.0	140.000	280.00	140.000
2	Shweli-3 (MOEP)	1,050	1,050.0	525.000	1,050.00	525.000
3	Bawgata (MOEP)	160	160.0	80.000	160.00	80.000
4	Upper Bu (MOEP)	150	150.0	75.000	150.00	75.000
5	Middle Paunglaung (MOEP)	100	100.0	50.000	100.00	50.000
6	Thahtay (MOEP)	111	111.0	55.500	111.00	55.500
7	Upper Keng Tong (MOEP)	51	51.0	25.500	51.00	25.500
8	Chibwe	3,400	1,700.0	850.000	340.00	170.000
9	Laza	1,900	950.0	475.000	190.00	95.000
10	Upper Thanlwin (Kunlong)	1,400	700.0	350.000	140.00	70.000
11	Gawlan	100	50.0	25.000	10.00	5.000
12	Wxhonhgze	60	30.0	15.000	6.00	3.000
13	Lawngdin	435	217.5	108.750	43.50	21.750
14	Hkan Kwan	140	70.0	35.000	14.00	7.000
15	Tongxingqiao	320	160.0	80.000	32.00	16.000
16	Hutgyi	1,360	680.0	340.000	136.00	68.000
17	Shweli-2	520	260.0	130.000	52.00	26.000
18	Saindin	77	38.3	19.125	7.65	3.825
19	Dapein-2	168	84.0	42.000	16.80	8.400
20	Manipur	380	190.0	95.000	38.00	19.000
21	Belin	280	280.0	140.000	280.00	140.000
22	Ngot Chaung	17	16.6	8.300	16.60	8.300
23	Yangon - Htantapin	270	270.0	270.000	270.00	270.000
24	Yangon- Thilawa	650	650.0	650.000	650.00	650.000
25	Boakpyin	500	250.0	250.000	50.00	50.000
26	Ngayukong	500	500.0	500.000	500.00	500.000
27	Ayeyarwady / Yangon	500	500.0	500.000	500.00	500.000
28	Tanintharyi, Mon, Kayin	1,000	300.0	300.000	300.00	300.000
29	Shan, Kayah	1,930	579.0	579.000	579.00	579.000
30	Chin, Rakhine, Ayeyarwady, Yangon	1,102	330.0	330.000	330.00	330.000
31	Sagaing, Magway, Mandalay, Shan, Tanintharyi	200	200.0	200.000	200.00	200.000
			10,907.4	**7,243.175**	**6,603.55**	**4,991.275**

Source: Prepared by JICA Study Team

Table 5.2-3 Power Supply between 2022 and 2026 Variables

2022 - 2026		Installed Capacity	IPP supply ratio of 50%		IPP supply ratio 10%	
				Dry : (×0.5)		Dry : (×0.5)
1	Ywathit-Thanlwin	4,000	2,000	1,000.0	400.0	200.0
2	Wutsok	1,800	900	450.0	180.0	90.0
3	Kaunglanhpu	2,700	1,350	675.0	270.0	135.0
4	Yenan	1,200	600	300.0	120.0	60.0
5	Pisa	2,000	1,000	500.0	200.0	100.0
6	Laymyro	600	300	150.0	60.0	30.0
7	Laymyro-2	90	45	22.5	9.0	4.5
8	Natabat-Kayah	180	90	45.0	18.0	9.0
9	Naung Pha	1,000	500	250.0	100.0	50.0
10	Mantaung	200	100	50.0	20.0	10.0
11	Keng Tong	96	48	24.0	9.6	4.8
12	Wan Ta Pin	25	13	6.3	2.5	1.3
13	So Lu e	165	83	41.3	16.5	8.3
14	Mongwa	50	25	12.5	5.0	2.5
15	Keng Yang	28	14	7.0	2.8	1.4
16	He Kou	88	44	22.0	8.8	4.4
17	Namkha	200	100	50.0	20.0	10.0
18	Natabat-Kachin	200	100	50.0	20.0	10.0
19	Kalewa	600	300	300.0	60.0	60.0
			7,611	**3,955.5**	**1,522.2**	**791.1**

Source: Prepared by JICA Study Team

Table 5.2-4 Power Supply between 2027 and 2031 Variables

2027 - 2031		Installed Capacity	IPP supply ratio of 50%		IPP supply ratio 10%	
				Dry : (×0.5)		Dry : (×0.5)
1	Htu Kyan	105	52.5	26.25	10.500	5.2500
2	Hanna	45	22.5	11.25	4.500	2.2500
3	Thakya	150	75.0	37.50	15.000	7.5000
4	Palaung	105	52.5	26.25	10.500	5.2500
5	Bawlake	180	90.0	45.00	18.000	9.0000
6	Upper Thanlwin- Mong Tong	7,110	3,555.0	1,777.50	711.000	355.5000
			3,847.5	**2,693.25**	**1,885.275**	**1,319.6925**

Source: Prepared by JICA Study Team

5.2.4 Progress of Ongoing Power Generation Projects

Current progress of the development sequences of each of the IPP projects is one of the key points for planning of the PGDP. Therefore, JICA Study Team has collected data and information on the progress of the IPP projects and compiled them into Table 5.2-6 for hydropower projects, Table 5.2-7 for gas-fired projects and Table 5.2-8 for coal-fired projects.

IPP's lead time from MOU to COD (Commercial Operation Date) is estimated on the basis of project features such as river location and dam height as shown in Table 5.2-5.

Information of HPP type (reservoir or run-of-river) is also shown in Table 5.2-6.

Table 5.2-5 Lead Time of IPP's Hydropower Development

(Unit : year)

	Sub river		Main river	
	Dam height under 150m	Dam height over 150m	Dam height under 150m	Dam height over 150m
MOU - F/S[*1] -MOA	2	3	2	3
MOA - EIA[*2] - JVA	2	3	3	4
JVA-Construction - COD	5	7	7	10

*1 F/S : Feasibility Study
*2 EIA : Environmental Impact Assessment

Information on the new gas-fired IPP projects was obtained through interviews with TPD (as of February 2014).

For Ywama (52MW) and Thaketa (53.6MW), PPAs has been contracted.

For Mawlamyaing (phase 1: 98MW, phase 2: 132MW), a GT1 unit was put into operation in 2014.

As for the Korean IPP (MOA contracted) at Thaketa, the Chinese IPPs (MOU contracted) at Thaketa, Hlawga (MOU contracted) and Ayeyarwady (MOU contracted), their fuel is LNG (Liquid Natural Gas) and its import plan is suspended. Therefore, the progress of these projects is subject to the procurement of fuel (which may experience difficulties until 2022 when new gas-fired will be developed).

According to MOEP, after a MOU is concluded, an F/S (Feasibility Study) report should be submitted within one year, and an EIA (Environmental Impact Assessment) and SIA (Social Impact Assessment) should be submitted within six months after submission of the F/S report. However, there could be exceptions depending on the agreement with the projects. In essence, MOA has no specific expiration period.

The MOEP's own projects such as Kyaukphyu (GE, GT), Myin Gyan (GTCC) and Thaton (GTCC, replace) are under progress. The projects at Kyause (GE) and Ywama (GT) were put into operation in 2014.

Table 5.2-6 Progress of Future HPPs

		Installed Capacity (MW)	Stage	Main River Subsidiary River	Dam Height (m)	Type of Hydropower Plant		Available Capacity for Myanmar (MW)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
									2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
A	Phyu Chaung	40	construction		74.7	Reservoir type	2014																									
B	Nancho	40	construction		50.9	Run-of-river type	2014																									
C	Baluhaung-3	52	BOT		-	Run-of-river type	2014				BOT																					
D	Upper Baluchaung	29	BOT		35	Run-of-river type	2015				BOT																					
E	Upper Paunglaung	140	construction		98.14	Reservoir type	2015																									
F	Ann	10	suspended		47.9	Reservoir type																										
G	Thahtay	111	construction		90.8	Reservoir type	2019																									
H	Upper Keng Tong	51	construction		57	Reservoir type	2019																									
I	Upper Yeywa	280	construction		60.96	Reservoir type	2020																									
J	Shweli-3	1050	construction		119.8	Reservoir type	2021																									
K	Bawgata	160	Peliminary Work		70.1	Reservoir type	2021																									
L	Upper Bu	150	On-going		137.5	Reservoir type	2021																									
M	Middle Paunglaung	100	Investigation		82.9	Run-of-river type	2021																									
N	Belin	280	terminated	-	117	Rservoir type	2021																									
O	Ngotchaung	16.6	MOU		-	Run-of-river type	2021						MOU		MOA		JVA					COD										
1	Myitsone	6000	JVA	-	139.6	Reservoir type																										
2	Chipwi	3400	JVA	M	206	Reservoir type	2021	1700			JVA (June 2010)										COD											
3	Wutsok	1800	MOA	M	141	Reservoir type	2026	900			MOU			MOA				JVA										COD				
4	Kaunglanhpu	2700	MOA	M	223	Reservoir type	2026	1350			MOU			MOA				JVA										COD				
5	Renam (Yenam)	1200	MOA	M	159	Reservoir type	2026	600			MOU			MOA				JVA										COD				
6	Hpizaw (Pisa)	2000	MOA	M	153	Reservoir type	2026	1000			MOU			MOA				JVA										COD				
7	Laza	1900	JVA	M	196	Reservoir type	2021	950			JVA (June 2010)										COD											
8	Chipwinge	99	(Prepared to Commercial)	-	47.6	Reservoir type	2013																									
9	Dapein-2	168	MOU	S	59	Reservoir type	2021	84		MOU		MOA		JVA					COD													
10	Gawlan	100	MOA	S	47	Reservoir type	2021	50				MOU		MOA		JVA					COD											
11	Wu Zhongze	60	MOA	S			2021	30																								
12	Hkan Kawn	140	MOA	S			2021	70				MOU		MOA		JVA					COD											
13	Tongxingqiao	320	MOA	S	63		2021	160				MOU			MOA			JVA							COD							
14	Lawngdin	435	MOA	S	79		2021	217.5				MOU			MOA			JVA							COD							
15	Upper Thanliwn (Kunlong)	1400	MOA	M	103		2021	700				MOU			MOA				JVA										COD			
16	Naopha	1000	MOU	M	90	Reservoir type	2026	500			MOU			MOA				JVA											COD			
17	Mantong	200	MOU	M	109	Reservoir type	2026	100			MOU		MOA			JVA							COD									
18	Tamanthi	1200	MOU																													
19	Shwezaye	660	MOU																													
20	Tanintharyi	600	MOU																													
21	Upper Thanliwn (Mongton)	7110	MOU	M	241	Reservoir type	2031	3555				MOU			MOA				JVA										COD			
22	Hutgyi	1360	MOA	M	117.6	Reservoir type	2021	680				MOU			MOA				JVA										COD			
23	Sinedin	76.5	MOA	S	70.1	Reservoir type	2021	38.25					MOU			MOA			JVA							COD						
24	Lemro (Laymyo)	600	MOA	S	205	Reservoir type	2026	300					MOU			MOA			JVA							COD						
25	Lemro-2 (Laymyo - 2)	90	MOA	S	48.2	Reservoir type	2026	45					MOU		MOA		JVA					COD										
26	Ywathit (Thanlwin)	4000	MOA	M	147	Reservoir type	2026	2000					MOU			MOA				JVA										COD		
27	Nam Tamhpak (Kayah)	180	MOA	S	29.9	Reservoir type	2026	90					MOU		MOA		JVA					COD										
28	Htu Kyan (Tuzxing ?)	105	MOA	S	86	Reservoir type	2031	52.5					MOU		MOA		JVA					COD										
29	Hseng Na	45	MOA	S	43.9	Reservoir type	2031	22.5					MOU		MOA		JVA					COD										
30	Tha Hkwa	150	MOA	S	38.1	Reservoir type	2031	75					MOU		MOA		JVA					COD										
31	Palaung	105	MOA	S	108	Reservoir type	2031	52.5					MOU		MOA		JVA					COD										
32	Bawlake	180	MOA	S	108	Reservoir type	2031	90					MOU		MOA		JVA					COD										
33	Shweli-2	520	MOA	S	92(82)	Reservoir type	2021	260					MOU			MOA			JVA							COD						
34	Keng Tong	96	MOU	S	54(73)	Reservoir type	2026	48	MOU		MOA		JVA					COD														
35	Wan Ta Pin	25	MOU	S	42.5(57)	Reservoir type	2026	12.5	MOU		MOA		JVA					COD														
36	So Lue	165	MOU	S	125(130)	Reservoir type	2026	82.5	MOU		MOA		JVA					COD														
37	Mong Wa	50	MOU	S	43.9	Reservoir type	2026	25	MOU		MOA		JVA					COD														
38	Keng Yang	28	MOU	S	27.8(36)	Reservoir type	2026	14	MOU		MOA		JVA					COD														
39	He Kou	88	MOU	S	50.5(52)	Reservoir type	2026	44	MOU		MOA		JVA					**COD**														
40	Nam Kha	200	MOU	-	120	Reservoir type	2026	100																								
41	Mawlike	520	MOU	-																												
42	Nam Tamhpak (Kachin)	200	MOU	S	17.4/55.2	Reservoir type	2026	100																								
43	Manipur	380	MOU	S	160.6	Reservoir type	2021	190						MOU			MOA			JVA							COD					
	Sub Total		*44064.1*												*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Table 5.2-7 Progress of Future Gas-fired IPP Projects (as of February 2014)

			Stage of the project	Current Situation of Contract	Contract Date	Contract Expiration
Hlawga	Local/IPP	Phase 1	commissioning	MOA	29/03/2013	No Expiration
				PPA	nearly finished	
		Phase 2	after PPA, under construction	MOA	29/03/2013	No Expiration
	JV/IPP	Phase 1	MOU	MOU	27/07/2012	27/04/2015
		Phase 2	MOU	MOU	27/07/2012	27/04/2015
Ywama	Local/IPP		commissioning	MOA	02/08/2013	No Expiration
				PPA	First week 02/2014	
Ahlone	Local/IPP	Phase 1	Operated	MOA	16/11/2012	No Expiration
				PPA	nearly finished	
		Phase 2	under construction	MOA	16/11/2012	No Expiration
				PPA	nearly finished	
Thaketa	Local/IPP		commissioning	MOA	27/08/2013	No Expiration
				PPA	First week 02/2014	
	JV/IPP	Phase 1	MOA	MOA	04/10/2012	No Expiration
		Phase 2	MOA	MOA	04/10/2012	No Expiration
	JV/IPP	Phase 1	MOU	MOU	02/01/2013	31/10/2015
		Phase 2	MOU	MOU	02/01/2013	31/10/2015
Mawlamyaing	Local/IPP	Phase 1	MOA	MOA	09/09/2013	No Expiration
				PPA	nearly finished	
		Phase 2	MOA	MOA	09/09/2013	No Expiration
				PPA	nearly finished	
Kanpouk (NEW)	Local/IPP or JV/IPP	Phase 1	MOU	MOU	11/04/2013	31/07/2014
		Phase 2	MOU	MOU	11/04/2013	31/07/2014
Ayeyarwady (NEW)	JV/IPP		MOU	MOU	25/07/2013	25/07/2015

Source: MEPE

Table 5.2-8 Progress of Future Coal-fired IPP Projects

MOU had singed

No.	Project name & Location	Installed Capacity	Final Status	Remarks
Yangon Region				
1	Htantapin Township, Near Kukowa River	2 × 135 MW (1st Phase) 2 × 135 MW (or) 1 ×300 MW (2nd Phase)	On (19.8.2013), developers replied that they have no changes concerned with the location of the project, but at present, they are trying to get a place for jetty in the Yangon River for the transportation of coal.	-MOU had been signed on (11.2.2010). -Overview of FSR had been replied on (22.8.2011).
2	Kyun Gyan Gon Township, Thoung Khon Village	2 × 150 MW (1st Phase) 2 × 300 MW (2nd Phase) 2 × 600 MW (3rd Phase)	Developer is preparing to reply the overview of FSR to DHPP.	-MOU had been signed on (24.8.2012).
3	Thilawa Industrial Zone	650~1,200 MW (1st Phase) 1,200~2,000 MW (2nd Phase) 3,000 MW (3rd Phase)	MOU had been signed on (21.3.2013).	-MOU had been signed on (21.3.2013). -Overview of FSR had been replied on (16.7.2013).
4	Kyauk Tan Township, Chaungwa Village	2 × 250 MW	On (3.7.2013), they had submitted MOU (Draft) to Ministry of Finance, Union Attorney General's Office and Ministry of National Planning and Economic Development.	-MOU had been signed on (8.10.2013).
Sagaing Region				
5	Kale District, Kalewa Township	2 × 135 MW (1st Phase) 2 × 135 MW (2nd Phase)	HPGE is preparing to reply the overview of Financial Analysis Report to DHPP.	-MOU had been signed on (27.5.2010). -Overview of FSR had been replied on (15.6.2010).
Tanintharyi Region				
6	Myeik Township, Lotlot Village	1 × 50 MW	On (19.10.2012), HPGE replied the Pros and Cons and Inspection ways of Clean Coal Technology to DHPP.	-MOU had been signed on (27.7.2012).
7	Kawthaung District, Boakpyin Township, Manawlone	1 × 250 MW (1st Phase) 1 × 250 MW (2nd Phase)	On (25.7.2013), HPGE replied the overview of Financial Analysis Report to DHPP.	-MOU had been signed on (21.9.2012). -Overview of FSR had been replied on (14.6.2013).
Ayeyarwady Region				
8	Ngayok Kaung	2 × 270 MW (or) 2 × 300 MW	HPGE is preparing to reply the overview of FSR Implementation Report to DHPP.	-MOU had been signed on (11.4.2013).
Shan State				
9	Keng Tong	25 MW	On (25.5.2012) HPGE reported compare with previous sulfur reduction report to MOEP.	-MOU had been signed on (1.10.2013).

* FSR : Feasibility Study Report

MOU Proposals

No.	Project name & Location	Installed Capacity	Final Status	Remarks
Yangon Region				
1	Htan Ta Bin Township, Shwe Lin Ban Industrial Zone	1 × 350 MW (1st Phase) Total 1,050 MW	On (13.9.2013), HPGE replied the overview of FSR to DHPP	
Tanintharyi Region				
2	Dawei Special Economic Zone	1 × 400 MW (1st Phase) 2 ×1,800 MW(2nd Phase)	On (8.11.2012), they had submitted MOU (Draft).	

Source: HPGE

There are 11 candidate coal-fired projects which are planned to be developed via IPP schemes. MOUs for nine of the projects have been contracted as of February 2014. See Table 5.2-8 for further details.

In addition, it was necessary to obtain information regarding the rehabilitation plans of existing plants.

The rehabilitation plans for existing gas-fired plants are shown in Table 5.2-9 (collected from interviews with TPD). Total current generation 366MW will increase to 574MW after the rehabilitations are carried out. The increment to the overall power supply by these projects is added to the power generation supply plan from 2017.

According to interviews with HPGE, the rehabilitation plan for the Tigyit coal-fired TPP has been already discussed within MOEP. The approval of Parliament is required for the project to begin implementation. The rehabilitation plan (30MW→120MW) is added to the power generation supply plan from 2016.

Table 5.2-9 Gas-fired Plant Rehabilitation Plans

Region/State	Station	Installed Capacity (MW)		Type	COD	Current Generation (MW)	Rehabilitation	Replacement	Planned *1	Installed Capacity (After Replacement)
Yangon	Hlawga GTCC	33.3	154.2	GT	1996.01	88			116	154.2
		33.3		GT						
		33.3		GT						
		54.3		ST	1999.04					
	Ywama GTCC	18.45	70.3	GT	1980	50			57	70.3
		18.45		GT						
		24		GT	2004					
		9.4		ST	2004					
	Ahlone GTCC	33.3	154.2	GT	1995.04	76			116	154.2
		33.3		GT						
		33.3		GT						
		54.3		ST	1997.02					
	Tharkayta GTCC	19	92	GT	1990.03	57	86			92
		19		GT						
		19		GT						
		35		ST	1997.02					
Mon	Thaton GT	18.45	50.95	GT	1985	35		106 (GTCC)		106
		16.25		GT	2001					
		16.25		GT						
Magwe	Kyunchaung GT	18.1	54.3	GT	1974	24.5			39	54.3
		18.1		GT						
		18.1		GT						
Mon	Mawlamyaing GT	6	12	ST	1980	3			0 *2	0
		6		ST						
Ayeyarwady	Myanaung GT	16.25	34.7	GT	1975&84	12			15	34.7
		18.45		GT						
Bago	Shwedaung GT	18.45	55.35	GT	1984	20.5			39	55.35
		18.45		GT						
		18.45		GT						
Magwe	Mann GT (Production stop in 2005)	18.45		GT	1980	0			0 *3	36.9
		18.45	36.9	GT						
		Sub Total		***714.9***		***366***				
							574 (GTCC 481, GT93)			757.95

Source: MEPE

Note *1 Generation when more gas is available.
*2 Power supply is not counted according to new power plant construction (Myanmar Lighting).
*3 Power supply in not counted according to the spare from 2005.

5.2.5 Policy of the PGDP

This report reviews three scenarios described in Section 5.3. In this Section, the common policy of the PGDP and forecast for each power source are described (as used for planning the three scenarios).

(1) Power Demand Forecast

As described in Chapter 3, the power demand forecast for the High Case is applied to the formulation of the PGDP based on discussions with MOEP considering recent GDP (Gross Domestic Product) growth trends.

(2) Policy of Energy

As a major premise of the PDP, it is necessary to develop the PGDP in line with other policies included in energy (for example, stable supply of electricity, power access for all, supply at minimum cost, considerations of affordability, energy security, environmental and social considerations, safety, etc.) that are described in Chapter 2.

(3) Geographical Features and Electric Power

Myanmar has abundant water resources and fossil fuels which have been developed for power generation. Electric power demand is firstly concentrated in the Yangon Region and secondly in Mandalay. As the correlation between geography and electric power is generally close in terms of location of power plants, procurement of fuel and the demand areas, the policies concerning geographical features and electric power in Myanmar are as follows.

1) Common matters

In Myanmar there are four main rivers - Thanlwin, Sittoung, Ayeyarwady and Chindwin (a sub-river of the Ayeyarwady) - which flow from north to south. As these main rivers and their tributaries have large hydropower potential, first priority of power generation has been being given to hydropower development. However, as hydropower development needs large amounts of initial investment and is expected to have impacts to the natural and social environments, careful planning and design needs to be conducted paying special attention to issues such as chronologic power supply and demand balance, appropriate technology of design and construction, adequate cost efficiency, and realistic environmental mitigation measures.

JICA Study Team took into account demand and supply balance, power system planning, power supply ratio (IPPs) of foreign and domestic usage and environmental impacts in a comprehensive manner.

2) North and Northeast (Kachin State and Eastern Shan State)

As the upstream areas of the Ayeyarwady and the Thanlwin Rivers in the north and northeast parts of the country have large hydropower potential, there are several plans for large-scale hydropower projects. However, currently no large power demand corresponding to such large hydropower potential is expected because the areas are remote and far from the major demand center such as Mandalay and Yangon. But these areas are near the boundary with China. Therefore, most of the large scale hydropower projects in these areas have been planned to be constructed by JV/IPPs for power supply export to China. These projects are promoted by MOEP and Chinese companies with no expenditure on the Myanmar side.

These JV/IPPs are being promoted for the main purpose of power export to China. However it will become necessary to revise these development plans from the viewpoint of future power demands and supply balance in these areas. There are many villages without the benefit of electricity in the north and northeast. In addition, cities located in these areas are also a target for potential demand. In the northern middle part of the country, demand in the Mandalay area is large and other nearby cities such as Mytgyinar and Barhmaw also have demands for power.

Since the direct distance from the Ayeyarwady upper stream area (upper north “Putao”) to Mandalay is 700 km, construction of a 230 kV transmission line will be costly.

Ongoing projects already being promoted by JV/IPPs are to be developed based on the progress to date. Priorities of other projects presently planned in this region should be re-evaluated based on necessity of their development in regards to local power demand, etc.

As the middle stream areas along the Ayeyarwady and the Thanlwin Rivers (located in the north middle part of the country) also have large hydropower potential, there are also several plans for hydropower projects with large capacity. They are planned 230kV power systems with the power to be transmitted to Mandalay and Yangon through the national grid. There is clear advantages in power development in this region. Generally, output of HPPs is decreased during the dry season if the HPPs have no reservoir. However, HPPs with large reservoirs can regulate river inflow by water storage during the rainy season. If environmental influences can be mitigated, HPPs with a reservoir would be effective in generating power during the dry season.

In these areas, electrification by hydropower development is promoted. The HPPs supply electric power for cities in the north and middle of the country as well as rural areas. The possibility of supply to the south (Yangon) by long transmission lines is also under consideration.

3) Yangon Area

In the Yangon Area, which is the largest demand center and has around half of the total demand in the country, electric power is supplied from power plants in the northern areas as well as surrounding gas-fired plants. This will continue for the near future. For demand increases in the future, the power supply should be reinforced with development of hydropower in the north and middle areas of the country as well as by gas-fired and coal-fired projects in the Yangon Area and expansion of the overall power system.

However, it would be difficult to construct seaports for unloading LNG and coal from abroad because of insufficient water depth in Yangon, which is located on a river delta. Land acquisition and EIA are also difficult. As a result, it is not easy to construct large-scale TPPs and it is expected to be more appropriate to supply power from new transmission lines along the Indian Ocean coast. Reliability of the power supply will be improved by thermal plants along the Indian Ocean coast coupled with system expansion as described below.

In this area, although it is necessary to consider the possibility of procurement of gas and coal fuel, TPPs are feasible to correspond to rapid demand increases. The priority and start up timing of development should be decided considering detail plans and the situation of coal-fired TPPs in the Indian Ocean.

4) Indian Ocean Coast (Bay of Bengal and Andaman Sea)

Yangon, the largest demand center in the country, is located in this coastal area and presently development of new large-scale SEZs (Special Economic Zone(s)) is planned (Thilawa, Dawei and Kyaukphyu). For a reliable power supply to meet these demands and to electrify the area widely, a high voltage transmission line system along the coast would be ideal. Moreover, when this high voltage transmission line is connected to the south - north expanded line currently planned, power supply to Yangon Area and SEZs will be additionally secured.

Thilawa SEZ is planned to start operation in 2015, with electric power required then. Dawei and Kyaukphyu will have good seaports and more expected economic activity. A basic concept of development of power generation is to construct power plants near the demand areas, namely in SEZs or their adjacent areas in this case.

In Kyaukphyu, the port has been already developed and it is possible to haul coal by large ship. Therefore, coal-fired TPPs can be promoted early and effectively. When the new 500kV transmission line is constructed, a route passing over Arakan Yoma or along the coast to Yangon could be an alternative. In Kyaukphyu, a new GT (50MW) is planned to connect to a 230kV substation. This plan is incorporated in this study.

The Ngayok harbor near Pathein along the Bay of Bengal is a good port due to its sufficient water depth. A company in India has a plan for coal-fired IPP projects near here.

The Dawei region is a good candidate for a seaport with sufficient water depth. For coal-fired plant construction, it is necessary to construct port facilities. Regarding the transmission line route to Yangon, there is Mawlamyaing which is the third largest city in Myanmar; i.e., power demand in the region is expected to increase with the economic growth in the future. The route can be selected along the coast. There is also the possibility of an international transmission line connection to Thailand. In addition, coal fields have been discovered in the north of Dawei.

In Thailand, 70% of power is generated by gas-fired TPPs, with approximately 20% of the gas imported from Myanmar. Therefore, development of coal-fired TPPs and selling electricity to Thailand is expected to be the trade-off of Myanmar's gas export to Thailand. In Thailand, large capacity hydropower, coal-fired and nuclear power plants cannot be promoted because of environmental issues. This situation expected to continue in the future.

On the coast of the Andaman Sea, Kalegauk, located 300km from Yangon, is also good candidate site for ports due to favorable water depth. Power supply from there to Yangon and Mawlamyaing is possible, although investigations for harbor development are necessary in the future.

While electrification is delayed in these coastal areas, there are large nearby cities such as Yangon and Mawlamyaing. Also along the coast of the Bay of Bengal, electrification rates are low. While the national electrification ratio is 26%, it is under 10% in Rakhine State, Ayeyarwady Region and Tanintharyi Region, which are the three least electrified regions in Myanmar. Electrification rates should be increased for raising the living standards. If the high voltage power system can be expanded, the low voltage power and distribution system can also be expanded and the region will be better electrified.

Power generation development along the east-west coastal line is recommended so that national and regional economic development and living standard improvements through rural electrification can be facilitated. For SEZs such as Dawei and Kyaukphyu, large capacity thermal plants can be developed and connected to them by a high voltage power system. This system interconnection can be promoted to supply not only to large demand areas but also to low electrification areas and neighboring countries. By system interconnection with the bulk south-north high voltage line, it will be possible to adjust power flows to the Yangon Area.

5) Border areas

In the boundary states or regions, the electrified area will be increased by system expansion. It is challenging to supply electricity by grid expansion to all households by 2030. Thus it is effective to consider resolving non-electrified villages by developing diesel, small hydropower, biomass, solar, wind and geothermal in off-grid areas.

In the states and regions around the borders (Kachin State, Shan State, Kayah State, Kayin State, Mon State, Tanintharyi Region, Sagaing Region, Chin State and Rakhine State), there will be some areas where no connection to the power system can be expected in the future. Therefore, off grid electrification should be promoted in these areas.

(4) Forecast for each Power Source

1) Hydro

As of December 2013, the total installed capacity of HPPs is 2,780MW (Total 20 power plants). The amount of total power generation in 2012 was 6,536GWh. As rated output capacity reaches 76.9% of the total generating plants, hydropower is the most important power source in Myanmar.

However, there are few large capacity HPPs, with most of them having been commissioned in this decade. HPPs with 100MW or more are only four: Shweli-1 (600MW: operational in 2009), Paunglaung (280MW: operational in 2005), Yeywa (790MW: operational in 2010) and Baluchaung-2 (168 MW: operational in 1960/74). Because Shweli-1 was developed with JV/IPP from China, only 300MW (50% of 600MW) is transmitted to Myanmar.

Output from HPPs varies greatly between the rainy season and the dry season. In the dry season, the actual output is only half of the rated output. About 70% of rated power is generated during rainy season. Paunglaung and Yeywa have been operated in accordance with daily load peaks in both rainy and dry seasons. As all gas and coal TPPs have been operated as base power supplies, this control function plays a significant role in the operation of the national system.

Three HPPs of Nancho (40MW), Baluchaung-3 (52MW) and Upper Paunglaung (140MW) are scheduled to be operational in 2014. Other hydropower projects have been developed by DHPI as well. Development plans by JV/IPPs or IPPs with China have also been implemented with Chinese initiative. These sites are located in Kachin State and Shan State in the border areas with China (the Thanlwin River basin and the Ayeyarwady River basin). Development of rivers contributes to hydropower generation, but there are problems as follows:

a. In Kachin State and Shan State, power demand is negligible around the project site.

b. The eastern parts of Kachin State and Shan State are 500km or more away from the trunk transmission system of Myanmar.

c. Even if power is transmitted to the largest demand area of Yangon, the distance of transmission is 1,000km or more, where considerable power transmission loss and voltage decrease will occur.

d. Development of large rivers has significant environmental impacts on society and nature.

Therefore, the following measures are appropriate for the long term development plan in these regions.

a. Hydropower projects by JV/IPPs in Kachin State and Shan State should be evaluated and prioritized individually by considering the benefits to Myanmar. Regarding the western part of Shan State, it is assumed that the priority is higher because it is more feasible to connect with the national transmission system from here.

b. Regarding the projects planned at the main rivers of the Thanlwin and the Ayeyarwady, development should proceed only after appropriate environmental consideration is performed.

There are many comparatively large-scale hydropower development plans in the Chindwin River basin in Sagaing Region and the Thanlwin River basin in Kayah State besides the ones mentioned above. Development of hydropower projects in these river basins should also be evaluated and prioritized within the context of environmental considerations. As described in Section 7.5.2 (5), “Large Scale hydropower” is defined as any project over the installed capacity of 1,000MW on main rivers, with “Medium and Small scale hydropower” defined as any project less than 1,000MW. Regardless of size, all HPPs need to carefully evaluate their environmental impact as well as their lead time for development.

From the viewpoint of system operation, HPPs with reservoirs which can implement seasonal operations are prioritized. In addition, sites located near the trunk transmission system, not on large rivers and having less environmental impacts are prioritized higher. Considering these aspects, HPPs such as Shweli-2 (520MW: Shan State), Shweli-3 (1,050MW: Shan State), Upper Yeywa (280MW: Shan State) and Middle Paunglaung (100MW: Shan State) are promising for further development.

Moreover, it is preferable to implement rehabilitation of reinforcement of aged plants such as Baluchaung-1, -2, Sedawgyi and Kinda from the aspect of preventive measures for sustainable operations.

Small hydropower projects in both on/off grid contexts should be developed considering economic efficiency and environmental impacts. It will not easy to extend the national transmission and distribution system to all regions by 2030. Therefore, if there are enough potential sites, small HPPs should also be developed in off grid areas such as Kachin State, the eastern part of Shan State, the eastern part of Kayah State, Tanintharyi Region, Chin State and Sagaing Region.

2) Gas

The total installed capacity of gas-fired TPPs is 715MW as of 2013, with a required gas quantity of 230 mmcfd. The installed capacity ratio is 19.8% of the total. But total current output is 366MW, which is half of the installed capacity. There are three reasons for the output decrease. Firstly, the actual gas supply quantity is 163 mmcfd against the required gas quantity. Secondly, the gas heat level is decreased from the planned level. The plan was based on onshore gas fields, but currently almost everything is based on offshore gas fields. Offshore gas includes inactive gas such as nitrogen and carbonic acid (rate: 30%); onshore gas includes little inactive gas. Therefore, the heat level of offshore gas is decreased. Equipment also tends to deteriorate more quickly.

In 2015, the Shwe gas field (operated by a Korean company for exports to China) will be commissioned and start to supply approximately 100 mmcfd for the domestic market. Negotiations to re-purchase the exported gas have already been concluded for the Yadana and Zawtika gas fields. As a result, the amount for domestic supply is increased in Yadana (150 →225 mmcfd) and Zawtika (60→100 mmcfd). In 2015, a total of 490 mmcfd will be supplied to the domestic market. 319 mmcfd, which is 65% of total, will be provided for electric power generation. It will be two times bigger than the current gas supply quantity.

New gas supplies will start after the M-3 gas field commissioning in 2019. The gas supply forecast is shown in Chapter 4. It is assumed that the quantity from the Yadana gas field will decrease starting from around 2020 and the Zawtika gas field from around 2024. New gas field supplies will be expected from around 2022.

In this PGDP, it is assumed that gas thermal power generation will have been implemented by 2030 in accordance with the gas supply condition. As aging TPPs - including four gas plants in Myanmar - decrease their power generation efficiency, rehabilitation or replacement of existing plants with the latest GT or GTCC is also effective. There are plans to introduce GTs of dual fuel (light oil or gas) and GEs (combusted crude oil or crude petroleum).

As for LNG, an import plan has been studied in Myanmar as shown in Section 4.1.4. Although a LNG import plan is not expected to be realized until after 2016-2017 at the earliest, the current situation remains unclear in Myanmar. It will be necessary to supply fuel by oil or LNG until 2022, when new gas fields will be commissioned. In this study, imported oil is used as an alternative fuel because of procurement feasibility. It should be noted that from the aspect of energy security, it is important that procurement of LNG is studied for an updated PGDP in the future.

3) Coal

Currently, the only coal-fired TPP in Myanmar is Tigyit TPP located in Shan State. The rated output is 120MW (60MW × 2 plants and commissioned in 2004). The actual output is only 30MW. However, coal is assumed to be promising for domestic energy electric power generation.

Coal-fields in Myanmar are found in 34 sites throughout six regions as shown in Chapter 4. Coal types include sub-bituminous coals and lignite (brown coals). Heating values are within the range of 3,300 ~ 6,600 kcal/kg, which is not high grade coal. However, it is suitable for the fuel of thermal power generation because of the low inclusion of sulfur. Coal having a higher heating value of 6,000 kcal/kg or more is confirmed in Kalewa, Darthwekyauk and Banchaung. However, coal having a lower heating value of 3,300 kcal/kg is also confirmed at the same site of Kalewa, and it is assumed that the heating value differs in coal seam and quarry only.

Coal price in the domestic market is 60,000 kyat/ton (58 USD/ton by HPGE), which is considerably cheaper compared with imported coal from Indonesia (110 USD/ton, 6,000 kcal/kg). Therefore, on-site power plants are expected to be feasible for development.

IPP developers have already submitted development plans for coal-fired TPPs near Yangon and the Bay of Bengal. These are planned to import coal from Indonesia or Australia.

For the long term PGDP, on-site power plants with domestic coal and IPP plants with imported coal are assumed. Because of low generation costs, coal thermal power is expected for to serve as the base power supply. The base power supply ratio is 40 - 50% of full load in 2013, and it is assumed that this configuration will continue until 2030.

The coal-fired projects with less than 300MW - which are feasible given the current grid size - listed in this report are currently being planned by MOEP and are expected to be developed soon. Although the current size of the grid system is technically inadequate to install large scale coal-fired power plants/USC (Ultra Super Critical) as of now, they could be put into operation in the near future. MOEP should employ the best available technology for coal-fired plants for higher efficiency in accordance with expected grid size increases (i.e., USC can be put into operation in the future) as well as for the technological innovation benefits.

4) Renewable energy

As for photovoltaic, wind and biogas power, MOEP, local government and other ministries have prepared their own development plans. MOI (Ministry of Industry) covers photovoltaic, MOAI covers small hydropower, and MOST (Ministry of Science and Technology) covers biogas. As there are potential sites for geothermal plants, investigations are expected to be executed in the future.

Although there are some proposed projects such as the Minbuu (50MW) solar power project, these are still at the preliminary stage and lack MOUs.

It is preferable to establish a long term renewable energy development targets in the energy and electric power policy. A target for power supply capacity of renewable energy can be set at 10% by 2030 considering examples of energy compositions in other Southeastern Asian countries and the grid operational reliability as described below.

1) In Thailand, the capacity of renewable energy in 2008 was 1,750MW, which was 7.6% of the maximum power (23,074MW) for that year. In Vietnam, the capacity of renewable energy in 2015 will be 1,200MW, which is 8.7% of the maximum power (13,867MW) in 2009 ("Electric Power Industry in Overseas Countries," Japan Electric Power Information Center, INC. (2011)).

In Myanmar, maximum power in 2030 is estimated to be 14,542MW. Because progress in Myanmar in 2030 is expected to be similar to current levels in Thailand and Vietnam, the renewable energy development ratio can be 10% (slightly higher than that in Thailand and Vietnam).

2) According to a study of Japanese electric power companies, the maximum quantity of renewable energy which can be connected to the grid is 15% of the maximum power. The study is based on a sophisticated power system operation. Thus, an appropriate limit for renewable energy capacity in Myanmar is about 10% in order to ensure stable power supply.

The development policy of each scenario by power source for the short, middle and long term is summarized in Table 5.2-10.

Table 5.2-10 Development Policy for Each Scenario by Power Source

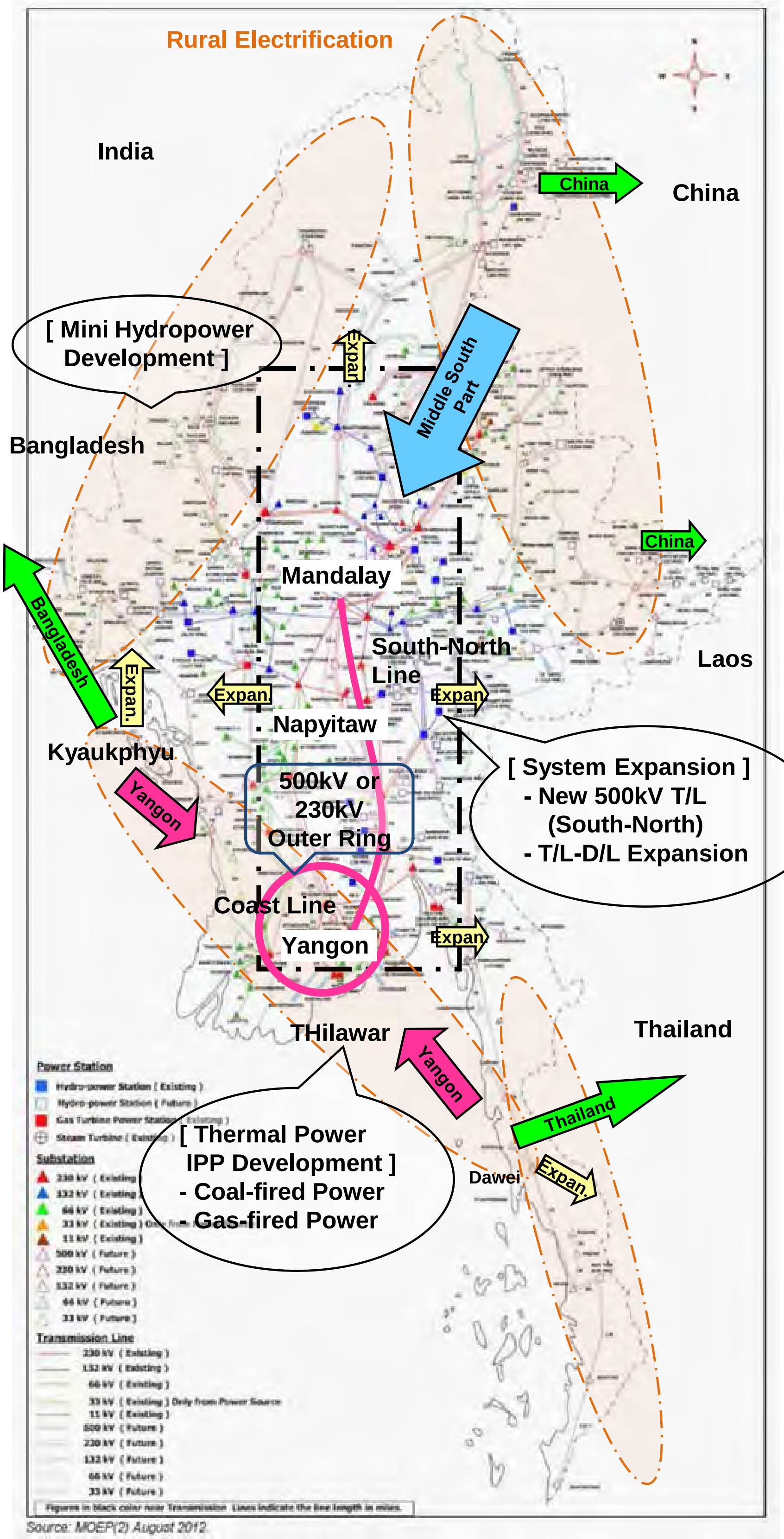
Power Source		2015			2020			2030		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Gas-fired		Development based on MOEP's Plan			Development based on MOEP's Plan			Development of plants based on the gas supply forecast after 2022, commissioning of new gas fields	-	Development of plants based on the gas supply forecast after 2022, commissioning of new gas fields
Hydro-power	Medium and Small Scale (~1,000MW)	Development based on MOEP's Plan			Development based on MOEP's Plan			Development of Large, Medium and Small scale hydropower plants based on MOEP's Plan	Development of Large, Medium and Small scale hydropower plants based on MOEP's Plan	Development of Medium and Small scale hydropower plants based on MOEP's Plan
	Large Scale (1,000MW~)	-			-					-
Coal-fired		-			Development based on MOEP's Plan			Development to compensate the shortage of gas and all hydropower plants	Development to compensate the shortage of all hydropower plants	Development to compensate the shortage of gas and Medium and Small hydropower plants
Renewable Energy		-			Development from 2019			Development to aim at 10% in total power supply in 2030		

S1 : Domestic energy consumption scenario
S2 : Least cost scenario
S3 : Power resources balance scenario

(5) Impact Factors for each Scenario

The following factors will influence power generation development and are evaluated for analysis:

1) Available amount of domestic primary energy (gas and coal).
2) Appropriate generating reserve capacity (ratio).
3) Feasibility of IPPs and date for plant commissioning.
4) Fluctuation of power supply and demand during rainy and dry seasons.

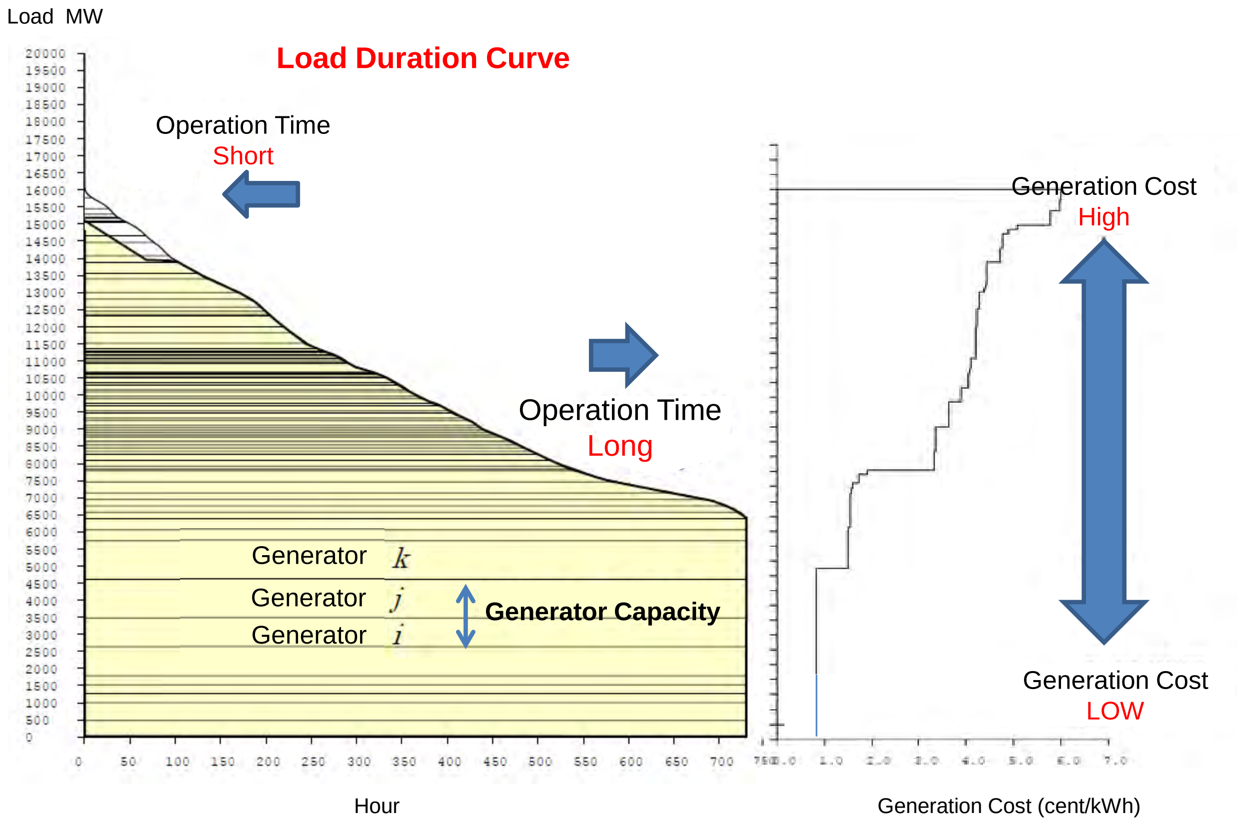


Source: MOEP(2) August 2012

Fig. 5.2-1 Conceptual Map of PGDP

5.2.6 Optimal Power Generation Development Program

The optimal (least cost) power generation development program “WASP (Wien Automatic System Planning)” used in this study was developed by the IAEA (International Atomic Energy Agency) and has used for various countries’ power generation development optimization. Based on the load duration curve, the power generation facilities of lower construction and operation costs are simulated to be operated sequentially (Fig. 5.2-2).

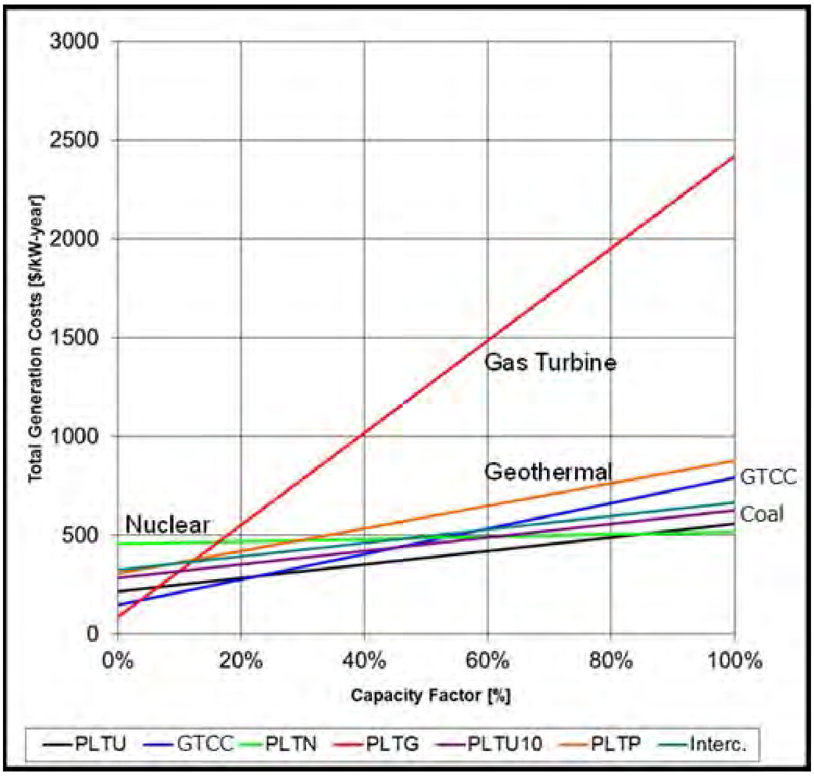


Source: WASP Manual

Fig. 5.2-2 WASP Simulation Concept

Data input for power plants are applied to calculate the generation cost by means of a screening curve (Fig. 5.2-3). In this figure, GT is often used for peak load because of its poor efficiency compared with other power sources.

✔Main input data for power plant:
- Installed capacity (MW)
- Fuel type (coal, lignite, oil, natural gas, GT)
- Heating rate (Kcal/kWh)
- Fuel cost (cents/million kcals)
- Fixed O&M cost (USD/ (kW･month))
- Scheduled maintenance days per years (days)
- Forced outage rate (%)
- Capital cost (USD/kW)



Source: WASP Manual

Fig. 5.2-3 Example of Screening Curve

WASP program's input and execution screen is shown in Fig. 5.2-4. By the simulation process, total generation costs, outage probability, and so forth for each year can be calculated. Optimal power generation development based on the simulation is then verified and proposed.

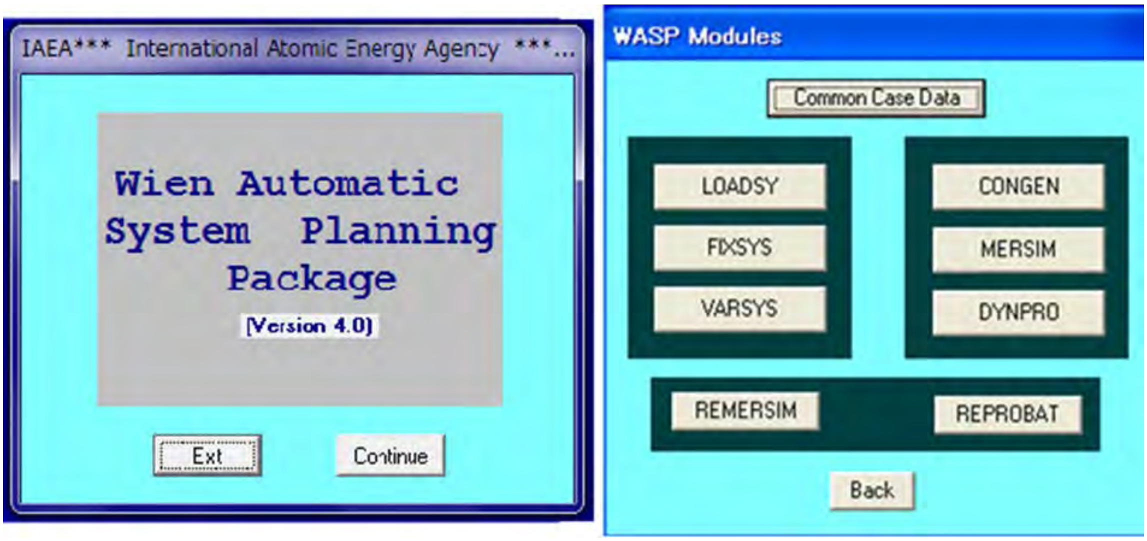


Fig. 5.2-4 WASP Input and Execution Screen

Power generation development analysis was done by using WASP based on the above-mentioned principles and expectations. The main analysis basic plan and conditions for the calculations were prepared as shown below based on discussions with MOEP. The demand forecast is based on the results from Chapter 3.

✔Basic Plan

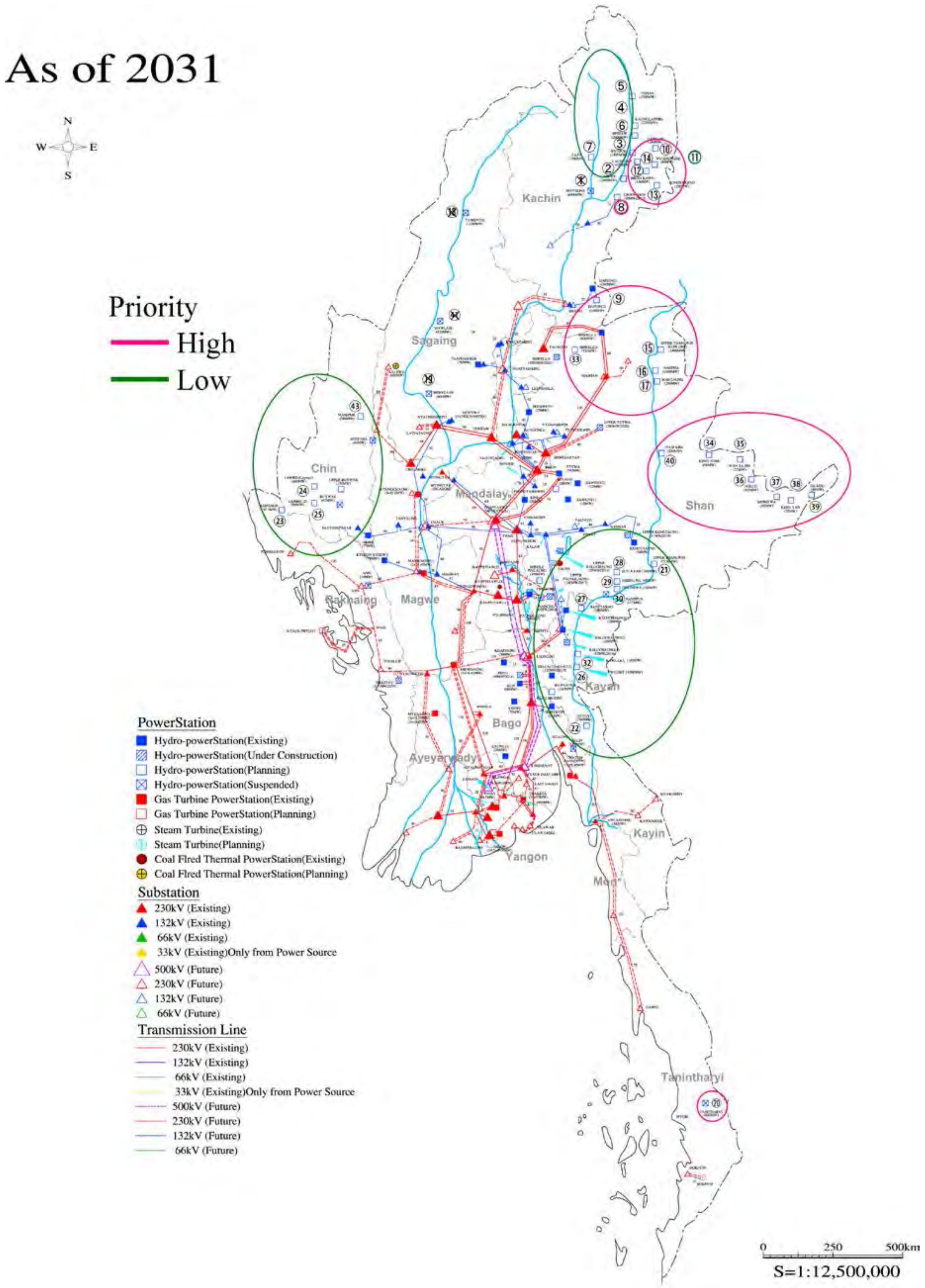
- Demand will reach 14.5GW in 2030 at annual energy increase rate, 13% (kWh basis)
- Actual capacity in dry season, 19GW, should meet the demand counting on 30% reserve margin (kW Basis)
- Existing gas-fired TPPs' power supply is based on the PDP in Myanmar (June 2013)
- Existing coal-fired TPPs' power supply is based on hearing from HPGE of MOEP
- Existing HPP's power supply is based on daily maximum power output data (May 2013)
- Effect of existing gas-fired TPPs' rehabilitation is in 2017
- Effect of existing coal-fired TPPs' rehabilitation is in 2017
- Future gas-fired TPP' candidates were provided due to TPD of MEPE (maximum total installed capacity: 4GW)
- Future coal-fired TPP' candidates were provided by HPGE (maximum total installed capacity for Myanmar: 8GW)
- Future HPP's power supply is 50% of installed capacity as dry season. (The ratio is daily maximum power supply output data (May 2013) /installed capacity)

Basic conditions, including capital costs, were determined based on the evaluation of collected data such as existing projects, reports, interviews with relevant persons from each department and related international publications in the electric power sector.

✔Future power plants

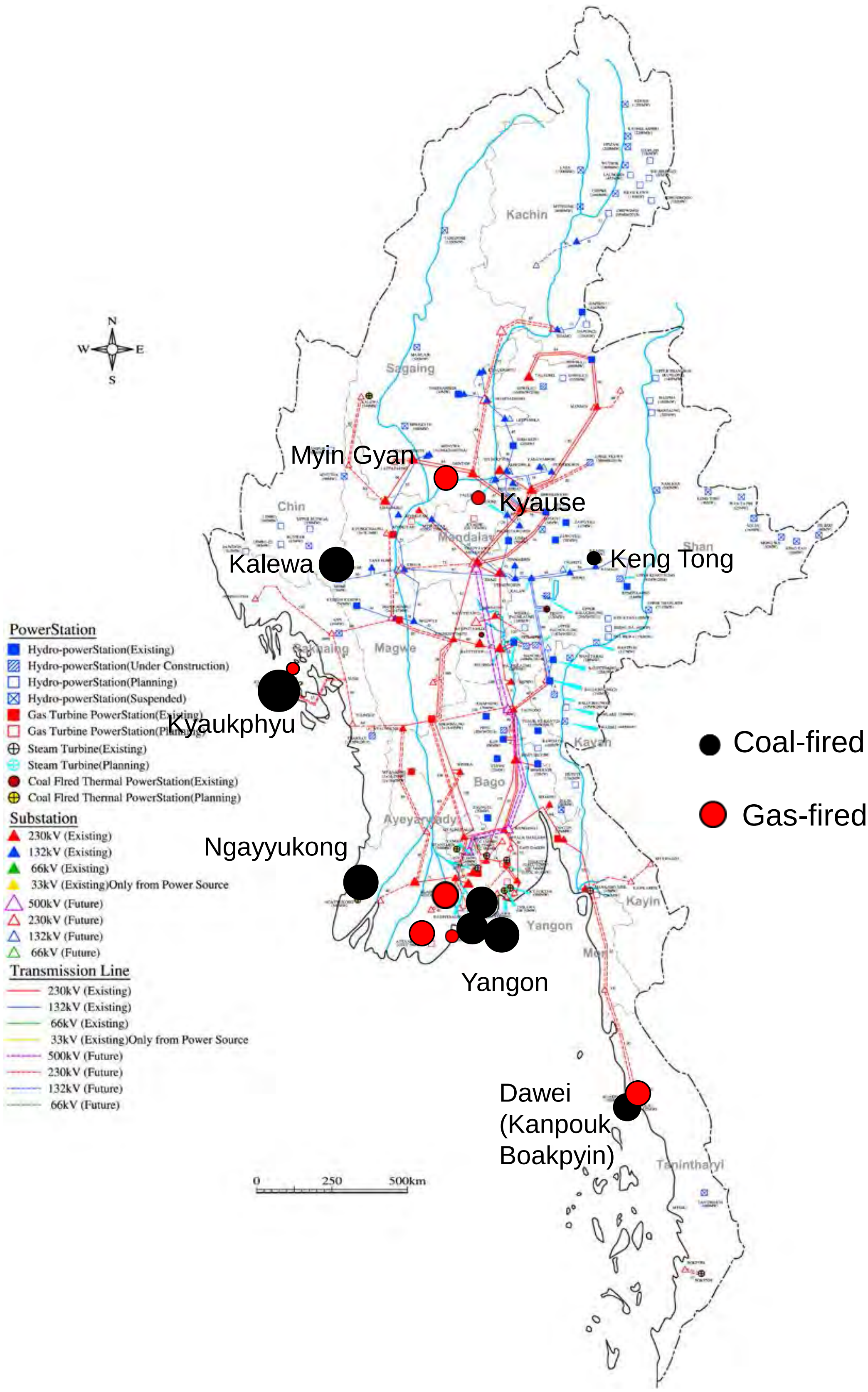
Resource	Capital Cost (USD/kW)	Efficiency (%)	Fuel Cost ($/MMbtu)	O&M COST		Remarks
				Fixed ($/kW-month)	Variable ($/MWh)	
Hydropower	2,000	-	0	0.6	0	- Capacity Factor 50% on average overall hydro p/s record. - Small and medium hydro's capital cost is same as large one, depends on site, scale, compensation and other elements.
Thermal						
Gas-Turbine	1,100	31.1	11.19 (Gas) 18.0 (LNG) 19.4 (HSD)	1.9	2	- Gas fuel cost includes the construction cost for gas pipeline and appurtenant infrastructures. - Capital cost is based on the latest plants in Myanmar. - Efficiency of GT & GC is based on GTW 2013 that of GE is on Hlawga (55MW).
Gas Combined	1,200	50.6		2.3	1	
Gas Engine	890	45.6		1.9	2	
Coal-Fired	1,500 - 2,200	38 - 43	4.26	2.5	2	- Capital cost is based on the past project data including appurtenant infrastructures. - Coal fuel import cost is 110 USD/ton including transportation. - Heating value: 6,500 (kcal/kg) Higher efficiency is available by USC in the future
Renewable Energy						
Photovoltaic (PV)	3,600	-	0	0.6	0	- Capacity Factor 17% (Thailand case) PV cost is refer to IRENA report 2012. - Battery cost of 600 USD/kW is included in Capital Cost for the power system stability.

Location of future candidate HPPs and TPPs are described in Fig. 5.2-5 and Fig. 5.2-6.



Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Fig. 5.2-5 Location of Future HPPs



Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Fig. 5.2-6 Location of Future TPPs

5.3 COMPARISON OF THREE SCENARIOS

5.3.1 Review of Scenario 1: Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)

Based on the basic conditions as shown in the previous Section, the result of the Domestic Energy Consumption Scenario (Scenario 1) - which is oriented in Large Scale Hydro - is described below.

1) Based on the PDP in Myanmar, 'primary' and 'possible' hydro plans are included.

2) Gas-fired TPPs are necessary for short term power supply and are developed up to 4.2GW, which is equivalent to the sum of the listed projects.

3) As the power generation unit price is cheapest, 'primary' and 'possible' HPPs are developed up to 31.0GW.

4) Coal-fired TPPs are developed up to 2.6GW to compensate for insufficient power supply.

Gas-fired TPPs are assumed to be without LNG, as there is the possibility that import of LNG is unclear. In this case, the power supply will be insufficient until 2022.

Table 5.3-1 and Fig. 5.3-1 show the supply plan of 2013 ~ 2030 and power supply transition for each fiscal year. Power supply composition for the Scenario is shown in Fig. 5.3-2 in 2020 and 2030.

Table 5.3-1 Supply Planning of the Domestic Energy Consumption (Large Scale Hydro Oriented)

As of 2030 Year: New Coal 2.6GW, New Hydro 16.8GW, New Gas 4.2GW (Installed capacity for Myanmar)

Item/Plant Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Peak Demand (MW)	2,055	2,248	2,527	2,840	3,192	3,587	4,032	4,531	5,092	5,723	6,431	7,227	8,121	9,125	10,253	11,520	12,944	14,542	
Required Generation Energy (GWh)	12,064	13,560	15,242	17,132	19,256	21,642	24,323	27,336	30,721	34,524	38,797	43,597	48,990	55,048	61,853	69,497	78,083	87,727	699556.8
Existing Plant																			
Combined Cycle	271	271	271	271	481	481	481	481	481	481	481	481	481	481	481	481	481	481	
Gas Turbine	95	95	95	95	93	93	93	93	93	93	93	93	93	93	93	93	93	93	
Coal	60	60	60	60	120	120	120	120	120	120	120	120	120	120	120	120	120	120	
Hydropower	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	
(Existing Sub Total)	1556	1556	1556	1556	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	
Candidate Plant																			
Gas	378	566	782	0	0	0	0	0	0	743	743	167	336	127	386	0	0	0	4228
Coal					570	870	600	600	0	0	0	0	0	0	0	0	0	0	2640
Hydropower (dry : Install ×0.5)	116	85	51	0	42	81	0	88	333	745	365	169	95	896	1521	500	1525	1778	8390
Renewable							100	100	100	100	200	200	200	200	200	200	200	200	2000
(Candidate Sub Total in each year)	494	651	833	0	612	951	700	788	433	1588	1308	536	631	1223	2107	700	1725	1978	17258
Development Plant Total	494	1145	1978	1978	2590	3541	4241	5029	5462	7050	8358	8894	9525	10748	12855	13555	15280	17258	
Total Supply Capacity	2050	2701	3534	3534	4414	5365	6065	6853	7286	8874	10182	10718	11349	12572	14679	15379	17104	19082	
(capacity-peak)	-4.784	453.2	1007.4	694.13	1222.1	1777.5	2033	2321.6	2193.5	3151.1	3750.8	3491.1	3228.2	3447	4425.9	3858.8	4160.5	4539.8	
Reserved Margin (%)	-0.233	20.162	39.872	24.442	38.287	49.548	50.423	51.235	43.073	55.061	58.322	48.307	39.752	37.775	43.167	33.496	32.143	31.218	

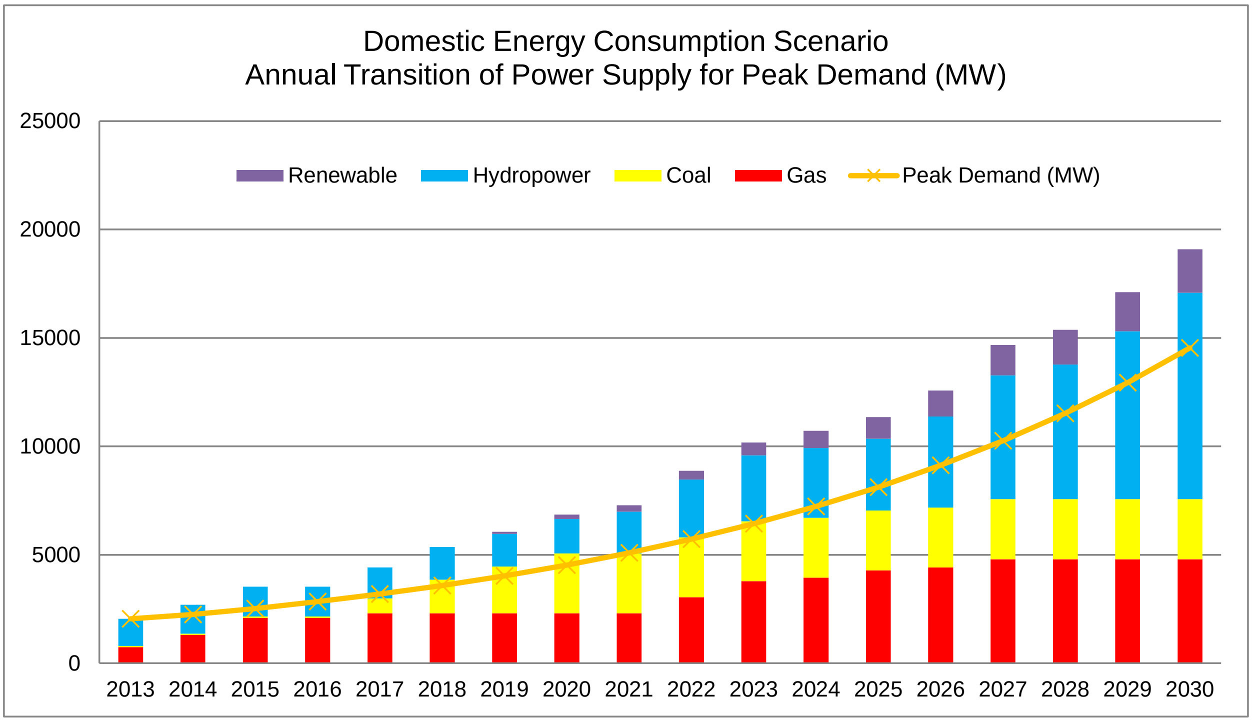


Fig. 5.3-1 Annual Transition of the Power Supply for the Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)

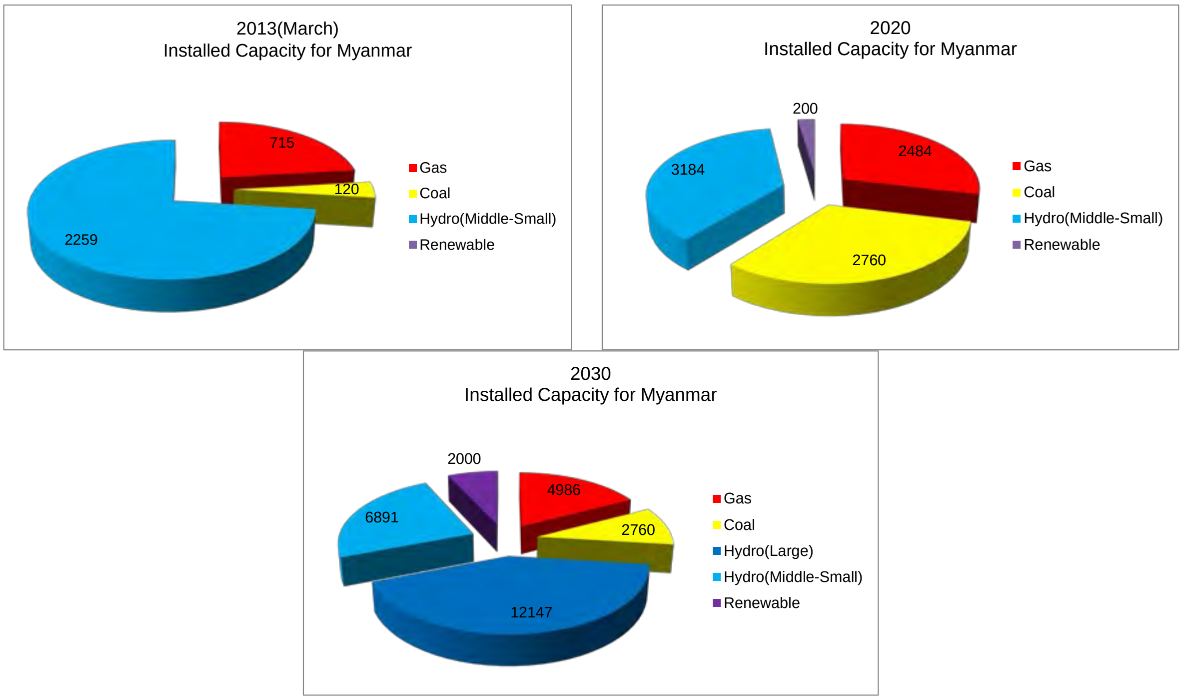


Fig. 5.3-2 Power Supply Composition of the Domestic Energy Consumption Scenario (Large Scale Hydro Oriented) on 2013, 2020 and 2030

Table 5.3-2 Operational Start Plan of New HPPs: Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)

		Installed Capacity (MW)	Proponent	Contraction Condition	COD	Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
A	Phyu Chaung	40.0	MOEP		2014	40.00		40																	
B	Nancho	40.0	MOEP		2014	40.00		40																	
C	Baluhaung-3	52.0	Local/IPP		2014	52.00		52																	
D	Upper Baluchaung	30.4	Local/IPP		2015	30.40			30.4																
E	Upper Paunglaung	140.0	MOEP		2015	140.00			140																
F	Ann	10.0	MOEP																						
G	Thahtay	111.0	MOEP		2019	111.00							111												
H	Upper Keng Tong	51.0	MOEP		2019	51.00							51												
I	Upper Yeywa	280.0	MOEP		2020	280.00											280								
J	Shweli-3	1,050.0	MOEP		2021	1,050.00											1050								
K	Bawgata	160.0	MOEP		2021	160.00									160										
L	Upper Bu	150.0	MOEP		2021	150.00										150									
M	Middle Paunglaung	100.0	MOEP		2021	100.00										100									
N	Belin	280.0	Local/IPP		2021																				
O	Ngotchaung	16.6	Local/IPP		2021	16.60									16.6										
P	Dapain (only supply)	101.0	MOEP		2016					101															
1	Myitsone	6,000.0	JV/IPP	JVA																					
2	Chipwi	3,400.0	JV/IPP	JVA	2021	1,700.00																		1700	
3	Wutsok	1,800.0	JV/IPP	MOA	2026	900.00															900				
4	Kaunglanhpu	2,700.0	JV/IPP	MOA	2026	1,350.00																		1350	
5	Renam (Yenam)	1,200.0	JV/IPP	MOA	2026	600.00															600				
6	Hpizaw (Pisa)	2,000.0	JV/IPP	MOA	2026	1,000.00																	1000		
7	Laza	1,900.0	JV/IPP	JVA	2021	950.00																950			
8	Chipwinge	99.0	JV/IPP	(Prepared to Commercial)	2013	99.00		99																	
9	Dapein - 2	168.0	JV/IPP	MOU	2021	84.00						84													
10	Gawlan	100.0	JV/IPP	MOA	2021	50.00											50								
11	Wu Zhongze	60.0	JV/IPP	MOA	2021	30.00											30								
12	Hkan Kawn	160.0	JV/IPP	MOA	2021	80.00											80								
13	Tongxinqiao	340.0	JV/IPP	MOA	2021	170.00												170							
14	Lawngdin	600.0	JV/IPP	MOA	2021	300.00												300							
15	Upper Thanliwn (Kunlong)	1,400.0	JV/IPP	MOA	2021	700.00																700			
16,17	Naopha, Mantong	1,425.0	JV/IPP	MOU	2026	712.00																712			
18	Tamanthi	1,200.0	JV/IPP	MOU																					
19	Shwezaye	660.0	JV/IPP	MOU																					
20	Taninthayi	600.0	JV/IPP	MOU																					
21	Upper Thanliwn (Mongton)	7,110.0	JV/IPP	MOU	2031	3,555.00																			3555
22	Hutgyi	1,360.0	JV/IPP	MOA	2021	680.00																680			
23	Sinedin	76.5	JV/IPP	MOA	2021	38.25													38.25						
24	Lemro (Laymyo)	600.0	JV/IPP	MOA	2026	300.00													300						
25	Lemro-2 (Laymyo - 2)	90.0	JV/IPP	MOA	2026	45.00										45									
26	Ywathit (Thanlwin)	4,000.0	JV/IPP	MOA	2026	2,000.00																			
27	Nam Tamhpak (Kayah)	180.0	JV/IPP	MOA	2026	90.00										90									
28	Htu Kyan (Tuzxing?)	105.0	JV/IPP	MOA	2031	52.50															52.5				
29	Hseng Na	45.0	JV/IPP	MOA	2031	22.50															22.5				
30	Tha Hkwa	150.0	JV/IPP	MOA	2031	75.00															75				
31	Palaung	105.0	JV/IPP	MOA	2031	52.50															52.5				
32	Bawlake	180.0	JV/IPP	MOA	2031	90.00															90				
33	Shweli-2	520.0	JV/IPP	MOA	2021	260.00												260							
34	Keng Tong	128.0	JV/IPP	MOU	2026	64.00										64									
35	Wan Ta Pin	33.0	JV/IPP	MOU	2026	17.00										17									
36	Solue	160.0	JV/IPP	MOU	2026	80.00										80									
37	Mong Wa	50.0	Local/IPP	MOU	2026	50.00										50									
38	Keng Yang	40.0	JV/IPP	MOU	2026	20.00										20									
39	He Kou	100.0	JV/IPP	MOU	2026	50.00										50									
40	Nam Kha	200.0	JV/IPP	MOU	2026																				
41	Mawlaik	520.0	JV/IPP	MOU																					
42	Nam Tamhpak (Kachin)	200.0	JV/IPP	MOU	2026																				
43	Manipur	380.0	JV/IPP	MOU	2021	190.00														190					
		Sub Total		*44655.5*		*18,677.75*		*231*	*401.4*	*502.4*	*502.4*	*586.4*	*748.4*	*748.4*	*925*	*1591*	*3081*	*3811*	*4149.3*	*4339*	*6131.8*	*9174*	*10174*	*13224*	*16779*
								231	170.4	101	0	84	162	0	176.6	666	1490	730	338.25	190	1792.5	3042	1000	3050	3555

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Table 5.3-3 Operational Start Plan of New TPPs: Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)

			Installed Capacity (MW)		COD	Available Capacity for Myanmar (MW)		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
								2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Gas Turbine	Yeama	GT	240		2014.2	240		240																	
	Kyaukphyu (New)	GT	50		2014.12	50			50																
	Thilawa		50		2016	50				50															
(Sub Total)							Cumulative	240	290	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Combined Cycle	Ahlone	GT	82		2013.6	82		82																	
		ST	39		2014.9	39			39																
	Mawlamyaing	GTCC	98		2015	98			98																
		GTCC	132		2016	132				132															
	Hlawga		243		2014.11	243											243								
			243		2015.5	243												243							
	Thaketa		167		2015.2	167													167						
			336		2016.1	336														336					
			127		2014.12	127															127				
			386		2016.3	386																386			
	Kanpouk (New)		175		2015.3	175			175																
			350		2016.2	350				350															
	Myin Gyan (New)		250		2015.8	250				250															
	Hlaingtharyar (New)		500		2016	500												500							
	Ayeyarwady (New)		500		2021	500											500								
(Sub Total)							Cumulative	82	394	1126	1126	1126	1126	1126	1126	1126	1869	2612	2779	3115	3242	3628	3628	3628	3628
							Each year	82	312	732	0	0	0	0	0	0	743	743	167	336	127	386	0	0	0
Gas Engine	Hlawga	GE	26		2013.5	26		26																	
		GE	28.55		2014.2	28.55		28.55																	
	Ywama	GE	52		Commissioning 2013.7	52		52																	
	Thaketa	GE	53.6		Commissioning 2013.7	53.6		53.6																	
	Kyause (New)		100			100		100																	
	Kyaukpyu (New)		3					3	-3																
(Sub Total)							Cumulative	263.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15
			Sub Total	4228.15			Cumulative	585.15	944.15	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	2469.2	3212.2	3379.2	3715.2	3842.2	4228.2	4228.2	4228.2	4228.2
							Each year	585.15	359	782	0	0	0	0	0	0	743	743	167	336	127	386	0	0	0
Coal-fired	Yangon-Thilawar	Coal	1300		2021	1300																			
		Coal	700		2026	700																			
		Coal	1000		2031	1000																			
	Yangon-Kunchangon	Coal	300		2021	300						300													
		Coal	600		2026	600							600												
		Coal	1200		2031	1200								600	600										
	Yangon-Htantapin	Coal	270		2021	270																			
		Coal	270		2026	270																			
	Ngayukong (Ayeyarwady Div.)	Coal	540		2021	540																			
	Kalewa (Sagaing Div.)	Coal	540		2026	540						270	270												
	Boakpyin (Tanintharyi State)	Coal	500		2021	250	Domestic 50%																		
	Yangon-Kyauktan	Coal	500		2021	500																			
	Keng Tong (Shan State)	Coal	25		2021	25																			
	Kyaukphyu (New Propose)	Coal	500		2021	500																			
		Coal	750		2026	750																			
		Coal	750		2029	750																			
	Dawei-SEZ (Tanintharyi)	Coal	400		2021	400																			
		Coal	3600		2026	1800	Domestic 50%?																		
	Yangon-Htantapin Industrial Zone	Coal	350		2021	350																			
		Coal	700		2026	700																			
	ShwePyi (Tanintharyi)	Coal	8				off-grid																		
	Myeik (Tanintharyi)	Coal	50				off-grid																		
(Sub Total)			Sub Total	14853		12745	cumulative	0	0	0	0	570	1440	2040	2640	2640	2640	2640	2640	2640	2640	2640	2640	2640	2640
							each year					570	870	600	600	0	0	0	0	0	0	0	0	0	0

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

5.3.2 Review of Scenario 2: Least Cost Scenario

In this Section, a review of results for the Least Cost Scenario (Scenario 2) is described. Scenario 2 has the following features.

1) Gas power station plans are substituted by cost effective coal power stations.
2) Development of gas-fired power decreases to 1.7GW against Scenario 1.
3) Development of coal-fired power increases to 4.9GW against Scenario 1.
4) Development of hydropower is 31.0GW, the same as in Scenario 1.

Table 5.3-4 and Fig. 5.3-3 show supply plans for 2013 ~ 2030 and the power supply transition in each fiscal year. The power supply composition of the Scenario is shown in Fig. 5.3-4 in 2020 and 2030.

Table 5.3-4 Supply Planning of the Least Cost Scenario

AS of 2030 Year: New Coal 4.9GW, New Hydro 16.8GW, New Gas 1.7GW (Installed capacity for Myanmar)

Item/Plant Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Peak Demand (MW)	2,055	2,248	2,527	2,840	3,192	3,587	4,032	4,531	5,092	5,723	6,431	7,227	8,121	9,125	10,253	11,520	12,944	14,542	
Required Generation Energy (GWh)	12,064	13,560	15,242	17,132	19,256	21,642	24,323	27,336	30,721	34,524	38,797	43,597	48,990	55,048	61,853	69,497	78,083	87,727	699557
Existing Plant																			
Combined Cycle	271	271	271	271	481	481	481	481	481	481	481	481	481	481	481	481	481	481	
Gas Turbine	95	95	95	95	93	93	93	93	93	93	93	93	93	93	93	93	93	93	
Coal	60	60	60	60	120	120	120	120	120	120	120	120	120	120	120	120	120	120	
Hydropower	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	
(Existing Sub Total)	1556	1556	1556	1556	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	
Candidate Plant																			
Gas	378	566	782	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1726
Coal					570	870	600	600		650	650	0	700	270	0	0	0	0	4910
Hydropower (dry: Install ×0,5)	116	85	51	0	42	81	80	88	333	0	365	309	620	896	1521	500	1525	1778	8390
Renewable							100	100	100	100	200	200	200	200	200	200	200	200	2000
(Candisate Sub Total in each year)	494	651	833	0	612	951	780	788	433	750	1215	509	1520	1366	1721	700	1725	1978	17026
Development Plant Total	494	1145	1978	1978	2590	3541	4321	5109	5542	6292	7507	8016	9536	10902	12623	13323	15048	17026	
Total Supply Capacity	2050	2701	3534	3534	4414	5365	6145	6933	7366	8116	9331	9840	11360	12726	14447	15147	16872	18850	
(capacity-peak)	-4.784	453.2	1007.4	694.13	1222.1	1777.5	2113	2401.6	2273.5	2393.1	2899.8	2613.1	3239.2	3601	4193.9	3626.8	3928.5	4307.8	
Reserved Margin(%)	-0.233	20.162	39.872	24.442	38.287	49.548	52.407	53	44.644	41.816	45.089	36.158	39.887	39.462	40.904	31.482	30.351	29.623	

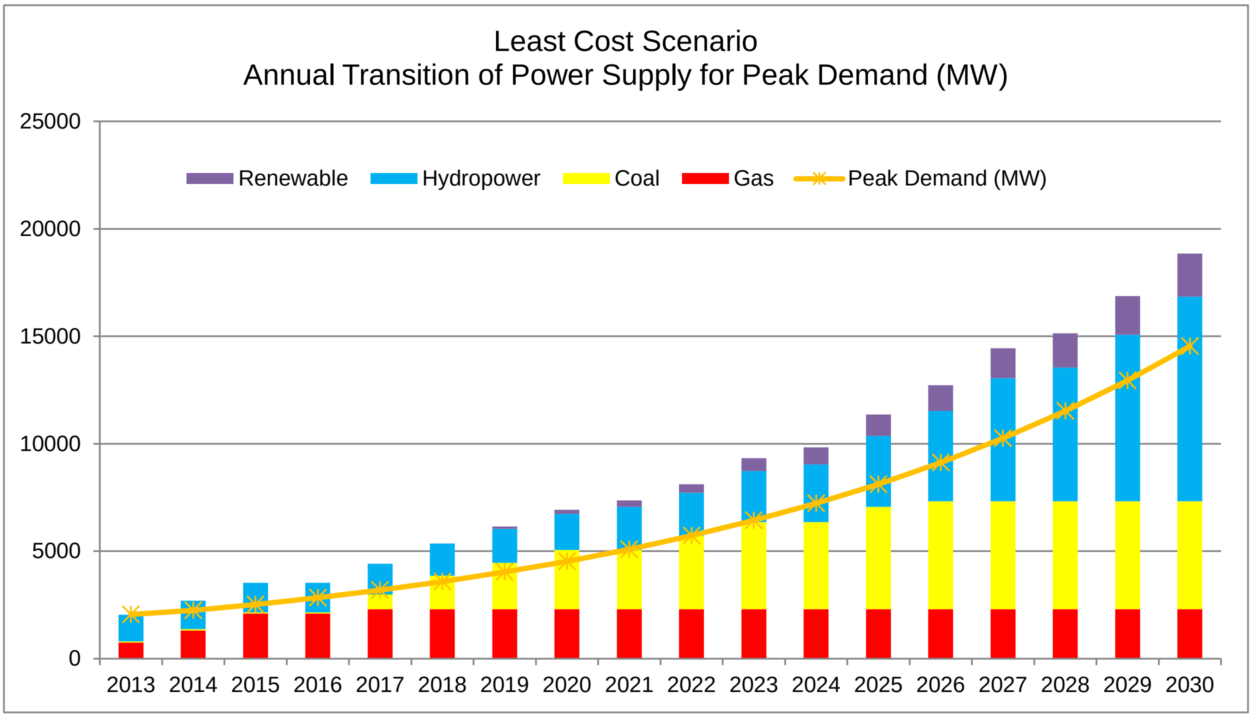


Fig. 5.3-3 Annual Transition of the Power Supply for the Least Cost Scenario

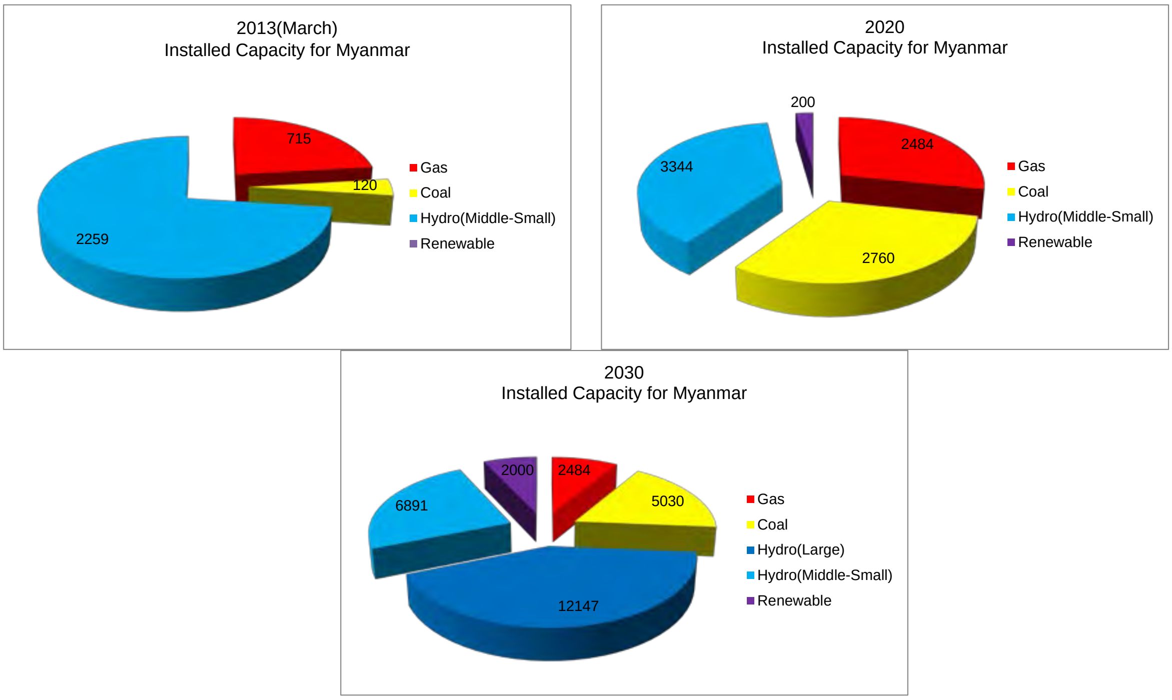


Fig. 5.3-4 Power Supply Composition of the Least Cost Scenario on 2013, 2020, 2030

Table 5.3-5 Operational Start Plan of New HPPs: Least Cost Scenario

		Installed Capacity (MW)	Proponent	Contraction Condition	COD	Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
A	Phyu Chaung	40.0	MOEP		2014	40.00		40																	
B	Nancho	40.0	MOEP		2014	40.00		40																	
C	Baluhaung-3	52.0	Local/IPP		2014	52.00		52																	
D	Upper Baluchaung	30.4	Local/IPP		2015	30.40			30.4																
E	Upper Paunglaung	140.0	MOEP		2015	140.00			140																
F	Ann	10.0	MOEP																						
G	Thahtay	111.0	MOEP		2019	111.00							111												
H	Upper Keng Tong	51.0	MOEP		2019	51.00							51												
I	Upper Yeywa	280.0	MOEP		2020	280.00													280						
J	Shweli-3	1,050.0	MOEP		2021	1,050.00														1050					
K	Bawgata	160.0	MOEP		2021	160.00									160										
L	Upper Bu	150.0	MOEP		2021	150.00										150									
M	Middle Paunglaung	100.0	MOEP		2021	100.00										100									
N	Belin	280.0	Local/IPP		2021																				
O	Ngotchaung	16.6	Local/IPP		2021	16.60									16.6										
P	Dapain (only supply)	101.0	MOEP		2016					101															
1	Myitsone	6,000.0	JV/IPP	JVA																					
2	Chipwi	3,400.0	JV/IPP	JVA	2021	1,700.00																		1700	
3	Wutsok	1,800.0	JV/IPP	MOA	2026	900.00															900				
4	Kaunglanhpu	2,700.0	JV/IPP	MOA	2026	1,350.00																		1350	
5	Renam (Yenam)	1,200.0	JV/IPP	MOA	2026	600.00															600				
6	Hpizaw (Pisa)	2,000.0	JV/IPP	MOA	2026	1,000.00																	1000		
7	Laza	1,900.0	JV/IPP	JVA	2021	950.00																950			
8	Chipwinge	99.0	JV/IPP	(Prepared to Commercial)	2013	99.00		99																	
9	Dapein-2	168.0	JV/IPP	MOU	2021	84.00						84													
10	Gawlan	100.0	JV/IPP	MOA	2021	50.00								50											
11	Wu Zhongze	60.0	JV/IPP	MOA	2021	30.00								30											
12	Hkan Kawn	160.0	JV/IPP	MOA	2021	80.00								80											
13	Tongxingqiao	340.0	JV/IPP	MOA	2021	170.00												170							
14	Lawngdin	600.0	JV/IPP	MOA	2021	300.00												300							
15	Upper Thanliwn (Kunlong)	1,400.0	JV/IPP	MOA	2021	700.00																700			
16,17	Naopha, Mantong	1,425.0	JV/IPP	MOU	2026	712.00																712			
18	Tamanthi	1,200.0	JV/IPP	MOU																					
19	Shwezaye	660.0	JV/IPP	MOU																					
20	Taninthayi	600.0	JV/IPP	MOU																					
21	Upper Thanliwn (Mongton)	7,110.0	JV/IPP	MOU	2031	3,555.00																			3555
22	Hutgyi	1,360.0	JV/IPP	MOA	2021	680.00																680			
23	Sinedin	76.5	JV/IPP	MOA	2021	38.25													38.25						
24	Lemro (Laymyo)	600.0	JV/IPP	MOA	2026	300.00													300						
25	Lemro-2 (Laymyo - 2)	90.0	JV/IPP	MOA	2026	45.00										45									
26	Ywathit (Thanlwin)	4,000.0	JV/IPP	MOA	2026	2,000.00																			
27	Nam Tamhpak (Kayah)	180.0	JV/IPP	MOA	2026	90.00										90									
28	Htu Kyan (Tuzxing?)	105.0	JV/IPP	MOA	2031	52.50															52.5				
29	Hseng Na	45.0	JV/IPP	MOA	2031	22.50															22.5				
30	Tha Hkwa	150.0	JV/IPP	MOA	2031	75.00															75				
31	Palaung	105.0	JV/IPP	MOA	2031	52.50															52.5				
32	Bawlake	180.0	JV/IPP	MOA	2031	90.00															90				
33	Shweli-2	520.0	JV/IPP	MOA	2021	260.00												260							
34	Keng Tong	128.0	JV/IPP	MOU	2026	64.00										64									
35	Wan Ta Pin	33.0	JV/IPP	MOU	2026	17.00										17									
36	So Lue	160.0	JV/IPP	MOU	2026	80.00										80									
37	Mong Wa	50.0	Local/IPP	MOU	2026	50.00										50									
38	Keng Yang	40.0	JV/IPP	MOU	2026	20.00										20									
39	He Kou	100.0	JV/IPP	MOU	2026	50.00										50									
40	Nam Kha	200.0	JV/IPP	MOU	2026																				
41	Mawlike	520.0	JV/IPP	MOU																					
42	Nam Tamhpak (Kachin)	200.0	JV/IPP	MOU	2026																				
43	Manipur	380.0	JV/IPP	MOU	2021	190.00														190					
		Sub Total		44655.5		18,677.75		231	401.4	502.4	502.4	586.4	748.4	908.4	1085	1751	1751	2481	3099.3	4339	6131.8	9174	10174	13224	16779
								231	170.4	101	0	84	162	160	176.6	666	0	730	618.25	1240	1792.5	3042	1000	3050	3555

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Table 5.3-6 Operational Start Plan of New TPPs: Least Cost Scenario

			Installed Capacity (MW)		COD	Available Capacity for Myanmar(MW)		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
								2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Gas Turbine	Yeama	GT	240		2014.2	240		240																	
	Kyaukphyu (New)	GT	50		2014.12	50			50																
	Thilawa	GT	50		2016	50				50															
(Sub Total)							Cumulative	240	290	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Combined Cycle	Ahlone	GT	82		2013.6	82		82																	
		ST	39		2014.9	39			39																
	Mawlamyaing	GTCC	98		2015	98			98																
		GTCC	132		2016	132				132															
	Hlawga		243		2014.11	243																			
			243		2015.5	243																			
	Thaketa		167		2015.2	167																			
			336		2016.1	336																			
			127		2014.12	127																			
			386		2016.3	386																			
	Kanpouk (New)		175		2015.3	175			175																
			350		2016.2	350				350															
	Myin Gyan (New)		250		2015.8	250				250															
	Hlaingtharyar (New)		500		2016	500																			
	Ayeyarwady (New)		500		2021	500																			
(Sub Total)							Cumulative	82	394	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126	1126
							Each year		312	732	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas Engine	Hlawga	GE	26		2013.5	26		26																	
		GE	28.55		2014.2	28.55		28.55																	
	Ywama	GE	52		Commissioning 2013.7	52		52																	
	Thaketa	GE	53.6		Commissioning 2013.7	53.6		53.6																	
	Kyause (New)		100			100		100																	
	Kyaukpyu (New)		3					3	-3																
(Sub Total)							Cumulative	263.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15
			Sub Total	4228.15			Cumulative	585.15	944.15	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2
							Each year	585.15	359	782	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal-fired	Yangon-Thilawa	Coal	1300		2021	1300											650	650							
		Coal	700		2026	700														700					
		Coal	1000		2031	1000																			
	Yangon-Kunchangon	Coal	300		2021	300						300													
		Coal	600		2026	600							600												
		Coal	1200		2031	1200								600	600										
	Yangon-Htantapin	Coal	270		2021	270															270				
		Coal	270		2026	270																			
	Ngayyukong (Ayeyarwady Div.)	Coal	540		2021	540																			
	Kalewa (Sagaing Div.)	Coal	540		2026	540						270	270												
	Boakpyin (Tanintharyi State)	Coal	500		2021	250	Domestic 50%																		
	Yangon-Kyauktan	Coal	500		2021	500																			
	Keng Tong (Shan State)	Coal	25		2021	25																			
	Kyaukphyu (New Propose)	Coal	500		2021	500																			
		Coal	750		2026	750																			
		Coal	750		2029	750																			
	Dawei-SEZ (Tanintharyi)	Coal	400		2021	400																			
		Coal	3600		2026	1800	Domestic 50%?																		
	Yangon-Htantapin Industrial Zone	Coal	350		2021	350																			
		Coal	700		2026	700																			
	ShwePyi (Tanintharyi)	Coal	8				off-grid																		
	Myeik (Tanintaryi)	Coal	50				off-grid																		
			Sub Total	14853		12745	cumulative					570	1440	2040	2640	2640	3290	3940	3940	4640	4910	4910	4910	4910	4910
							each year					570	870	600	600	0	650	650	0	700	270	0	0	0	0

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

5.3.3 Review of Scenario 3: Power Resources Balance Scenario

In this Section, results for the Power Resources Balance Scenario (Scenario 3) are described below.

1) Gas-fired TPPs are necessary for short term power supply and are developed up to 4.2GW which is equivalent to the sum of the listed projects.
2) As the power generation unit price is the cheapest, feasible HPPs are developed up to 10.0GW while considering the environmental impacts.
3) Coal-fired TPPs are developed up to 7.6GW as compensation for insufficient power supply.
4) It is effective to balance power resources in terms of energy security.

Table 5.3-7 and Fig. 5.3-5 show the supply plan 2013 ~ 2030 and power supply transition for each fiscal year. The power supply composition for the Scenario is shown in Fig. 5.3-6 for 2020 and 2030.

Table 5.3-7 Supply Planning of the Power Resources Balance Scenario

As of 2003 Year: New Coal 7.6GW, New Hydro 6.6GW, New Gas 4.2GW (Installed capacity for Myanmar)

Item/Plant Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Peak Demand (MW)	2,055	2,248	2,527	2,840	3,192	3,587	4,032	4,531	5,092	5,723	6,431	7,227	8,121	9,125	10,253	11,520	12,944	14,542	
Required Generation Energy (GWh)	12,064	13,560	15,242	17,132	19,256	21,642	24,323	27,336	30,721	34,524	38,797	43,597	48,990	55,048	61,853	69,497	78,083	87,727	699557
Existing Plant																			
Combined Cycle	271	271	271	271	481	481	481	481	481	481	481	481	481	481	481	481	481	481	
Gas Turbine	95	95	95	95	93	93	93	93	93	93	93	93	93	93	93	93	93	93	
Coal	60	60	60	60	120	120	120	120	120	120	120	120	120	120	120	120	120	120	
Hydropower	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	
(Existing Sub Total)	1556	1556	1556	1556	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	
Candidate Plant																			
Gas	378	566	782	0	0	0	0			743	743	167	336	127	386	0	0	0	4228
Coal					570	870	600	600	0	0	0	650	650	810	275	700	1000	870	7595
Hydropower (dry : Install × 0,5)	116	110	66	0	26	83	0	53	356	557	75	210	0	206	706	235	0	483	3282
Renewable							100	100	100	100	200	200	200	200	200	200	200	200	2000
(Candisate Sub Total in each year)	494	676	848	0	596	953	700	753	456	1400	1018	1227	1186	1343	1567	1135	1200	1553	17105
Development Plant Total	494	1170	2018	2018	2614	3567	4267	5020	5476	6876	7894	9121	10307	11650	13217	14352	15552	17105	
Total Supply Capacity	2050	2726	3574	3574	4438	5391	6091	6844	7300	8700	9718	10945	12131	13474	15041	16176	17376	18929	
(capacity-peak)	-4.784	478.2	1047.4	734.13	1246.1	1803.5	2059	2312.6	2207.5	2977.1	3286.8	3718.1	4010.2	4349	4787.9	4655.8	4432.5	4386.8	
Reserved Margin(%)	-0.233	21.274	41.456	25.851	39.039	50.273	51.068	51.036	43.348	52.02	51.107	51.448	49.381	47.66	46.697	40.414	34.245	30.166	

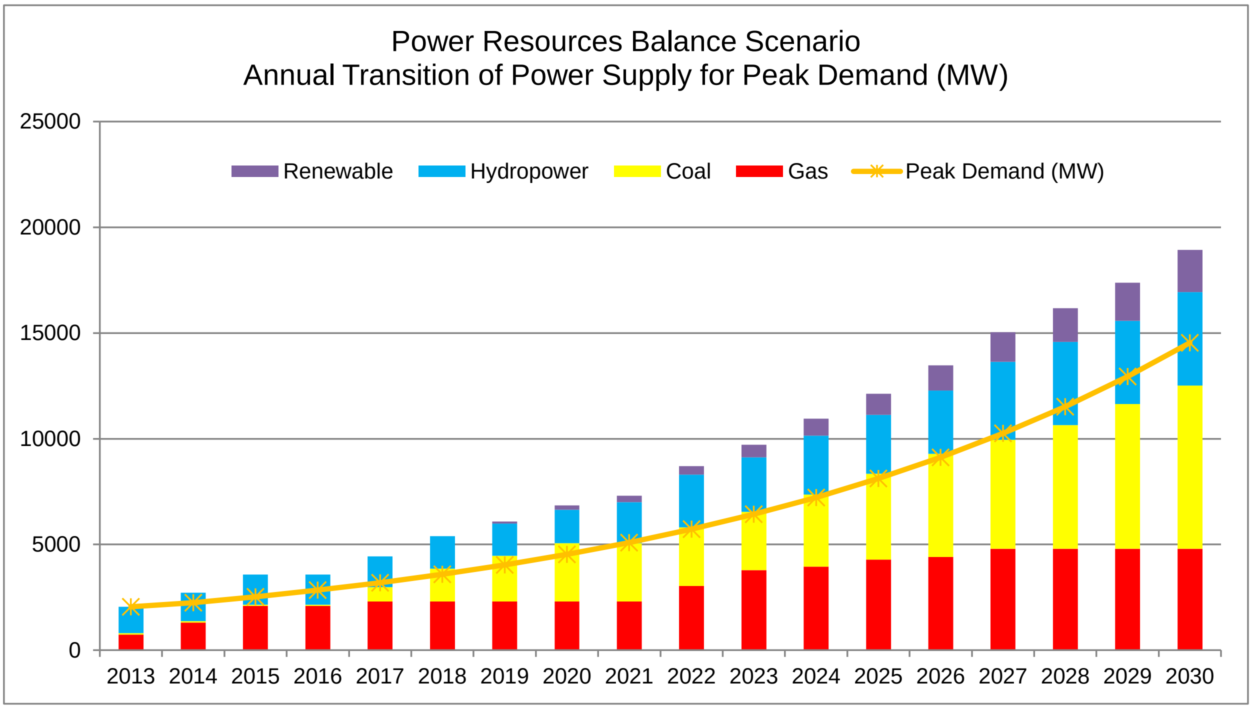


Fig. 5.3-5 Annual Transition of the Power Supply for the Power Resources Balance Scenario

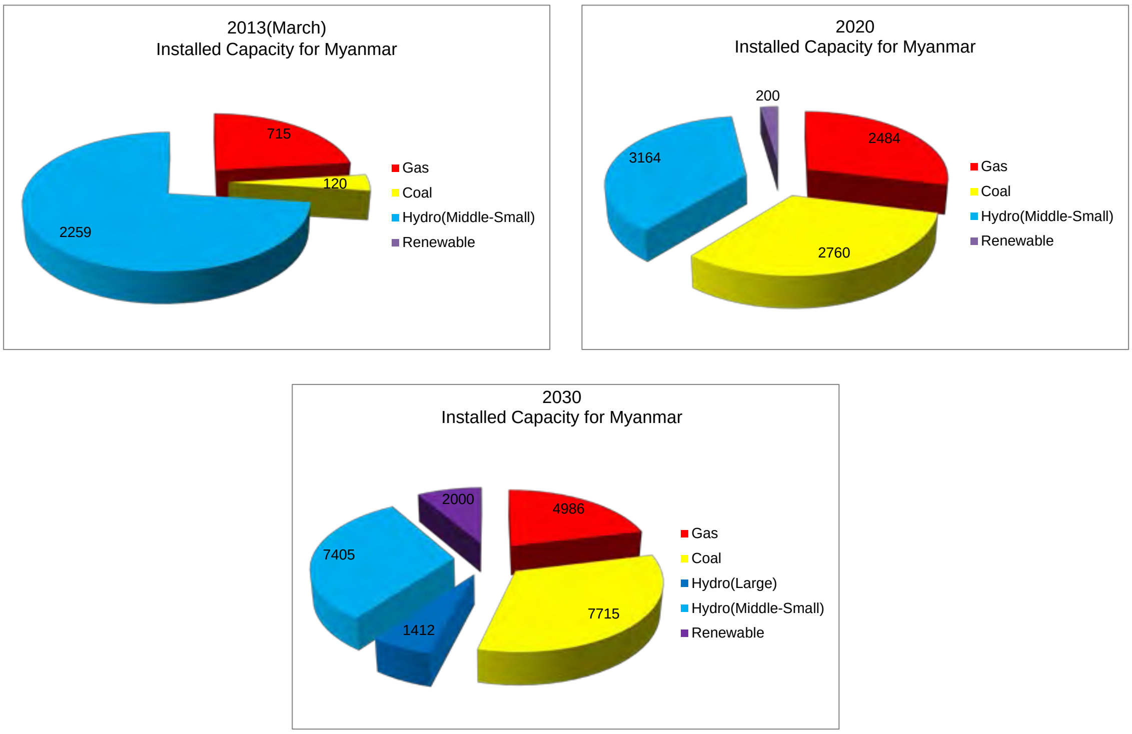


Fig. 5.3-6 Power Supply Composition of the Power Resources Balance Scenario on 2013, 2020 and 2030

Table 5.3-8 Operational Start Plan of New HPPs: Power Resources Balance Scenario

Project		Installed Capacity (MW)	Proponent	Contraction Condition	COD by MOEP Plan	Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remark
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
A	Phyu Chaung	40	MOEP		2013-14	40		40																		
B	Nancho	40	MOEP		2013-14	40		40																		
C	Baluhaung - 3	52	Local/IPP		2013-14	52		52																		
D	Upper	30.4	Local/IPP		2015-16	30.4				30.4																
E	Upper	140	MOEP		2014-15	140			140																	
F	Ann	10	MOEP		-	-																				
G	Thahtay	111	MOEP		2018-19	111										111										Power supply adjustment
H	Upper Keng Tong	51	MOEP		2017-18	51						51														
I	Upper Yeywa	280	MOEP		2018-19	280										280										Power supply adjustment
J	Shweli-3	1050	MOEP		2019-20	1050											1050									Power supply adjustment
K	Bawgata	160	MOEP		2021-22	160													160							Power supply adjustment
L	Upper Bu	150	MOEP		～2020-21	150												150								Power supply adjustment
M	Middle	100	MOEP		2018-19	100							100													
N	Belin	280	Local/IPP		～2021	-																				
O	Ngotchaung	16.6	Local/IPP		2017-18	16.6									16.6											Power supply adjustment
P	Dapain (only supply)	101	MOEP		2015-16	101				101																
Q	Projects	79	MOAI		2014-15	79			79																	
R	Dee Doke	66	Local/IPP		2018-19	66							66													
S	Keng Kham	6	MOAI		～2020-21	6									6											
T	Middle Yeywa	320	MOAI		2021-22	320										320										
U	Upper Sedawgyi	64	Local/IPP		2022-23	64											64									
1	Myitsone	6000	JV/IPP	JVA	-	-																				
2	Chipwi	3400	JV/IPP	JVA	～2021	-																				
3	Wutsok	1800	JV/IPP	MOA	～2026	-																				
4	Kaunglanhpu	2700	JV/IPP	MOA	～2026	-																				
5	Renam (Yenam)	1200	JV/IPP	MOA	～2026	-																				
6	Hpizaw (Pisa)	2000	JV/IPP	MOA	～2026	-																				
7	Laza	1900	JV/IPP	JVA	～2021	-																				
8	Chipwinge	99	JV/IPP	(Prepared to Commercial)	2013-14	99		99																		
9	Dapein-2	168	JV/IPP	MOU	2021-22	84									84											Lead time adjustment
10	Gawlan	100	JV/IPP	MOA	2026～	50															50					
11	Wu Zhongze	60	JV/IPP	MOA	～2021	-																				
12	Hkan Kawn	160	JV/IPP	MOA	2026～	80															80					
13	Tongxinqiao	340	JV/IPP	MOA	2026～	170																	170			
14	Lawngdin	600	JV/IPP	MOA	2026～	300																	300			
15	Upper Thanliwn (Kunlong)	1400	JV/IPP	MOA	2021-22	700																700				Lead time adjustment
16,17	Naopha, Mantong	1425	JV/IPP	MOU	2021-22	712																712				Lead time adjustment
18	Tamanthi	1200	JV/IPP	MOU	-	-																				
19	Shwezaye	660	JV/IPP	MOU	-	-																				
20	Tanintharyi	600	JV/IPP	MOU	2021-22	300																			300	Suspended information
21	Upper Thanliwn (Mongton)	7110	JV/IPP	MOU	～2031	-																				
22	Hutgyi	1360	JV/IPP	MOA	～2021	-																				
23	Sinedin	76.5	JV/IPP	MOA	～2021	-																				
24	Lemro (Laymyo)	600	JV/IPP	MOA	～2026	-																				
25	Lemro-2 (Laymyo - 2)	90	JV/IPP	MOA	～2026	-																				
26	Ywathit (Thanlwin)	4000	JV/IPP	MOA	～2026	-																				
27	Nam Tamhpak (Kayah)	180	JV/IPP	MOA	～2026	-																				
28	Htu Kyan (Tuzxing ?)	105	JV/IPP	MOA	～2031	-																				
29	Hseng Na	45	JV/IPP	MOA	～2031	-																				
30	Tha Hkwa	150	JV/IPP	MOA	～2031	-																				
31	Palaung	105	JV/IPP	MOA	～2031	-																				
32	Bawlake	180	JV/IPP	MOA	～2031	-																				
33	Shweli-2	520	JV/IPP	MOA	2022-23	260													260							Lead time adjustment
34	Keng Tong	128	JV/IPP	MOU	2026～	64															64					
35	Wan Ta Pin	33	JV/IPP	MOU	2026～	17															17					
36	So Lue	160	JV/IPP	MOU	2026～	80															80					
37	Mong Wa	50	Local/IPP	MOU	2016-17	50															50					Far from center
38	Keng Yang	40	JV/IPP	MOU	2026～	20															20					
39	He Kou	100	JV/IPP	MOU	2026～	50															50					
40	Nam Kha	200	JV/IPP	MOU	2026～	100																			100	Suspended information
41	Mawlike	520	JV/IPP	MOU	-	-																				
42	Nam Tamhpak (Kachin)	200	JV/IPP	MOU	2026～	100																			100	Suspended information
43	Manipur	380	JV/IPP	MOU	2021～	-																				
44	Namtu	200	JV/IPP	-	2026～	100																			100	
45	Mong Young	90	JV/IPP	-	2026～	45																			45	
46	Dun Ban	260	JV/IPP	-	2026～	130																			130	
47	Nam Li	330	JV/IPP	-	2026～	165																			165	
48	Nam Khot	50	JV/IPP	-	2026～	25																			25	
		Sub Total		46120.5		6558	0	231	450	581.4	581.4	632.4	798.4	798.4	905	1616	2730	2880	3300	3300	3711	5123	5593	5593	6558	
								231	219	131.4	0	51	166	0	106.6	711	1114	150	420	0	411	1412	470	0	965	

Note:This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Table 5.3-9 Operational Start Plan of New TPPs: Power Resources Balance Scenario

Project			Installed Capacity (MW)		COD	Available Capacity for Myanmar (MW)		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
								2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Gas Turbine	Yeama	GT	240		2014.2	240		240																	
	Kyaukphyu (New)	GT	50		2014.12	50			50																
	Thilawa		50		2016	50				50															
(Sub Total)							Cumulative	240	290	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Combined Cycle	Ahlone	GT	82		2013.6	82		82																	
		ST	39		2014.9	39			39																
	Mawlamyaing	GTCC	98		2015	98			98																
		GTCC	132		2016	132				132															
	Hlawga		243		2014.11	243											243								
			243		2015.5	243												243							
	Thaketa		167		2015.2	167													167						
			336		2016.1	336														336					
			127		2014.12	127															127				
			386		2016.3	386																386			
	Kanpouk (New)		175		2015.3	175			175																
			350		2016.2	350				350															
	Myin Gyan (New)		250		2015.8	250				250															
	Hlaingtharyar (New)		500		2016	500												500							
	Ayeyarwady (New)		500		2021	500											500								
(Sub Total)							Cumulative	82	394	1126	1126	1126	1126	1126	1126	1126	1869	2612	2779	3115	3242	3628	3628	3628	3628
							Each year		312	732	0	0	0	0	0	0	743	743	167	336	127	386	0	0	0
Gas Engine	Hlawga	GE	26		2013.5	26		26																	
		GE	28.55		2014.2	28.55		28.55																	
	Ywama	GE	52		Commissioning 2013.7	52		52																	
	Thaketa	GE	53.6		Commissioning 2013.7	53.6		53.6																	
	Kyause (New)		100			100		100																	
	Kyaukpyu (New)		3					3	-3																
(Sub Total)							Cumulative	263.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15	260.15
			Sub Total	4228.15			Cumulative	585.15	944.15	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	1726.2	2469.2	3212.2	3379.2	3715.2	3842.2	4228.2	4228.2	4228.2	4228.2
							Each year	585.15	359	782	0	0	0	0	0	0	743	743	167	336	127	386	0	0	0
Coal-fired	Yangon-Thilawar	Coal	1300		2021	1300													650	650					
		Coal	700		2026	700																	700		
		Coal	1000		2031	1000																		1000	
	Yangon-Kunchangon	Coal	300		2016	300						300													
		Coal	600		2018	600							600												
		Coal	1200		2020	1200								600	600										
	Yangon-Htantapin	Coal	270		2021	270															270				
		Coal	270		2026	270																			270
	Ngayukong (Ayeyarwady Div.)	Coal	540		2021	540															540				
	Kalewa (Sagaing Div.)	Coal	540		2026	540						270	270												
	Boakpyin (Tanintharyi State)	Coal	500		2021	250	Domestic 50%															250			
	Yangon-Kyauktan	Coal	500		2021	500																			
	Keng Tong(Shan State)	Coal	25		2021	25																25			
	Kyaukphyu (New Propose)	Coal	600		2021	600																			600
	Dawei-SEZ (Tanintharyi)	Coal	400		2021	400																			
		Coal	3600		2026	1800	Domestic 50%?																		
	Yangon-Htantapin Industrial Zone	Coal	350		2021	350																			
		Coal	700		2026	700																			
	ShwePyi (Tanintharyi)	Coal	8				off-grid																		
	Myeik (Tanintharyi)	Coal	50				off-grid																		
			Sub Total	13453		11345	cumulative			0	0	570	1440	2040	2640	2640	2640	2640	3290	3940	4750	5025	5725	6725	7595
							each year			0	0	570	870	600	600	0	0	0	650	650	810	275	700	1000	870

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

(1) Flowchart of the PDGP in Scenario 3

The flowchart of the PGDP for Scenario 3 is shown in Fig. 5.3-7.

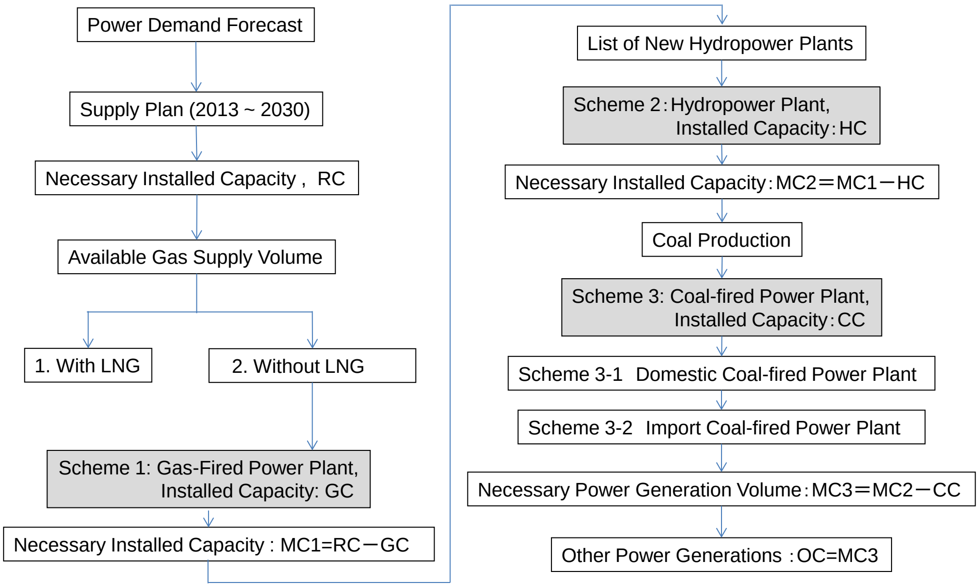


Fig. 5.3-7 Flow of PGDP: Scenario 3

The difference between the MOEP plan and Scenario 3 is shown in Fig. 5.3-8. The MOEP plan is explained precisely in Section 5.1.3.

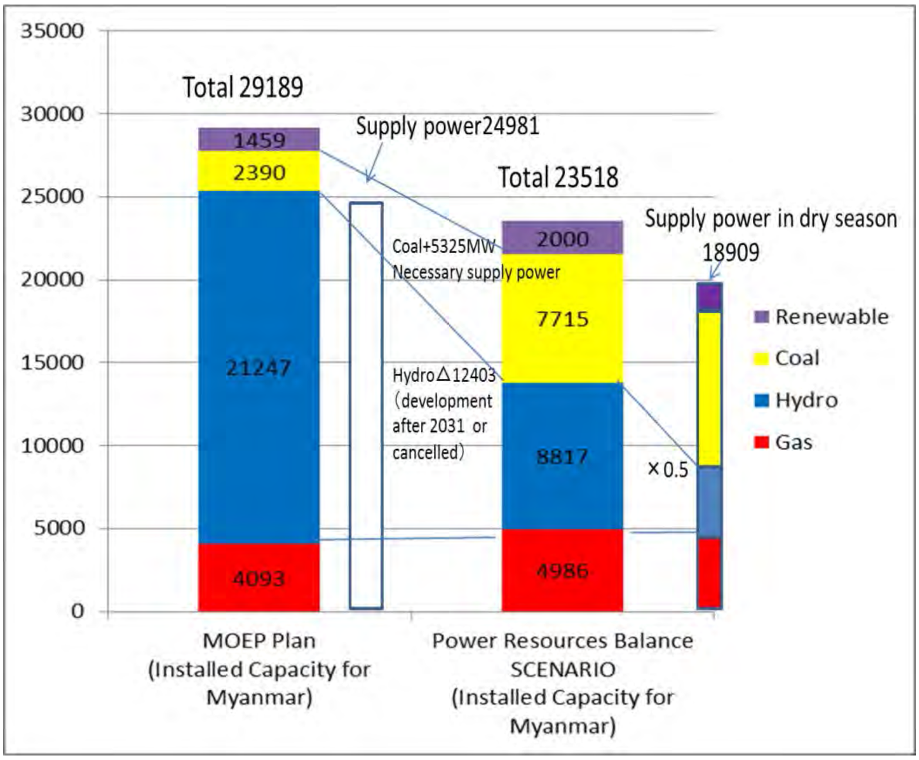


Fig. 5.3-8 Comparison of MOEP Plan and Scenario 3

(2) Hydropower

Characteristics and plans for hydropower development are described below.

- Hydropower output during the wet season is about 70% of installed capacity.
- Hydropower output decreases by 30% during the dry season (compared to the rainy season).
- Hydropower supply during the dry season is the basis for the overall power supply plan.
- IPPs by China and Thailand total 42.9GW (94.3%) of total hydropower capacity (45.5GW). Exclusively MOEP and MOAI total 13 projects, 2.6GW. Local IPPs total 5 projects, 0.8GW.
- Foreign IPPs aim at 50 % export of electric power and energy supply.

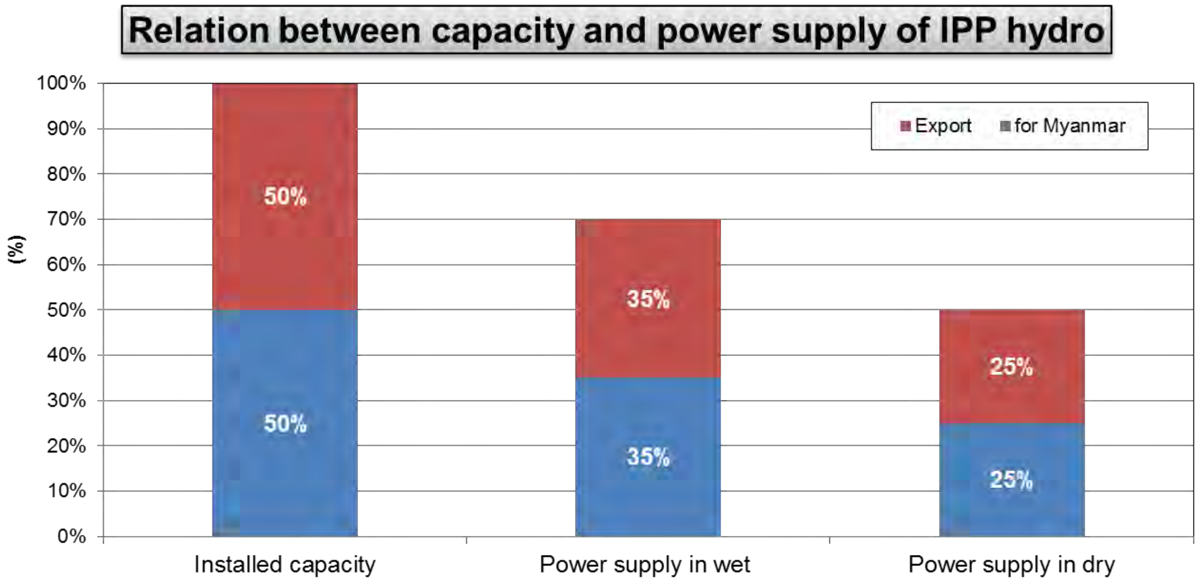
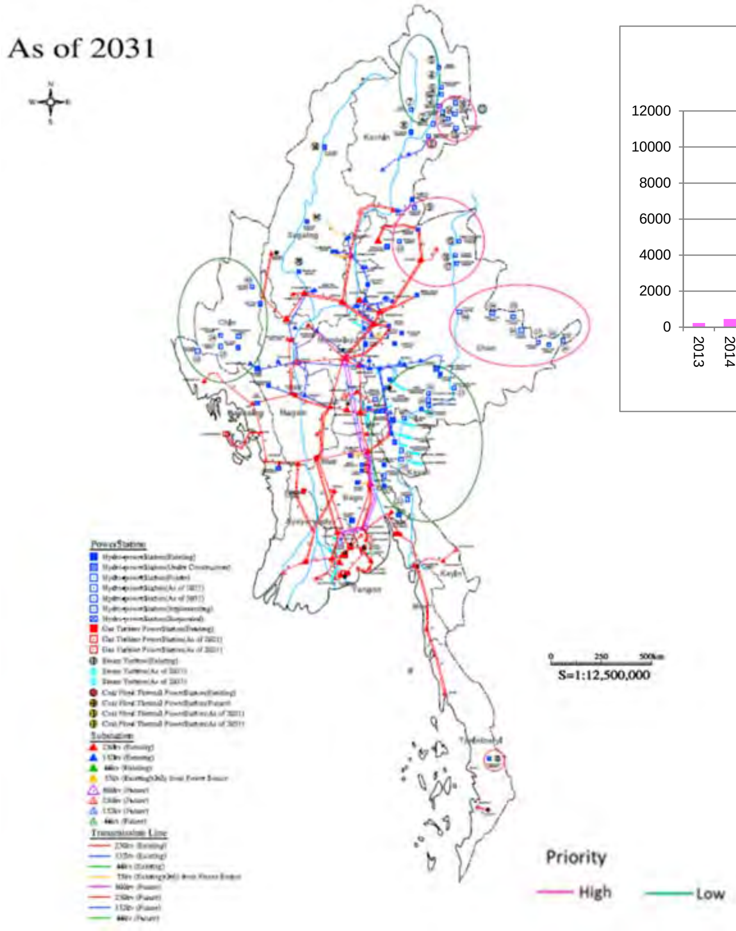


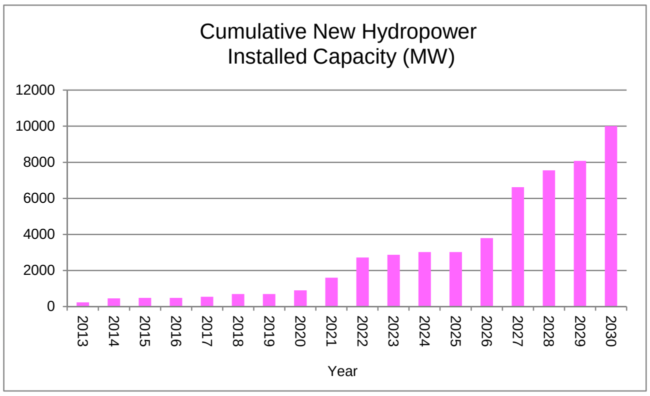
Fig. 5.3-9 Change of HPP Capacity in the Dry and Rainy Seasons

Actual output during the rainy season is 30% below installed capacity due to operational stops for inspection, deterioration or problems with equipment, restriction of transmission lines, etc. Furthermore, output during the dry season decreases 50% from the installed capacity due to lack of river discharge.

Large hydropower development requires a long lead time, often times decades from its initial planning to operation. The probability for large hydropower development is significantly affected by environmental impacts. Hydropower stations near border areas require long high voltage transmission line to demand centers such as Mandalay or Yangon.

All primary projects with a total capacity of 10 GW are to be promoted until 2030. Priority depends upon lead time and location. The pink colored area (10 GW) are primary. Main river development on the Ayeyarwady, Thanlwin and Chindwin (27.4GW) are anticipated to have a longer lead time.





New Total Capacity	:	10,009 MW
JV/IPP[*1]	:	7,203 MW
Local/IPP	:	279 MW
MOEP	:	2,527 MW

*1: A half of overall Installed capacity is counted for national use except Chipwinge (99MW).

Fig. 5.3-10 HPPs Development

Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

In Scenario 3, the trend of demand and supply balance is described below.

- Power supply during the dry season should meet maximum demand. The power supply is deducted from the total installed capacity by the reserve margin, power increases during the rainy season and IPP exports.
- Supply: total installed capacity is 27.7 GW; installed capacity for Myanmar is 23.5 GW; power supply during the dry season is 18.9 GW and meets the maximum demand of 14.5 GW with a 30% reserve margin in 2030.

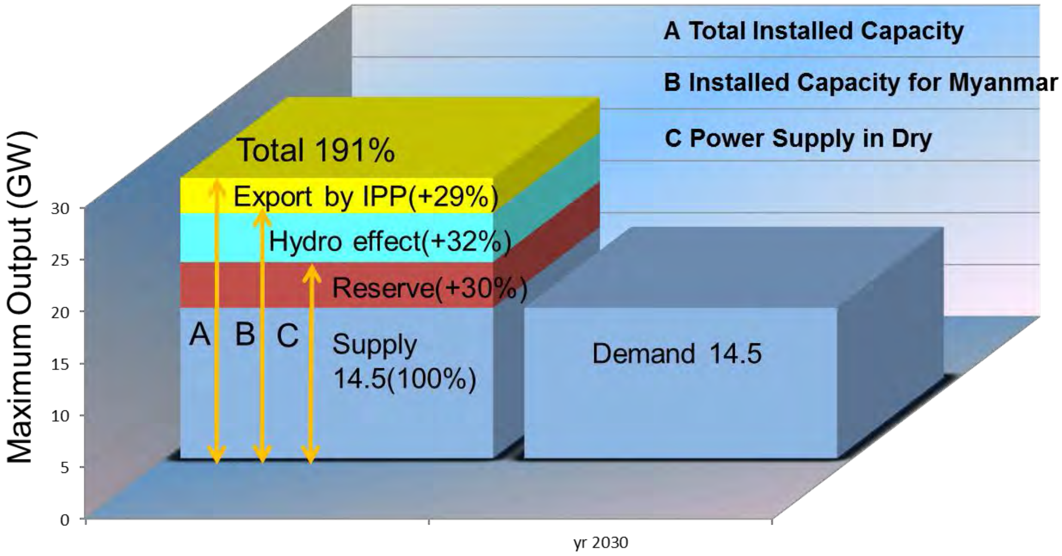


Fig. 5.3-11 Demand and Supply Balance

(3) Gas-fired

Gas-fired TPP development is based on following:

P1 : Maximum power of all existing gas-fired TPPs increases from 366MW to 574MW after rehabilitation/upgrading.

P2 : Regarding new gas-fired TPPs, projects with proceeding studies or high (emergency) priorities (Group 1: G1, G2, G3-1) come before the TPPs supplied by LNG (Group 2: G3-2]). Group 1 is to be developed by 2020, with Group 2 completed by 2030.

P3 : Group 1 (G1, G2, G3-1) is planned to receive imported oil until 2010 to supplement pipeline gas.

P4 : Overall installed capacity reaches 1.7GW by 2016 and 4.2GW by 2030.

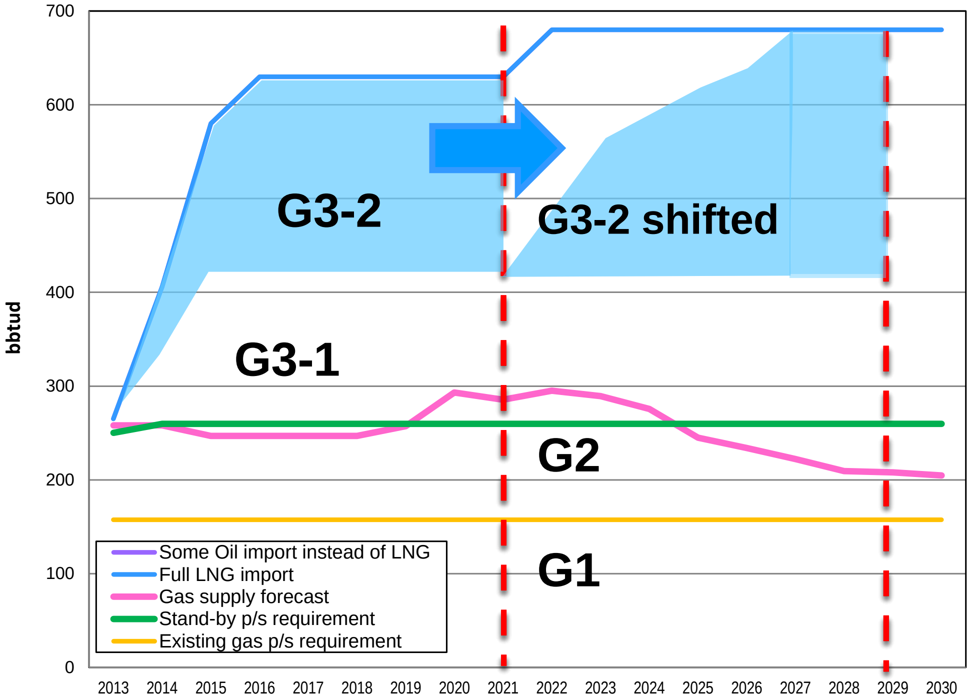


Fig. 5.3-12 Change of Gas Supply

The categories of gas-fired TPPs based on their plans and operational situations are shown in the table below.

Group*		Condition	Available Capacity (MW)**	Objectives	Project list
G1		Existing	1,023	Existing plants including those being rehabilitated and upgraded.	**Yangon : 4 plants, Other : 5 plants** (2013-2016 : 363MW, 2017-2030 : 574MW) **GE/GT : 5 plants** IPP: Hlawga(I), Ywama, Thaketa, Ahlone (I), MEPE: Ywama
G2		Stand-by	62	PPA under negotiation or finalization for IPP projects.	**GE/GT: 2 plants** IPP: Hlawga (II), Ahlone (II)
G3	G3-1	Fast track	700	Fast track planned projects to be commissioned by 2020. Dual fuel (Gas, HSD) type is expected until 2020.	**GT/CC: 7 plants** Thilawa, Kyause, Mawlamyaing, Kanpouk (I), Myin Gyan, Kyaukphyu, Thaketa (I)
	G3-2	Planned	2,789	Planned Projects to be commissioned by 2030.	**GT/CC: 6 plants** Hlaingtharyar, Hlawga, Thaketa, Thaketa (II), Ayeyarwady, Kanpouk (II)

Note: * Grouping may be changed in terms of gas allocation and project priority by the GoM (Government of Myanmar).

** Available capacity = (installed capacity) - (capacity deterioration by time)

*** Because many projects are completed one after another in Myanmar, some projects may be completed when this report is in the open.

HSD : High Speed Diesel Oil

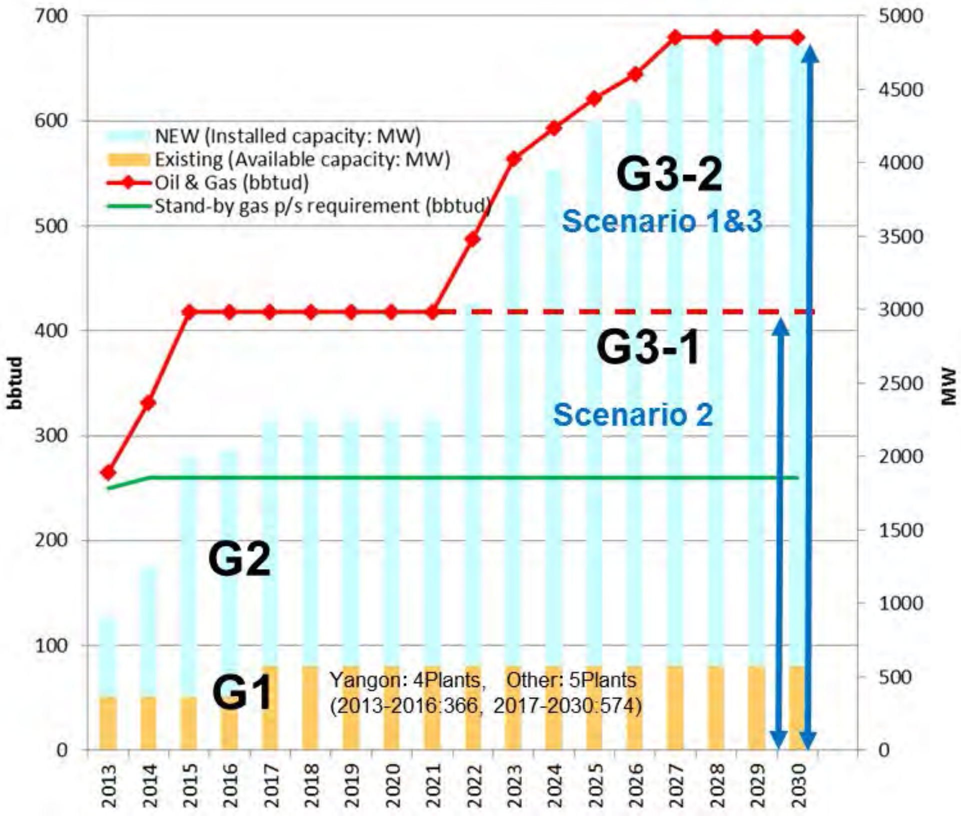
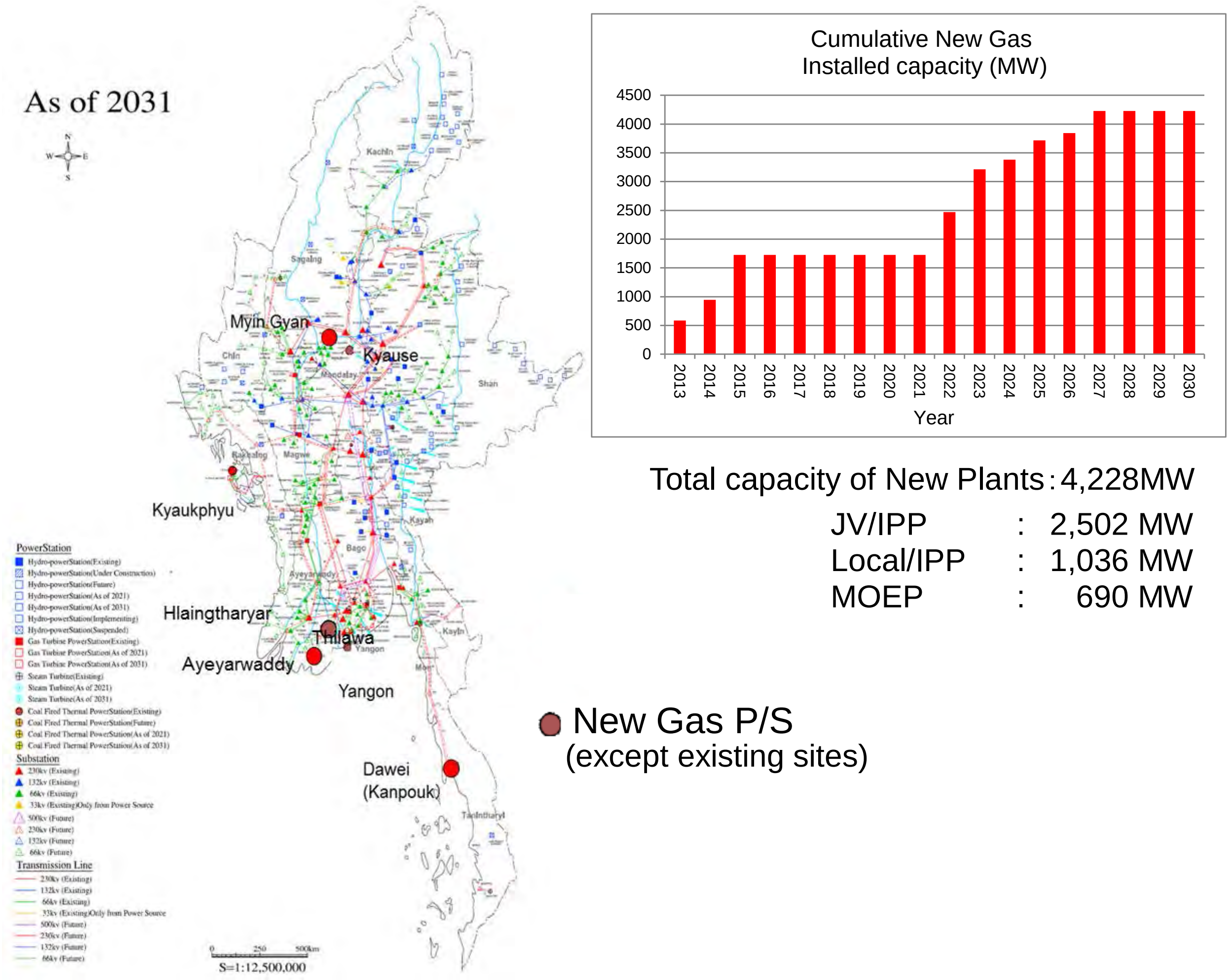


Fig. 5.3-13 Cumulative Capacity on Oil & Gas

The same gas-fired TPP development plan is assumed in Scenarios 1 and 3. Group 2 (G3-2) is removed in Scenario 2.

New sites for gas-fired TPPs are shown in Fig. 5.3-14.



Total capacity of New Plants : 4,228MW

JV/IPP	:	2,502 MW
Local/IPP	:	1,036 MW
MOEP	:	690 MW

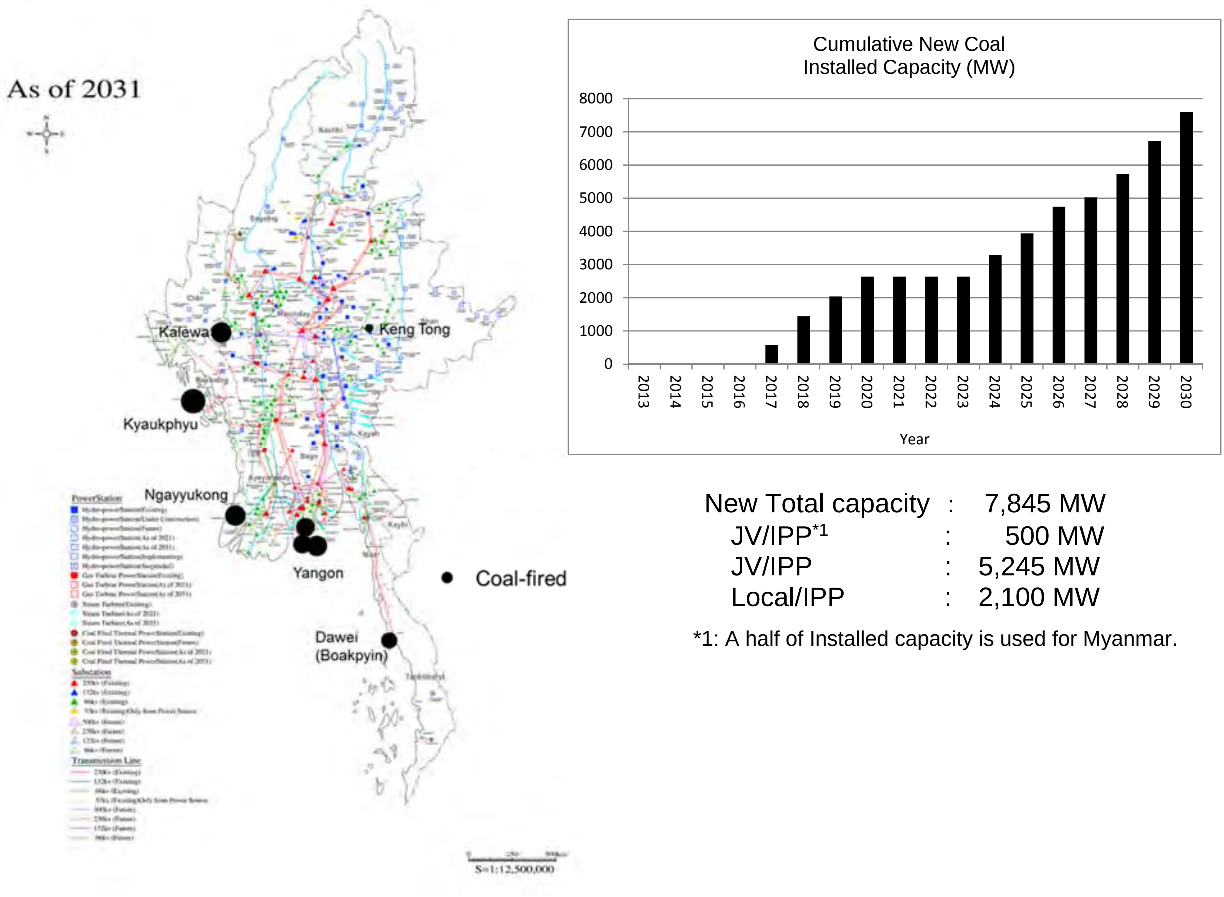
Fig. 5.3-14 Gas-fired TPPs Development

Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

(4) Coal

Finally, coal-fired TPPs, which should cover any shortage in the total power supply, are planned to be expanded as follows:

- As total demand is not fully met by both gas and hydropower, supplements with coal-fired power are required.
- A new coal-fired power station will be operational in 2017 and reach 7.8 GW in 2030.
- Domestic coal-fired power stations: 0.57 GW total (Kalewa 0.54 GW and Keng Tong 0.03 GW), only 7% of total coal electricity capacity (2030).
- Imported new coal-fired power stations generate 7.3 GW, 93 % of total coal-fired electricity capacity (2030).



New Total capacity	:	7,845 MW
JV/IPP^{*1}	:	500 MW
JV/IPP	:	5,245 MW
Local/IPP	:	2,100 MW

*1: A half of Installed capacity is used for Myanmar.

Fig. 5.3-15 Coal-fired TPPs Development

Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

In Scenario 3, transition of installed capacity by new plants is described as follows:

Hydropower stations are to be developed seamlessly up to 2030 with a total capacity of 10.0 GW. New coal-fired power stations start their operation after 2017, targeting 7.8 GW by 2030.

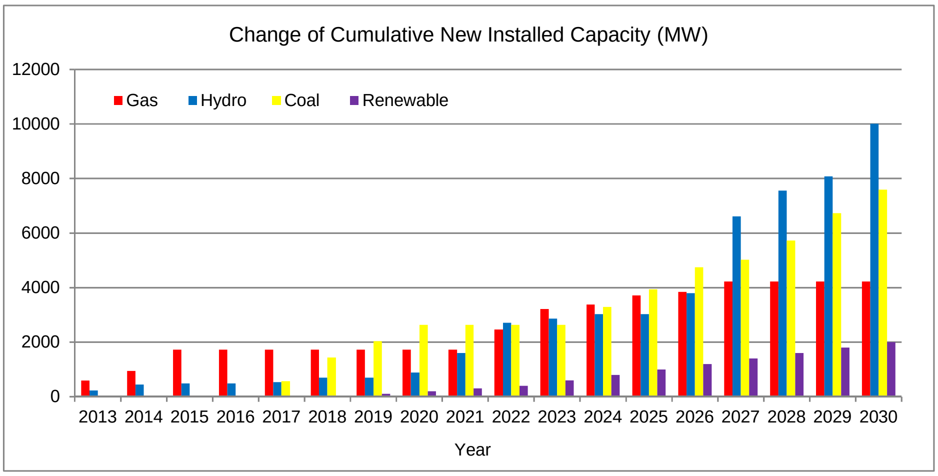


Fig. 5.3-16 Cumulative Change of Newly Installed Capacity

5.3.4 Comparison of Three Scenarios

From Section 5.2.7 to Section 5.2.9, three scenarios are proposed. The key points are summarized as follows:

The PGDP must meet the demand forecast for the short, middle and long terms. High case demand estimate: 4.5 GW in 2020 and 14.5 GW in 2030.

Proposed Scenarios:

Three Scenarios	1) Domestic energy consumption oriented via large scale hydro. 2) Least cost development to decrease long term marginal costs. 3) Power resources balance oriented.
Short Term (until 2020):	Planning and constructing gas TPPs are primary.
Middle and Long Term:	Scenarios become different after 2020. Renewable power development as of 2030 was targeted at 10% of total power supply.

Scenario No.	Priority	Concept	Power resources
1	Domestic Energy Consumption (Large Scale Hydro Oriented)	Scenario 1 is formulated based on large hydro oriented plan.	➢ Maximum utilization of domestic energy ➢ Possible hydropower plans including Large scale hydro ➢ Listed gas p/s plans
2	Least Cost	Scenario 2 aims to minimize the development and fuel cost.	➢ Possible hydropower plans including Large scale hydro ➢ Less gas p/s after 2016 ➢ Rest with coal and renewables.
3	Power Resources Balance	Scenario 3 is formulated considering the composition of power resources and feasibilities of development	➢ Hydropower plans with high feasibilities ➢ Modified gas p/s plans ➢ Rest with coal and renewables

(1) Power Supply Composition of Three Scenarios

Transition of installed capacity for Myanmar and the power supply during the dry season in each scenario is shown in Fig. 5.3-17 and Fig. 5.3-18 respectively.

Although the same amount of power supply during the dry season for all scenarios is assumed, the lowest capacity is realized in Scenario 3. Imported coal-fired power stations are substituted for large hydropower stations in Scenario 3. Possibility of gas capacity depends on new local gas supplies or imports.

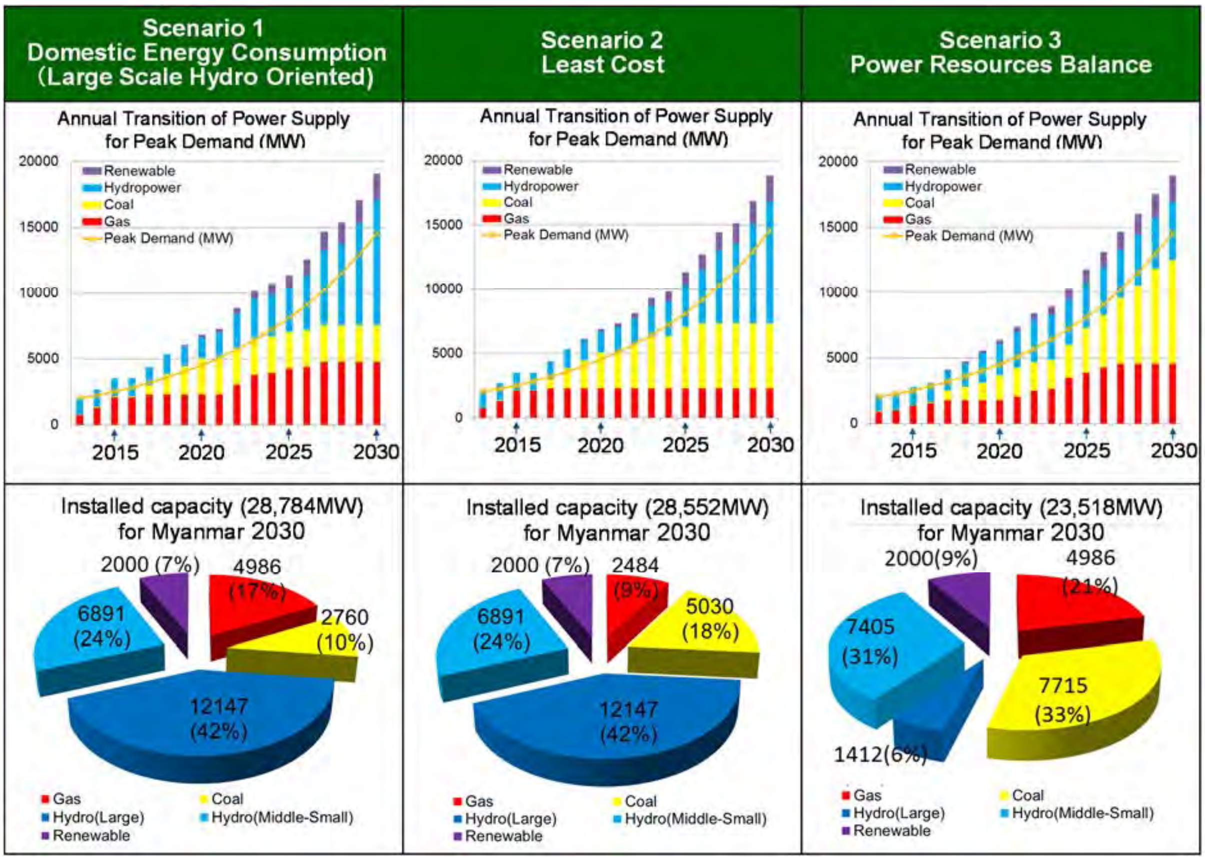


Fig. 5.3-17 Annual Transition of Power Supply and Installed Capacity for Myanmar for each Scenario

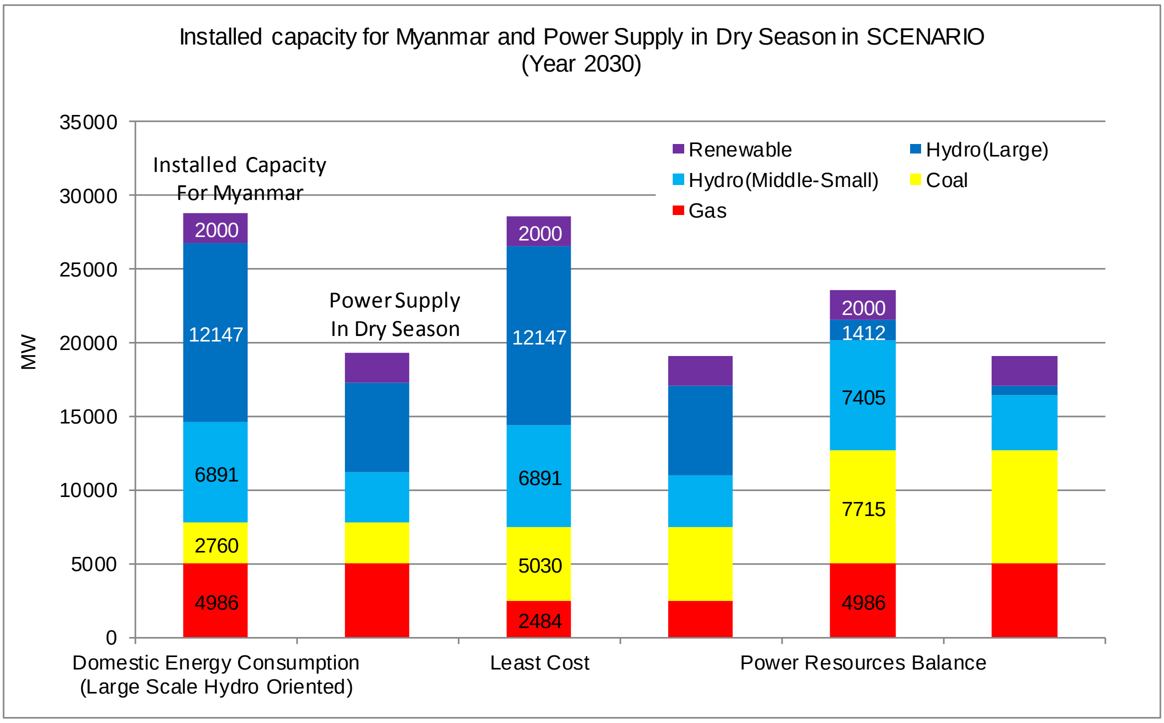
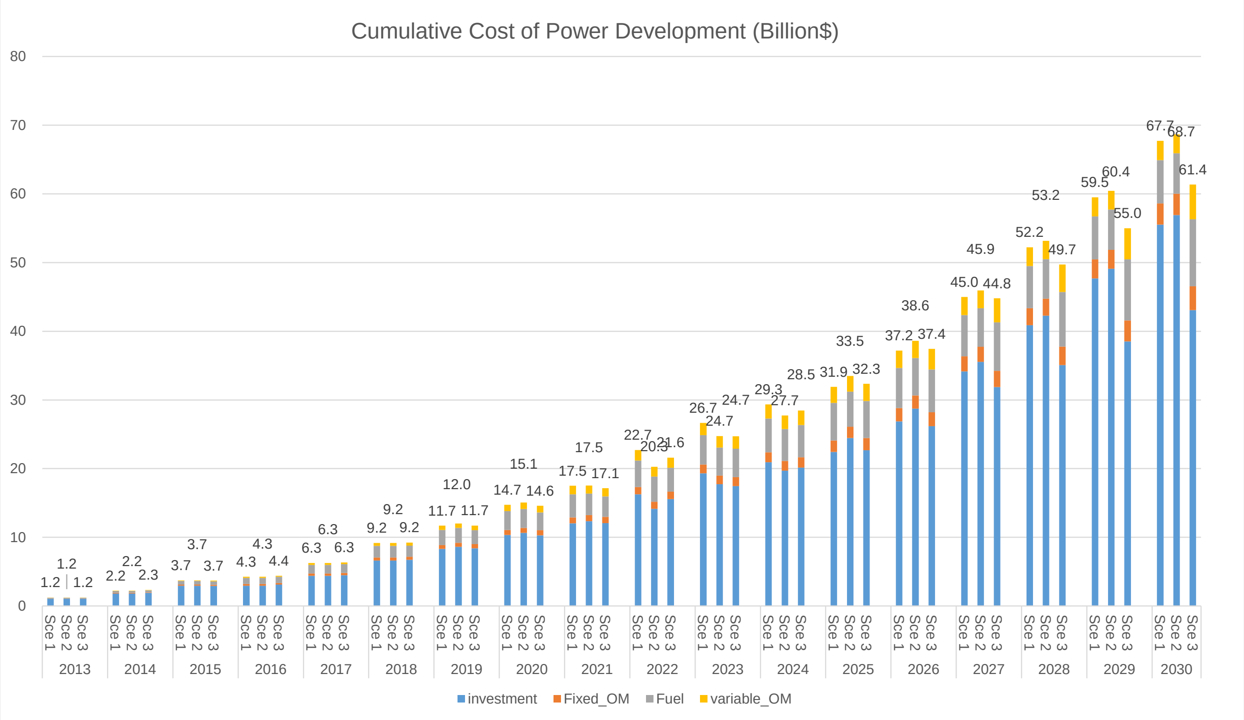


Fig. 5.3-18 Installed Capacity for Myanmar and Power Supply during the Dry Season for each Scenario

(2) Total Cost and LRMC (Long Run Marginal Cost) for the Three Scenarios

Cumulative cost of power development is shown in Fig. 5.3-19. In this figure, the cost of Scenario 2 in 2030 is higher than that of Scenario 1 because there are more coal-fired TPPs, whose initial cost is higher, in Scenario 2 than in Scenario 1. The cost of Scenario 3 in 2030 is lower than that of the other scenarios due to fewer HPPs.



Cost is not calculated from present value. O&M cost and Fuel cost include the existing facilities.

Fig. 5.3-19 Cumulative Cost of Power Development

Comparison of LRMC among the three scenarios is summarized as follows:

LRMC is calculated by the sum of the LRMC of generation capacity and the LRMC of energy. The method of calculating each LRMC is described below.

LRMC (generation capacity)

The LRMC for generation capacity is calculated theoretically by dividing the difference in investment cost between the increased demand case and the base case by demand increments.

Calculating Method

By considering the capital investment plan of minimum cost based on the assumption that the increased demand case is a certain amount higher than the base case, and dividing the difference in investment cost between the increased demand case and the base case, LRMC, which equals the capital investment cost when demand has increased per unit, is calculated.[2]

---

[2] Reference to the "Theory and Method of Analyzing Electricity Charge" Japan Bank for International Cooperation (2000)

Calculating Procedure

1) LRMC for generation capacity =

$$\frac{\text{Present value of the difference in investment cost over a certain time period between the increased demand case and the base case.}}{\text{Present value of the difference in demand over a certain time period between the increased demand case and the base case.}}$$

2) The result of 1) (A$/kW) is converted to the value of each year.

3) The result of 2) (B$/kW/year) is converted to $/kWh.
For example: in the case of the load factor multiplied by 60%
B / 365days / 24hours / 0.6 = C$/kWh

LRMC (energy)

Similarly, the LRMC for energy is calculated theoretically by dividing the difference in fuel and variable O&M costs between the increased demand case and the base case by energy increments.

$$\text{LRMC for energy} = \frac{\text{Present value of energy cost increments (million USD)}}{\text{Present value of energy output increments (GWh)}}$$

The lowest is realized in Scenario 2. But the difference with Scenario 3 is only around one US cent/kWh (Fig. 5.3-20). This figure is based on the calculation conditions in Section 5.2.6 with power generation energy simulated by WASP.

As a result, Scenario 3 is the most feasible to be realized and suggested as the optimal scenario.

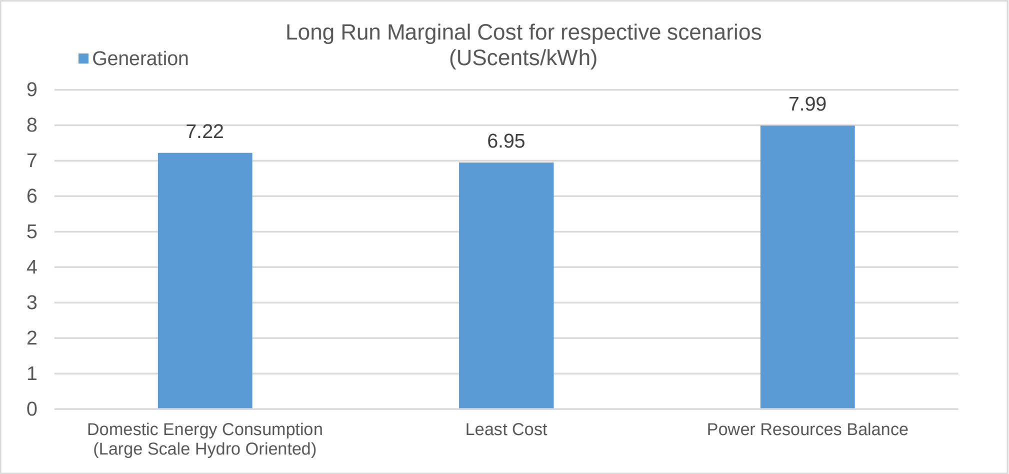
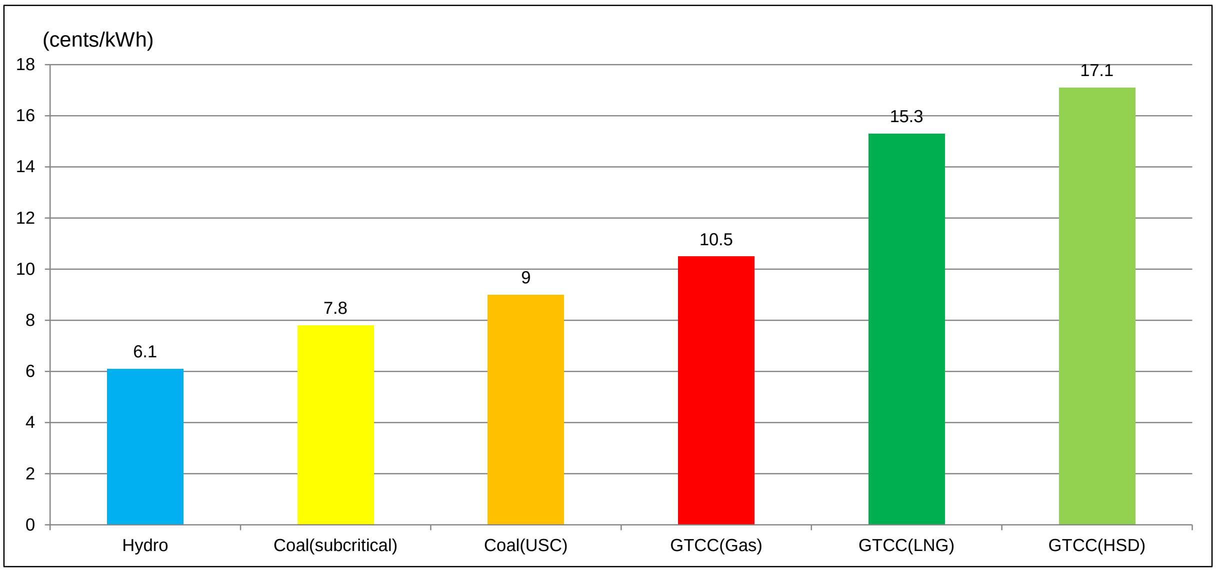


Fig. 5.3-20 Comparison of LRMC

Unit Cost is shown in Fig. 5.3-21. HPP development has the lowest cost, coal the second, and gas the highest. Although there is no international common methodologies in the cost conversion of CO_2 emission, unit costs including the CDM (Clean Development Mechanism) price (1.0 cents/kg in this estimation) are also calculated as a reference based on the emission of each power resource estimated in Section 7.5.9. As a result, it is confirmed that this consideration does not affect to the ranking of each unit cost.



Unit Cost [cents/kWh] = (Annual Capital Cost [USD/kW] + Annual Fixed O&M Cost [USD/kW･year] × Life Time [year]) × 100 / (Life Time [year] × 8760 hours/year× CF[-]) + Annual Fuel Cost [UScents/kWh]
+ Annual Variable O&M Cost [cents/kWh]

This figure doesn't include Environmental Cost [UScents/kWh], which equals CO_2 Cost [cents/g-CO_2] × CO_2 Emission per Unit [g-CO_2/kWh].
For reference, Unit Cost including Environmental Cost is; Hydro: 6.1, Coal (subcritical): 8.7, Coal (USC): 9.9, GTCC (Gas): 10.9, GTCC (LNG):15.7, GTCC (HSD): 17.5,
1.0 [cents/kg-CO_2] is adopted as CO_2 Cost. CO_2 Emission per Unit is based on Table 7.5-13 (Chapter 7)

Fig. 5.3-21 Comparison of Unit Costs for Each Power Resource

For reference, comparison of unit costs in case of domestic gas and that in case of domestic gas and HSD (High Speed Diesel) in 2016 is shown in Fig. 5.3-22.

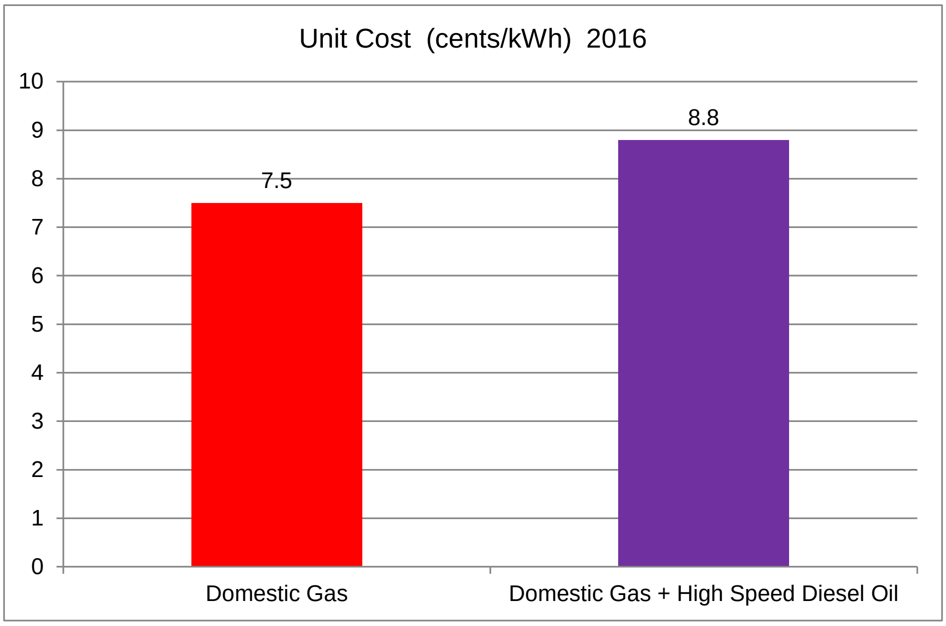


Fig. 5.3-22 Comparison of Unit Cost in 2016

(3) Result of Comparison of the Three Scenarios

Close discussions on the comparison of three scenarios had been implemented between MOEP and JICA Study Team throughout this study. Finally, Scenario 3 “Power Resources Balance” is confirmed as the optimum one to be proceeded for further study at the workshop on 27th May 2014, considering utilization of domestic energy, supply conditions of each primary energy and overall energy security. Basic concepts are shown below.

- Utilization of the domestic clean energy is essential and hydropower is the promising resource. However, it has various risks for the implementation such as power supply in dry season and impacts on social and natural environments.
- Natural gas is also the prioritized domestic energy for the development. However, the potential of gas yields for the power generation is assumed to be insufficient temporarily.
- Considering these constraints, the 3rd reliable primary energy resource should be ensured to satisfy the rapid power demand increase through 2030. The power generation development including the introduction of best available coal thermal plants is realistic.

5.4 DETAILED STUDY OF SCENARIO 3

5.4.1 Adjustment with MOEP regarding Scenario 3

The quantity of power supply and the operational year of power plants of Scenario 3 have been reviewed by recent interviews and discussions with MOEP.

(1) Review of Existing and the New Gas-fired TPPs

Installed capacity and expected operational time frames were reviewed in recent interviews (Fig. 5.4-1 and Table 5.4-1).

Total installed capacity for new gas-fired TPPs decreased from 4.2GW to 4.0GW. Total power supply for gas-fired TPPs will reach 4.6GW by newly installed capacity of 4.0 GW coupled with the existing 0.6GW in 2030.

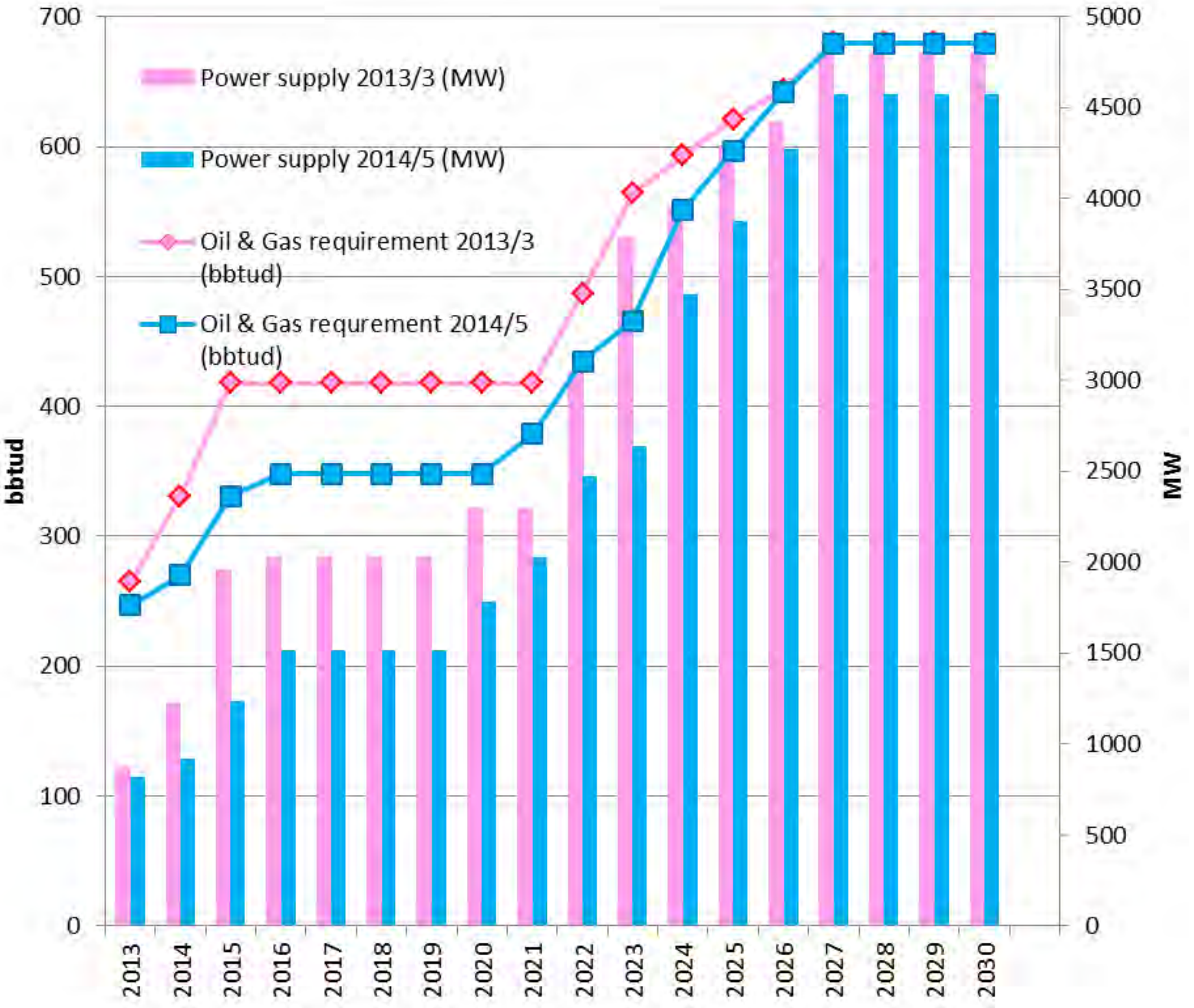


Fig. 5.4-1 Comparison of Power Supply and Oil and Gas Requirements (2013/3, 2014/5)

(2) Review of the Power Supply of the Existing Gas-fired TPP

The power supply and the operational years were reviewed based upon recent interviews with the parties concerned (Table 5.4-1).

The power supply of the existing coal-fired TPP (Tigyit) increases from 30MW to 120MW in 2016.

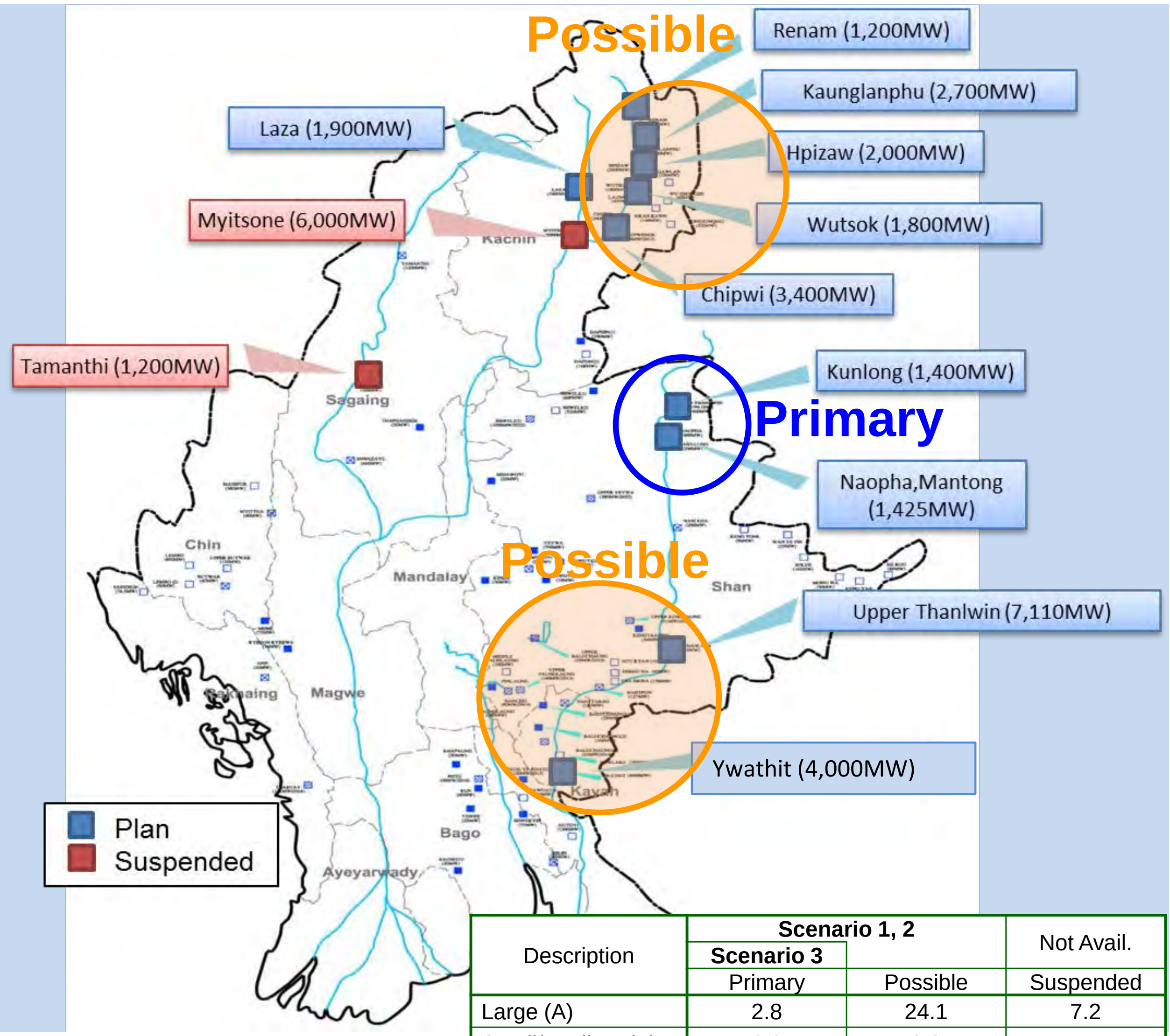
Table 5.4-1 List of Existing Gas-fired TPPs and Coal-fired TPPs

	Gas										Coal		Remark
Plant	Hlawga GTCC	Ywama GT	Ahlone GTCC	Thaketa GTCC	Thaton GT	Kyunchaung GT	Myanaung GT	Shwedaung GT	Mann GT	*(sub total)*	Tygit	*(sub total)*	Malawmyaing 12MW is not included as scrapped December 2013
FY Year	Installed capacity (MW)												
	154.2	70.3	154.2	92	51	54.3	34.7	55.35	36.9	*702.95*	120	*120*	
	Available capacity (MW)												
2013	43	31	76	50	35	24.5	12	13	0	*284.5*	30	*30*	Hearing from MOEP as of 04/06/2014
2014	43	31	76	50	35	24.5	12	13	0	*284.5*	30	*30*	
2015	43	31	76	0	35	24.5	12	13	0	*234.5*	30	*30*	Thaketa GTCC stop up to 2019. New Thaketa 100MW start, which is shown in New p/s list.
2016	43	31	76	0	106	24.5	12	13	0	*305.5*	120	*120*	Thaton GT 51MW to GTCC 106MW by rehabilitation
2017	43	31	76	0	106	24.5	12	13	0	*305.5*	120	*120*	
2018	43	31	76	0	106	24.5	12	13	0	*305.5*	120	*120*	
2019	43	31	76	0	106	24.5	12	13	0	*305.5*	120	*120*	
2020	116	57	116	86	106	39	15	39	0	*574*	120	*120*	From 2020 new gas supplied. Gas p/s available capacity from "Power System Development Sheme of MEPE (2.7.2013) except Tharkata and Thaton Thaketa 86MW by rehabilitation
2021	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2022	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2023	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2024	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2025	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2026	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2027	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2028	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2029	116	57	116	86	106	39	15	39	0	*574*	120	*120*	
2030	116	57	116	86	106	39	15	39	0	*574*	120	*120*	

(3) Review of the New Supply of HPP

The power supply and contract scheme (JV/IPP, Local/IPP) were reviewed based upon recent interviews with the parties concerned.

Total installed capacity in 2030 decreased from 10.0GW to 9.4GW (Fig. 5.4-2).



Description	Scenario 1, 2		Not Avail.
	Scenario 3		
	Primary	Possible	Suspended
Large (A)	2.8	24.1	7.2
Small/Medium (B)	6.6	3.3	1.5
(A) + (B)	9.4	27.4	8.7
Primary + Possible	36.8		
Potential	45.5		

Fig. 5.4-2 Installed Capacity of HPPs within Scenarios (GW)

(4) Review of the New Coal-fired TPP

The power supply and location were reviewed according to recent interviews with the parties concerned. The total installed capacity of the new coal-fired TPP for Myanmar increased from 7.6GW to 7.8GW.

5.4.2 Revised Power Supply Composition for Scenario 3

JICA Study Team sets the reserve rate of power supply at 30 ~ 40% and have reviewed operational years in consultation and coordination with MOEP.

The result is shown in Table 5.4-2 (supply planning), Fig. 5.4-3 (annual transition of power supply), Fig. 5.4-4 (power supply composition), Table 5.4-3 and Table 5.4-4 (operational years of HPPs, TPPs). The locations of new power plants are shown in Fig. 5.4-5 and Fig. 5.4-6.

Table 5.4-2 Supply Planning of the Revised Resources Balance Scenario

As of 2030 Year: New Coal7.8GW, New Hydro 8.9GW, New Gas 4.0 GW (Installed capacity for Myanmar)

Item/Plant Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	TOTAL
Peak Demand (MW)	2,055	2,248	2,527	2,840	3,192	3,587	4,032	4,531	5,092	5,723	6,431	7,227	8,121	9,125	10,253	11,520	12,944	14,542	
Required Generation Energy (GWh)	12,064	13,560	15,242	17,132	19,256	21,642	24,323	27,336	30,721	34,524	38,797	43,597	48,990	55,048	61,853	69,497	78,083	87,727	699557
Existing Plant																			
Combined Cycle	200	200	150	256	256	256	256	481	481	481	481	481	481	481	481	481	481	481	
Gas Turbine	84.5	84.5	84.5	49.5	49.5	49.5	49.5	93	93	93	93	93	93	93	93	93	93	93	
Coal	30	30	30	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	
Hydropower	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	1130	
(Existing Sub Total)	1444.5	1444.5	1394.5	1555.5	1555.5	1555.5	1555.5	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	1824	
Candidate Plant																			
Gas	534.3	99.1	365.6	212	0	0	0	0	243	443	167	836	400	400	300	0	0	0	4000
Coal	0	0	0	0	630	300	275	600	300	0	0	300	900	605	1030	910	1310	660	7820
Hydropower (dry: Install × 0,5)	51	130	51	25	49	323	525	78	392	486	240	0	0	181	0	235	0	554	3320
Renewable				50	50	50	50	100	100	100	100	200	200	200	200	200	200	200	2000
(Candisate Sub Total in each year)	585.3	229.1	416.6	287	729	673	850	778	1035	1029	507	1336	1500	1386	1530	1345	1510	1414	17140
Development Plant Total	585.3	814.4	1231	1518	2247	2920	3770	4548	5583	6612	7119	8455	9955	11341	12871	14216	15726	17140	
Total Supply Capacity	2029.8	2258.9	2625.5	3073.5	3802.5	4475.5	5325.5	6372	7407	8436	8943	10279	11779	13165	14695	16040	17550	18964	
(capacity-peak)	-24.98	11.097	98.911	233.63	610.59	888.02	1293.5	1840.6	2314.5	2713.1	2511.8	3052.1	3658.2	4040	4441.9	4519.8	4606.5	4421.8	
Reserved Margin(%)	-1.216	0.4937	3.9148	8.2267	19.129	24.753	32.082	40.62	45.449	47.407	39.056	42.232	45.047	44.273	43.323	39.234	35.589	30.407	

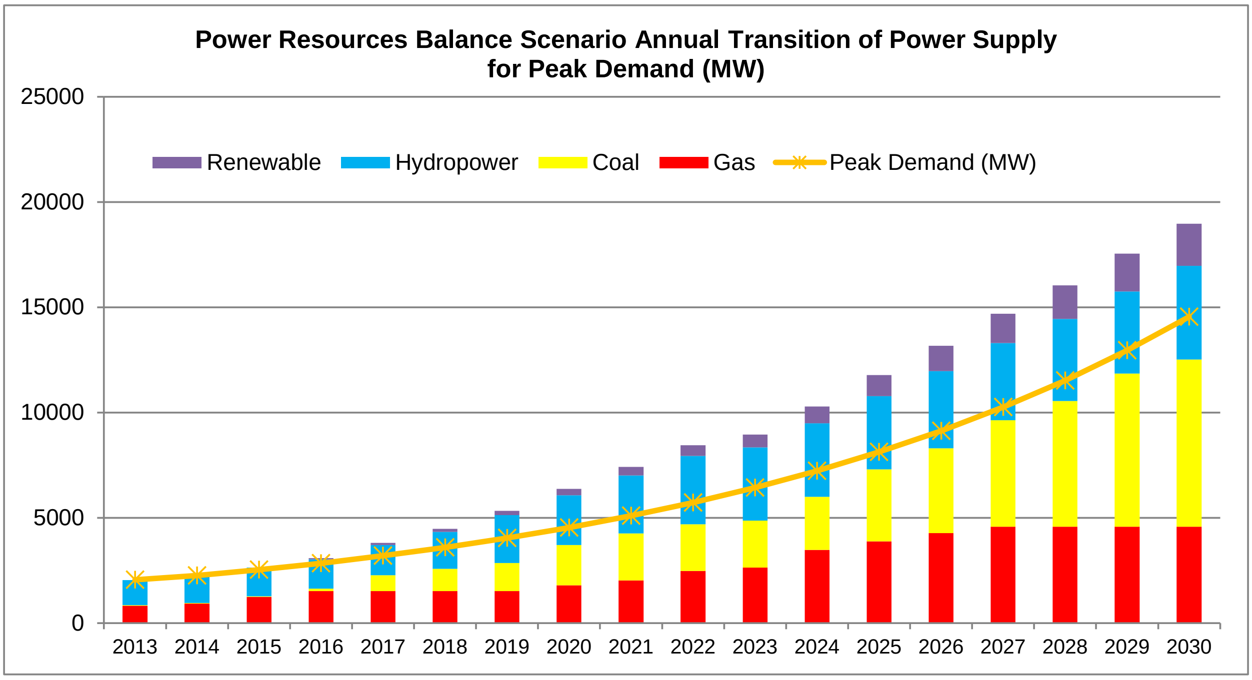


Fig. 5.4-3 Annual Transition of the Power Supply for the Revised Power Resources Balance Scenario

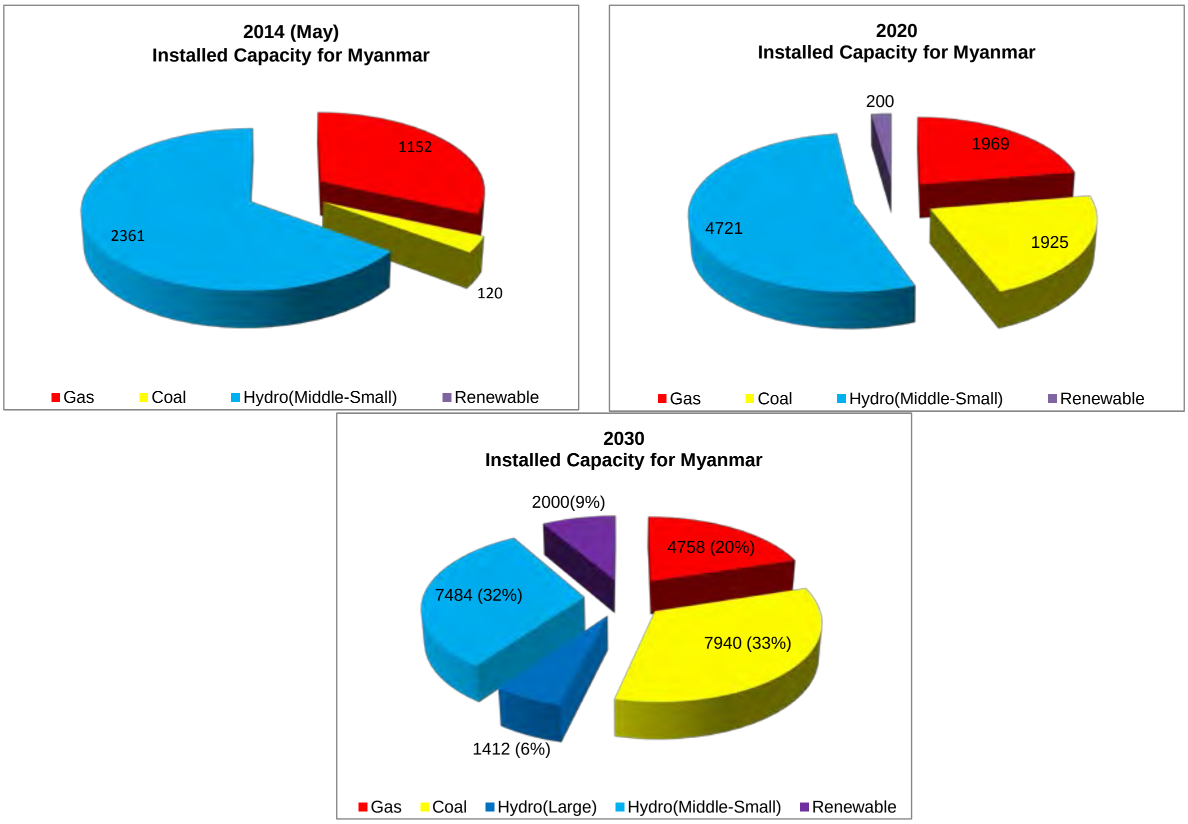


Fig. 5.4-4 Power Supply Composition of the Revised Power Resources Balance Scenario on 2014, 2020 and 2030

Table 5.4-3 Operational Start Plan of New HPPs: Revised Power Resources Balance Scenario (Final List)

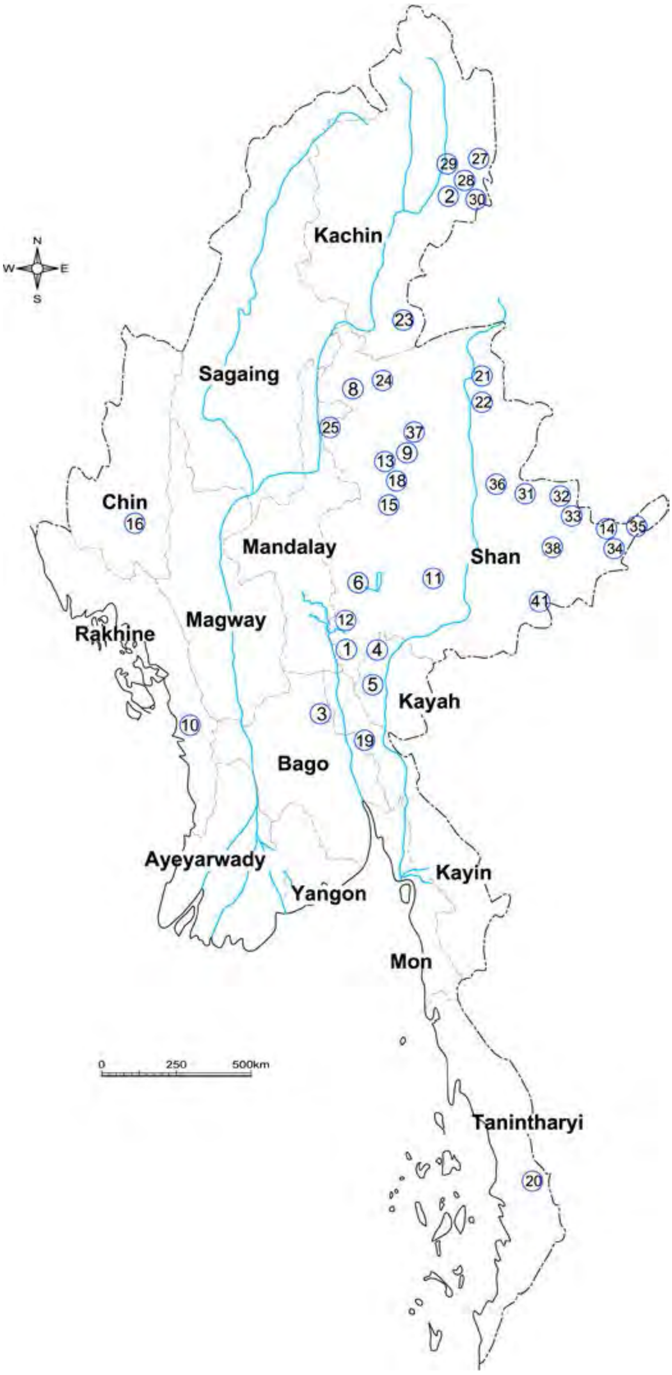
Project		Installed Capacity (MW)	Proponent	Contraction Condition	COD by MOEP Plan	Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remark
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	
A	Phyu Chaung	40	MOEP		2013-14	40			40																	
B	Nancho	40	MOEP		2013-14	40		40																		
C	Baluhaung - 3	52	Local/IPP		2013-14	52		52																		
D	Upper	30.4	Local/IPP		2017-18	30.4						30.4														
E	Upper	140	MOEP		2014-15	140			140																	
F	Ann	10	MOEP		-	-																				
G	Thahtay	111	MOEP		2018-19	111							111													
H	Upper	51	MOEP		2017-18	51						51														
I	Upper Yeywa	280	MOEP		2018-19	280							280													
J	Shweli - 3	1050	MOEP		2019-20	1050								1050												
K	Bawgata	160	MOEP		2021-22	160												160								Power supply adjustment
L	Upper Bu	150	MOAI		~ 2020-21	150									150											
M	Middle	100	MOEP		2018-19	100							100													
N	Belin	280	Local/IPP		~ 2021	-																				
O	Ngotchaung	16.6	Local/IPP		2017-18	16.6						16.6														
P	Dapain (only supply)	101	MOEP		2015-16	101				101																
Q	Projects	79	MOAI		2014-15	79			79																	
R	Dee Doke	66	Local/IPP		2018-19	66							66													
S	Keng Kham	6	MOAI		~ 2020-21	6									6											
T	Middle Yeywa	320	MOAI		2021-22	320												320								Power supply adjustment
U	Upper Sedawgyi	64	MOAI		-	64																			64	supended
V	Namtu	100	JV/IPP	-	2026~	50																			50	
W	Mong Young	45	JV/IPP	-	2026~	22																			22	
X	Dun Ban	130	JV/IPP	-	2026~	65																			65	
Y	Nam Li	165	JV/IPP	-	2026~	82																			82	
Z	Nam Khot	50	JV/IPP	-	2026~	25																			25	
1	Myitsone	6000	JV/IPP	JVA	-	-																				
2	Chipwi	3400	JV/IPP	JVA	~2021	-																				
3	Wutsok	1800	JV/IPP	MOA	~2026	-																				
4	Kaunglanpu	2700	JV/IPP	MOA	~2026	-																				
5	Renam (Yenam)	1200	JV/IPP	MOA	~2026	-																				
6	Hpizaw (Pisa)	2000	JV/IPP	MOA	~2026	-																				
7	Laza	1900	JV/IPP	JVA	~2021	-																				
8	Chipwinge	99	JV/IPP	(Prepared to Commercial)	2013-14	99		10					89													
9	Dapein-2	168	JV/IPP	MOU	2021-22	84										84										
10	Gawlan	100	JV/IPP	MOA	2026~	50															50					
11	Wu Zhongze	60	JV/IPP	MOA	~2021	-																				
12	Hkan Kawn	160	JV/IPP	MOA	2026~	80															80					
13	Tongxinqiao	340	JV/IPP	MOA	2026~	170																	170			
14	Lawngdin	600	JV/IPP	MOA	2026~	300																	300			
15	Upper Thanliwn (Kunlong)	1400	JV/IPP	MOA	2021-22	700										700										
16,17	Naopha, Mantong	1425	JV/IPP	MOU	2021-22	712											712									Power supply adjustment
18	Tamanthi	1200	JV/IPP	MOU	-	-																				
19	Shwezaye	660	JV/IPP	MOU	-	-																				
20	Tanintharyi	600	Local/IPP	MOU	2021-22	600																			600	suspended
21	Upper Thanliwn (Mongton)	7110	JV/IPP	MOU	~2031	-																				
22	Hutgyi	1360	JV/IPP	MOA	~2021	-																				
23	Sinedin	76.5	JV/IPP	MOA	~2021	-																				
24	Lemro (Laymyo)	600	JV/IPP	MOA	~2026	-																				
25	Lemro-2 (Laymyo-2)	90	JV/IPP	MOA	~2026	-																				
26	Ywathit (Thanlwin)	4000	JV/IPP	MOA	~2026	-																				
27	Nam Tamhpak (kayah)	180	JV/IPP	MOA	~2026	-																				
28	Htu Kyan (Tuzxing ?)	105	JV/IPP	MOA	~2031	-																				
29	Hseng Na	45	JV/IPP	MOA	~2031	-																				
30	Tha Hkwa	150	JV/IPP	MOA	~2031	-																				
31	Palaung	105	JV/IPP	MOA	~2031	-																				
32	Bawlake	180	JV/IPP	MOA	~2031	-																				
33	Shweli - 2	520	JV/IPP	MOA	2022-23	260											260									
34	Keng Tong	128	JV/IPP	MOU	2026~	64															64					
35	Wan Ta Pin	33	JV/IPP	MOU	2026~	17															17					
36	Solue	160	JV/IPP	MOU	2026~	80															80					
37	Mong Wa	50	Local/IPP	MOU	2016-17	50					50															
38	Keng Yang	40	JV/IPP	MOU	2026~	20															20					
39	He Kou	100	JV/IPP	MOU	2026~	50															50					
40	Nam Kha	200	JV/IPP	MOU	2026~	100																			100	
41	Mawlaik	520	JV/IPP	MOU	-	-																				
42	Nam Tamhpak (kachin)	200	JV/IPP	MOU	2026~	100																			100	
43	Manipur	380	JV/IPP	MOU	2021~	-																				
		Subtotal		*45680.5*		*6637*	*0*	*102*	*361*	*462*	*512*	*610*	*1256*	*2306*	*2462*	*3246*	*4218*	*4698*	*4698*	*4698*	*5059*	*5059*	*5529*	*5529*	*6637*	
								102	259	101	50	98	646	1050	156	784	972	480	0	0	361	0	470	0	1108	

Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Table 5.4-4 Operational Start Plan of New TPPs: Revised Power Resources Balance Scenario (Final List)

Project				Installed Capacity (MW)		COD	Available Capacity for Myanmar (MW)		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
									2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Gas Turbine	A	Ywama	GT	240		2013	240		240																	
	B	Kyaukphyu (New)	GT	50		2016	50				50															
	C	Thilawa		50		2015	50				50															
(Subtotal)								*Cumulative*	*240*	*240*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*	*340*
Combined Cycle	D	Ahlone	GT	84		2013	84		84																	
			ST	37		2014.9	37				37															
	E	Mawlamyaing	GTCC	98		2015	98			98																
			GTCC	132		2016	132					132														
	F	Hlawga		243		2021	243										243									
				243		2021	243											243								
	G	Thaketa		167		2023	167												167							
				336		2023	336													336						
				100		2015	100				100															
				400		2027	400															400				
	H	Kanpouk (New)		200		2022	200											200								
				300		2023	300																300			
	I	Myin Gyan (New)		250		2015.8	250				170	80														
	J	Hlaingtharyar (New)		400		2025	400														400					
	K	Ayeyarwady (New)		500		2024	500													500						
(Subtotal)								*Cumulative*	*84*	*182*	*489*	*701*	*701*	*701*	*701*	*701*	*944*	*1387*	*1554*	*2390*	*2790*	*3190*	*3490*	*3490*	*3490*	*3490*
								Each year		*98*	*307*	*212*	*0*	*0*	*0*	*0*	*243*	*443*	*167*	*836*	*400*	*400*	*300*	*0*	*0*	*0*
Gas Engine	L	Hlawga	GE	25		2013.5	25		25																	
			GE	25		2015	25				25															
	M	Ywama	GE	50		Commissioning 2013.7	50		50																	
	N	Thaketa	GE	50		Commissioning 2013.7	50		50																	
	O	Kyause (New)		82		2013	82		82		-82															
	P	Kyaukpyu (New)		4.4					3.3	1.1	-4.4															
	Q	Kanpouk	GE	20		2015	20				20															
(Subtotal)								*Cumulative*	*210.3*	*211.4*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*	*170*
				Subtotal	*4062*			*Cumulative*	*534.3*	*633.4*	*999*	*1211*	*1211*	*1211*	*1211*	*1211*	*1454*	*1897*	*2064*	*2900*	*3300*	*3700*	*4000*	*4000*	*4000*	*4000*
								Each year	*534.3*	*99.1*	*365.6*	*212*	*0*	*0*	*0*	*0*	*243*	*443*	*167*	*836*	*400*	*400*	*300*	*0*	*0*	*0*
	1	Yangon-Kunchangon (Virtue Land)	Coal	300		2016	300							300												
			Coal	990		2018	990														330	330	330			
			Coal	1980		2020	1980																	660	660	660
	2	Ngayukong (Ayarwady Div.,Tata)	Coal	550		under discussion	550								275							275				
	3	Kalewa (Sagaing Div.)	Coal	540		2017-2018	540						270								270					
	4	Boakpyin (Tanintharyi State)	Coal	500		2017-2018	250	Domestic 50%								250								250		
	5	Yangon-Kyauktan	Coal	1300		under discussion	1300										300			300			350		350	
	6	Keng Tong (Shan State)	Coal	600		under discussion	600														300				300	
	7	Thilawa (New)	Coal	360		2017	360						360													
	8	Ngaputaw	Coal	700		2021	700									350							350			
				Subtotal	*7820*		*7570*	*cumulative*	*0*	*0*	*0*	*0*	*630*	*930*	*1205*	*1805*	*2105*	*2105*	*2105*	*2405*	*3305*	*3910*	*4940*	*5850*	*7160*	*7820*
								each year	*0*	*0*	*0*	*0*	*630*	*300*	*275*	*600*	*300*	*0*	*0*	*300*	*900*	*605*	*1030*	*910*	*1310*	*660*

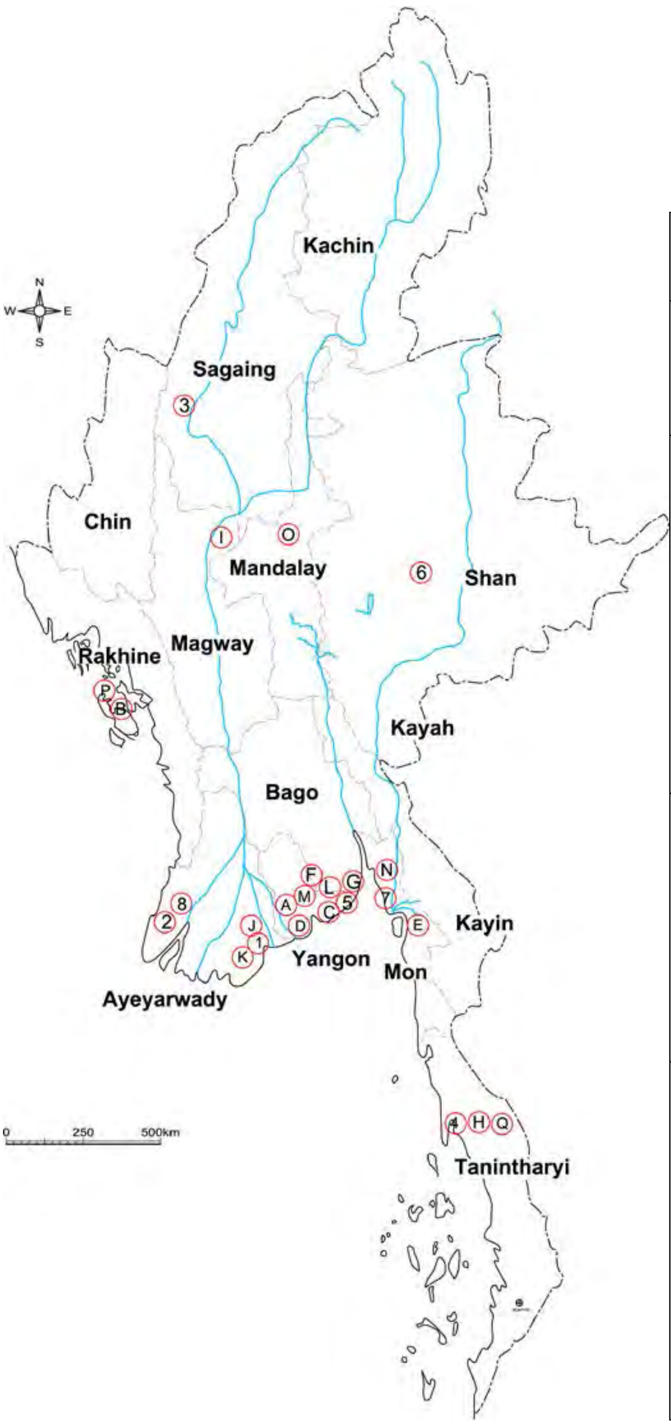
Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.



No.	Project	Installed Capacity for Myanmar(MW)	Operation Year
1	Nancho (MOEP)	40	2013-14
2	Chipwi Nge (JV)	99	2013-19
3	Phyu (MOEP)	40	2014-15
4	Upper Paunglaung (MOEP)	140	2014-15
5	Baluchaung-3 (BOT)	52	2013-14
6	Upper Baluchaung (BOT)	30.4	2017-18
7	Projects (MOAI)	79	2014-15
8	Shweli-3 (MOEP)	1050	2019-20
9	Upper Yeywa (MOEP)	280	2018-19
10	Thahtay (MOEP)	111	2018-19
11	Upper Keng Tawng	51	2017-18
12	Middle Paunglaung	100	2018-19
13	Dee Doke	66	2018-19
14	Mong Wa (BOT)	50	2016-17
15	Ngotchaung (BOT)	16.6	2017-18
16	Upper Bu (MOAI)	150	2020-21
17	Keng Kham (MOAI)	6	2020-21
18	Middle Yeywa	320	2023-24
19	Bawgata	160	2023-24
20	Tanintharyi	600	2030-31
21	Upper Thanlwin (Kunlong) (JV)	700	2021-22
22	Naopha, Mantong (JV)	712	2022-23
23	Dapein-2 (JV)	84	2021-22
24	Shweli-2 (JV)	260	2022-23
25	Upper Sedawgyi (MOAI)	64	2030-31
26	Nam Tamhpak (JV)	100	2030-31
27	Gaw Lan (JV)	50	2026-27
28	Hkan Kawn (JV)	80	2026-27
29	Lawngdin (JV)	300	2028-29
30	Tongxingqiao (JV)	170	2028-29
31	Keng Tong (JV)	64	2026-27
32	Wan Ta Pin (JV)	17	2026-27
33	So Lue (JV)	80	2026-27
34	Keng Yang (JV)	20	2026-27
35	He Kou (JV)	50	2026-27
36	Nam Kha (JV)	100	2030-31
37	Namtu (Hsipaw)	50	2030-31
38	Mong Young	22	2030-31
39	Dun Ban	65	2030-31
40	Nam Li	82	2030-31
41	Nam Khot	25	2030-31

Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Fig. 5.4-5 Location of New HPPs



	No	Project	Installed Capacity for Myanmar (MW)	Operation Year
Gas Turbine	A	Ywama	240	2013-14
	B	Kyaukphyu (New)	50	2015-16
	C	Thilawa	50	2015-16
Combined Cycle	D	Ahlone	121	2013-16
	E	Mawlamyaing	230	2014-17
	F	Hlawga	486	2021-23
	G	Thaketa	1003	2015-27
	H	Kanpouk (New)	500	2022-28
	I	Myin Gyan (New)	250	2015-17
	J	Hlaingtharyar (New)	400	2025-26
	K	Ayeyarwady (New)	500	2024-25
Gas Engine	L	Hlawga	50	2013-16
	M	Ywama	50	2013-14
	N	Thaketa	50	2013-14
	O	Kyause (New)	82	2013-14
	P	Kyaukpyu (New)	4.4	2013-15
	Q	Kanpouk	20	2015-16
Coal	1	Yangon-Kunchangon (Virtue Land)	3270	2018-2031
	2	Ngayukong (Ayarwady Division,Tata)	550	2019-2027
	3	Kalewa (Sagaing Division)	540	2017-2026
	4	Boakpyin (Tanintharyi State)	250	2020-2029
	5	Yangon-Kyauktan	1300	2021-2030
	6	Keng Tong (Shan State)	600	2025-2030
	7	Thilawa (New)	360	2017-18
	8	Ngaputaw	700	2020-2028

Note: This figure consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.

Fig. 5.4-6 Location of New TPPs

5.4.3 Revised Demand and Supply Balance for Scenario 3

In 2030, the total installed capacity will be 27.0GW, with the installed capacity for Myanmar 23.6GW and actual capacity during the dry season 19.0GW (which includes the reserve margin (kW) of approximately 30% of the demand). See Fig. 5.4-7.

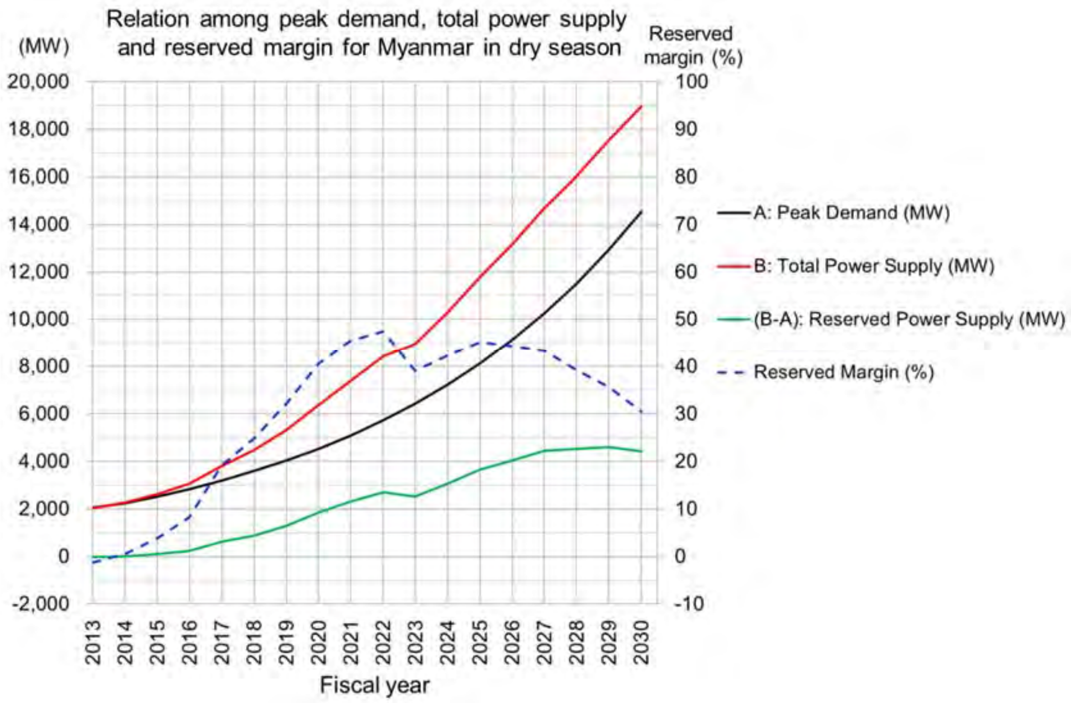
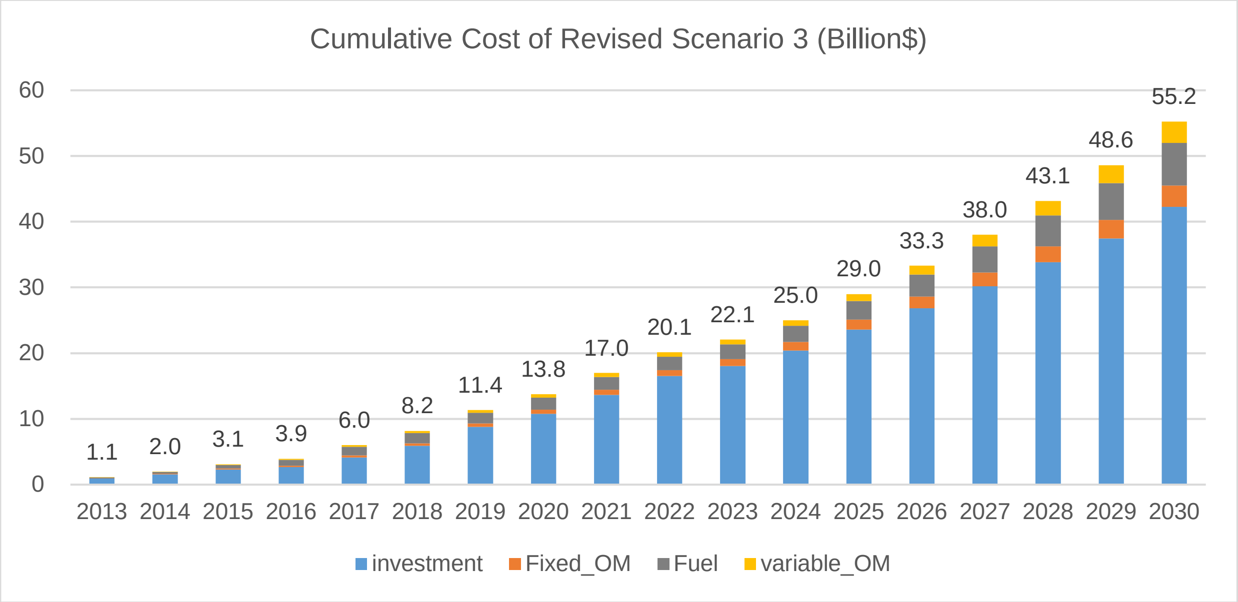


Fig. 5.4-7 Demand and Supply Balance during the Dry Season

5.4.4 Revised Total Cost and LRMC for Scenario 3

For the implementation cost of revised Scenario 3 until 2030, the capital cost will be approximately 42 billion USD and the O&M cost - including fuel cost - approximately 13 billion USD. The total cost is approximately 55 billion USD.



Cost is not calculated from present value. O&M cost and Fuel cost include the existing facilities.

Fig. 5.4-8 Cumulative Cost for Power Development

Calculation of the LRMC has been reviewed. As a result, the LRMC of revised Scenario 3 is 7.18 US cents/kWh (compared with the original Scenario 3, 7.99 US cents/kWh). As the operational year of the new coal-fired TPP is shifted outward, the value of LRMC decreases (Fig. 5.4-9).

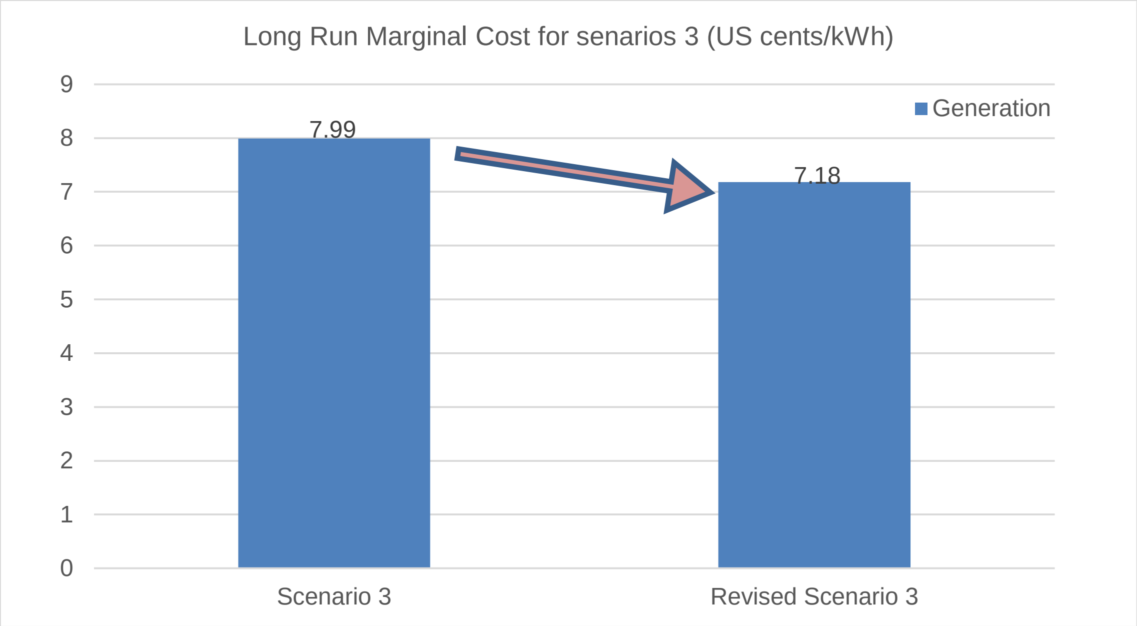


Fig. 5.4-9 Comparison of LRMC in Scenario 3 and Revised Scenario 3

5.5 CONCLUSION AND RECOMMENDATIONS FOR THE PGDP

5.5.1 Conclusion

(1) Current Status of Power Plants in Myanmar

JICA Study Team analyzed various data and new information on the existing, ongoing and future planned power plants, which are necessary for preparation of the PGDP. The status and key points of the main power sources are as follows.

1) Hydropower

Current actual capacity of hydropower is 1.1GW during the dry season, which is 50% of the installed capacity of the present plants. New large hydropower projects are located far from the major power demand areas, with development highly affected by environmental impacts. Medium and small hydro is economical and abundant as natural resources. Residual hydropower potential is estimated at 45.5GW.

2) Gas

The amount of current gas supply is 250 mmcfd to the power sector and will not be increased until March 2019, when M-3 is expected to commence supplying gas. The current actual capacity of gas-fired TPPs is 0.3GW, which is almost half of the installed capacity of all of the gas-fired TPPs at present. New gas plants will depend on securing a stable gas supply.

3) Coal

Currently, the only coal-fired TPP is Tigyit, with a capacity of 120MW (60 MW × 2 units). Domestic coal is of low quality but is marginally available for power generation. Coal is an economical resource and its procurement is not difficult. Power generation by imported coal and domestic coal will be used for the future base load.

(2) Formulation of Three Scenarios of the PGDP

Based on the facts, the PGDPs for the short/middle/long terms were prepared. Three scenarios - a domestic energy consumption scenario (large scale hydro oriented), a least cost scenario, and a power resources balance scenario - were proposed based on the conditions below.

1) Demand

Demand will reach 14.5GW in 2030, an annual energy increase rate of 13% on kWh basis.

2) Current power capacity

Total capacity as of May 2014 is 4.3GW, consisting of hydropower 3.0GW (70%), gas power stations 1.2GW (28%), and coal-fired power station 0.1GW (2 %).

3) Supply

Actual capacity during the dry season is 19.0GW, which includes a reserve margin (kW) of approximately 30% of the demand.

Close discussions on the comparison of three scenarios had been implemented between MOEP and JICA Study Team throughout this study. Finally, Scenario 3 “Power Resources Balance” is confirmed as the optimum one to be proceeded for further study at the workshop on 27th May 2014, considering utilization of domestic energy, supply conditions of each primary energy and overall energy security. Basic concepts are shown below.

- Utilization of the domestic clean energy is essential and hydropower is the promising resource. However, it has various risks for the implementation such as power supply in dry season and impacts on social and natural environments.
- Natural gas is also the prioritized domestic energy for the development. However, the potential of gas yields for the power generation is assumed to be insufficient temporarily.
- Considering these constraints, the 3rd reliable primary energy resource should be ensured to satisfy the rapid power demand increase through 2030. The power generation development including the introduction of best available coal thermal plants is realistic.

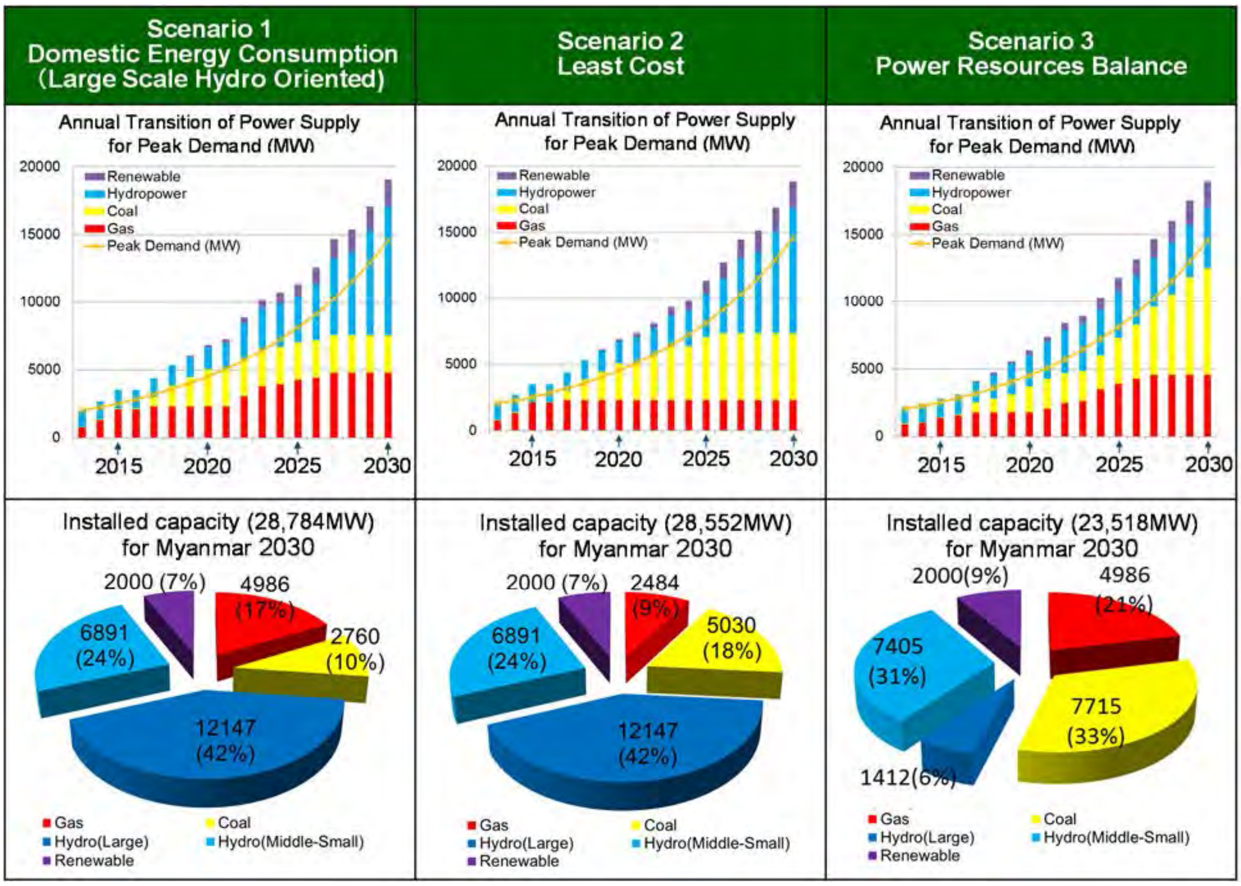


Fig. 5.5-1 Annual Transition of Power Supply and Installed Capacity for Myanmar in each Scenario

(3) Detailed Study of Scenario 3 "Power Resources Balance Scenario"

The features of each power source and the environmental mitigation for Scenario 3 are shown below.

1) Hydropower generation

Hydropower will be developed up to 9.4GW by 2030. Development is prioritized due to the required construction lead time and plant locations, etc.

2) Gas-fired power generation

The installed capacity of the existing gas-fired TPPs was 0.7GW in 2013. The power supply will increase from 0.3GW (currently) to 0.6GW through upgrades by 2020. The installed capacity will also increase to 0.8GW. New plants will be operated mainly by pipeline gas and partially liquid oil (2014 ~ 2021). The total new installed capacity is estimated to be 1.2GW in 2016 and at 4.0GW in 2030.

3) Coal-fired power generation

New on-site coal-fired TPPs will start operation from 2017 to 2030. Although domestic coal will be used totaling 1.14GW (Kalewa 0.54GW and Keng Tong 0.6GW), it will only be 15% of the total capacity of 7.82GW by 2030. Coal-fired TPPs using imported coal will start operation from 2017. Total new installed capacity for the plant using imported coal will be 6.68GW, which is 85% of the total 7.82GW.

4) Renewable

The PGDP sets a target of renewables for solar, wind, biomass, geothermal, etc. to be developed up to 2.0GW, which is equivalent to 10% of the power supply capacity by 2030.

5) Environmental mitigation

A package of renewables and pumped storage are effective measures to mitigate environmental effects as well as for maintaining system stability and reliability.

Greenhouse gas (CO_2) emissions from coal power stations can be resolved by new technology applications of USC coal power, integrated coal gasification combined cycles, carbon dioxide capture and storage, etc.

5.5.2 Recommendations

(1) Proposal of the Optimal PGDP

JICA Study Team collected information which is necessary for drafting plans for power supply, power supply composition, power supply introduction date, power supply point, and so on. All the information was integrated and discussions on the formulation of the optimum PGDP was implemented between MOEP and JICA Study Team within the context of total cost evaluation and power generation unit price evaluation for each power supply. The power supply composition proposed in this report is based on this basic policy. For new specific projects, it will be necessary to evaluate the site and determine the priority after reviewing validity, necessity, and so on.

Optimum power generation composition for Myanmar should be further studied by the GoM considering best utilization of domestic energy resources, supply conditions for each primary energy source and energy security.

In addition, the power supply composition proposed in this report depends upon various assumptions and uncertainties including the development situation and reserves of domestic gas, the international market price of coal, and the development availability of small and medium-sized hydropower projects. Therefore, it will be necessary to revise and update the PGDP periodically in the future.

This study aims to form the basis of PGDP in accordance with discussions with all concerned stakeholders considering demand forecast, primary energy, and environmental and social considerations. Sensitivity analyses concerning various conditions of the PGDP are expected to be key issues in the future.

(2) Short Term Countermeasures

Power loss reduction due to the rehabilitation of distribution lines and rehabilitation or replacement of power plants with poor fuel efficiency is effective as short term countermeasures to increase supply capacity. In addition, rehabilitation or replacement of failed parts is effective for some existing HPPs whose output has decreased because of deterioration. Rehabilitation or repowering projects need to be planned in a timely manner.

(3) Allocation of Gas Resources

In the context of appropriate allocation of limited gas resources, setting criteria for combustion efficiency and reviewing the IPP plans which do not meet these criteria, prioritization based on combustion efficiency could be used to determine allocation of gas for each power plant.

(4) Technical Transfer of the Simulation

This PGDP should be revised and updated in accordance with changes in the surrounding situation. Technical transfer concerning simulation software and calculation tools (such as WASP and Excel) has been implemented for MOEP staff concerned with this study. Continuous capacity building is also effective for them to better handle the PGDP by themselves.

CHAPTER 6

POWER SYSTEM DEVELOPMENT PLAN

CHAPTER 6 POWER SYSTEM DEVELOPMENT PLAN

6.1 OUTLINE OF THE POWER SYSTEM IN MYANMAR

The target of this study is facilities over 132kV and a section of 66kV facilities controlled by MEPE (Myanma Electric Power Enterprise). The existing power system along with the five-year power system development plan for Myanmar are shown in Fig. 6.1-1. In 2013, the maximum demand for electric power was 2,000MW, with approximately 50% of this demand concentrated around Yangon (the largest city in Myanmar). Within Myanmar, 75% of total demand is concentrated around Yangon and Mandalay.

In Myanmar, HPPs (hydropower plant(s)) have played the major role for the power generation development: currently, up to 2/3 of the rated capacity in the country is provided by hydropower. These HPPs had been developed primarily in northeastern part of the country. However, the high demand areas are located in the southern part of Myanmar. Therefore, until now, the 230kV power system has primarily been developed between the northern (generation) and southern (demand) areas.

The 230kV bulk power system was developed from the middle to the southern area of Myanmar via two main routes. Starting at the Thapyaywa substation, one of the routes runs through the eastern part of the country, while the other runs through the western. Those two routes connect with several HPPs before reaching the Yangon area.

A 132kV power system is supposed to complement the 230kV power system. It is located mainly in the northern areas of the country to bypass HPPs and the 230kV power system. They also play an important role in supplying power to rural areas.

Not only power plants, but power transmission facilities have been insufficiently developed as compared with other Southeast Asian countries. Technical problems relating to power transmission facilities include:

- Because most of the transmission lines consist of a single circuit, an accident could lead to a massive power outage.
- The capacity of transmission lines connecting northern and southern Myanmar are close to their limit.
- The numbers of aging facilities are increasing.

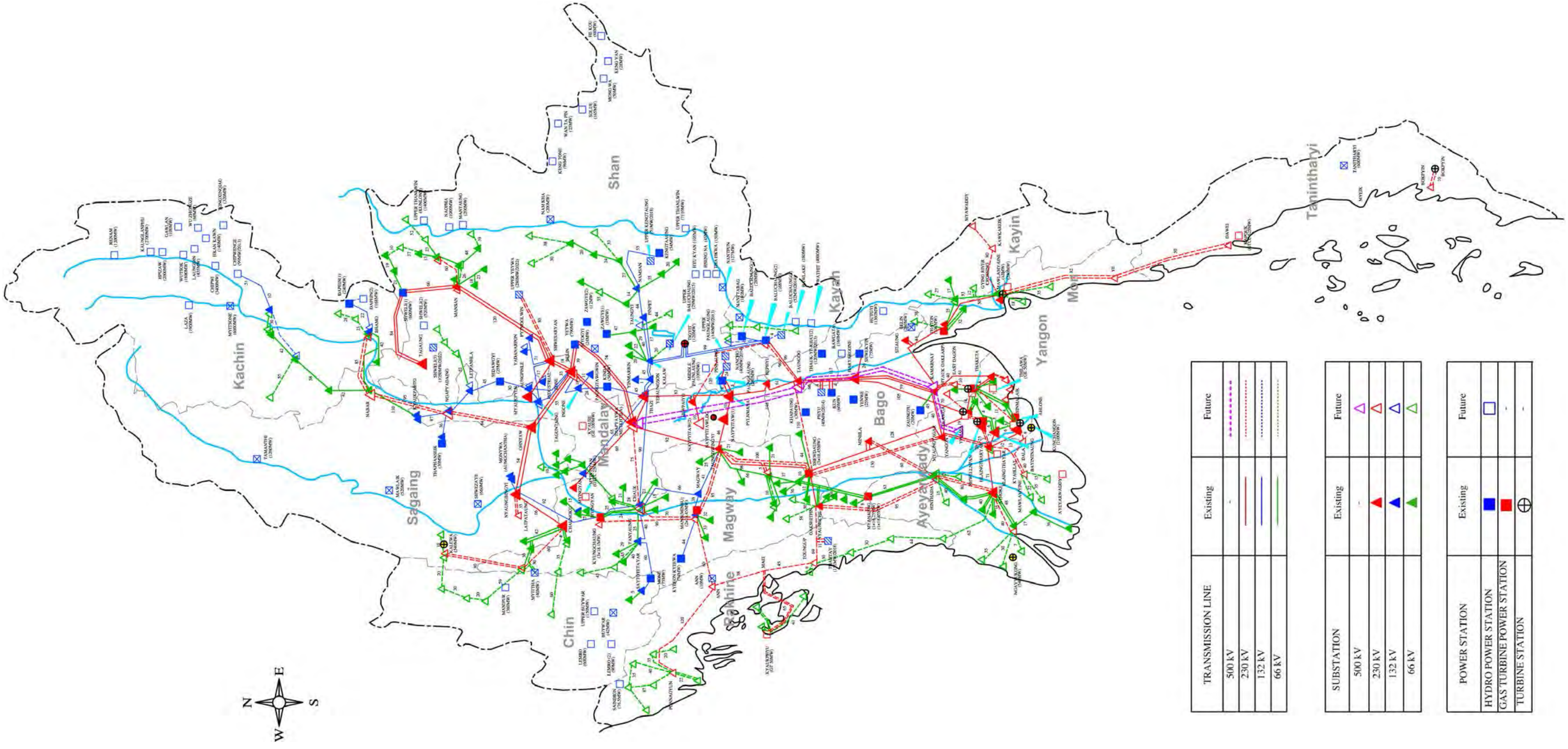
See Section 6.4 "Technical Problems of Transmission Power System" for further details. Transmission facilities in Myanmar are shown in Table 6.1-1.

Table 6.1-1 Transmission Facilities controlled by MEPE (as of 2013)

	230kV	132kV	66kV	**Total**
Number of T/Ls*	43	35	138	**216**
Length of T/Ls (km)	3,047	2,109	3,616	**8,772**
Number of substations	30	25	130	**185**
Substation rate (MVA)	3,760	1,323	1,975	**7,058**

*T/Ls: transmission lines

Source: MOEP (Ministry of Electric Power), 2013



Source: MOEP, 2013

Fig. 6.1-1 Existing Power System and the Five-Year Power System Development Plan

6.2 OUTLINE OF THE FIVE-YEAR POWER SYSTEM DEVELOPMENT PLAN (MEPE)

In this Section, the five-year plan for power system development plan as prepared by MEPE is described.

Table 6.2-1 Development Plan of Power System through 2015 by Region/State

No.	State/Region	Transmission Lines				Substations							
		500kV (mile)	230kV (mile)	132kV (mile)	66kV (mile)	500kV		230kV		132kV		66kV	
						No.	MVA	No.	MVA	No.	MVA	No.	MVA
1	Kachin State		285	60	89			3	300	1	60	5	34
2	Kayah State				145					2	150	3	65
3	Kayin State		80		39			2	200			2	10
4	Chin State				85							3	15
5	Mon State				91							6	100
6	Rakhine State		65		374							11	87
7	Shan State		60		213			2	200	1	100	5	50
8	Sagaing Region		80		30			1	100	1	100	3	20
9	Tanintharyi Region		142					2	200			2	20
10	Bago Region	167	366			2	1000						
11	Magway Region		385		65			4	400	3	180	2	20
12	Mandalay Region				38	1	500	2	200	4	400	3	60
13	Ayeyarwady Region		240		202			2	200			11	160
14	Yangon Region		135					5	900				
Total		**167**	**1,838**	**60**	**1,371**	**3**	**1,500**	**23**	**2,700**	**12**	**990**	**56**	**641**

Source: MOEP, 2013

6.2.1 Major Projects

The power system development plan until 2015 is shown in Fig. 6.2-1. Major projects include:

- Development of 230kV transmission lines from the north to the south (running through the middle of the country).
- Expansion of the 230kV power transmission system to transmit electric power to western, southwestern, and southern areas.
- Installation of new transmission lines for connecting new power stations to the grid.

The development of transmission lines for connecting northern to southern areas is important because these lines currently have low transmission capacities and are a weak link for the entire system. In consideration of the increase in power demand in the southern, some transmission lines which require immediate countermeasures have already been improved.

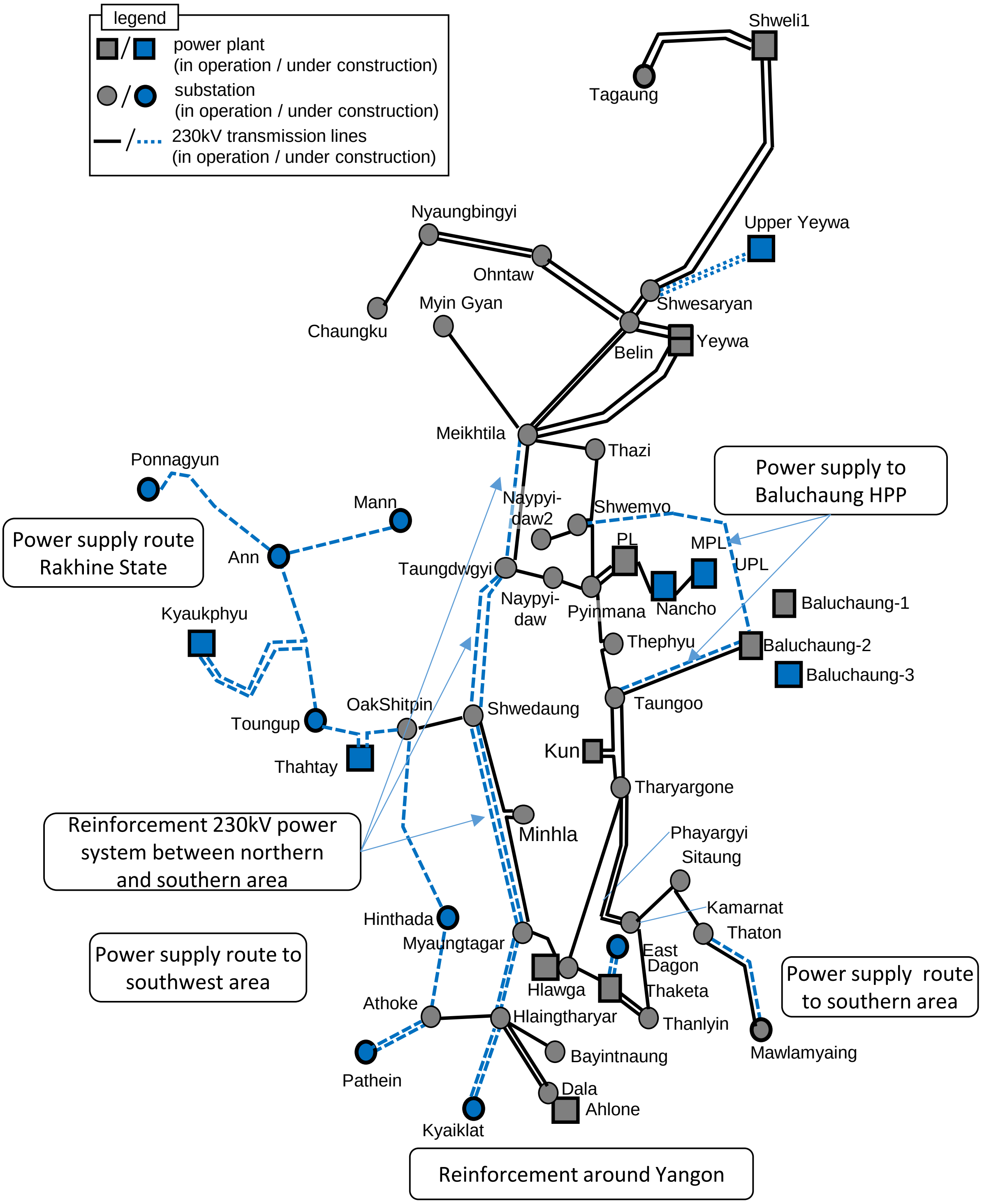


Fig. 6.2-1 Power System (existing and under construction) through 2015

6.2.2 Development Plan for Transmission Lines

The development plan for transmission lines through 2015 is shown in Table 6.2-2.

Table 6.2-2 Development Plan of Power Transmission Lines through 2015

No	Substation A	Substation B	Voltage Level (kV)	Length		Number of Circuit	Conductor Type	Number of conductors /Phase
				miles	km			
1	Baluchaung-2	Shwemyo	230	120.0	193.1	Single	605 MCM (Duck)	2
2	Upper Yeywa	Shwesaryan	230	80.0	128.8	Double	605 MCM (Duck)	2
3	Mann (minbuu) GT	Ann	230	67.0	107.0	Single	795 MCM (Drake)	1
4	Ann	Ponna KyunTong	230	116.0	186.0	Single	796 MCM (Drake)	1
5	OakShitpin	Toungup	230	61.3	98.6	Single	795 MCM (Drake)	1
6	Toungup	Kyuakphyu (GT)	230	108.4	174.4	Single	795 MCM (Drake)	1
7	Kyuakphyu (GT)	Ann	230	98.1	157.8	Single	795 MCM (Drake)	1
8	Athoke	Pathein	230	40.0	64.4	Single	605 MCM (Duck)	2
9	Oakshitpin	Hinthada	230	95.0	153.0	Single	605 MCM (Duck)	1
10	Hinthada	Athoke	230	80.0	128.8	Single	605 MCM (Duck)	2
11	Thaketa	East Dagon	230	10.0	16.1	Double	605 MCM (Duck)	2
12	Hlaingtharyar	Kyaiklat	230	30.0	48.3	Single	605 MCM (Duck)	1
13	Taungdwgyi	Shwedaung	230	100.0	160.9	Single	605 MCM (Duck)	2
14	Myaungtagar	Hlaingtharyar	230	28.0	45.1	Single	605 MCM (Duck)	2
15	Thaton	Mawlamyaing	230	50.0	80.5	Single	605 MCM (Duck)	2
16	Shwedaung	Myaungtagar	230	130.0	209.3	Double	605 MCM (Duck)	2
17	Washaung	Waingmaw (Myithyina)-Mogaung	132	70.0	112.7	Single	397.5 MCM (IBIS)	1
18	Baluchaung-3	Baluchaung-2	132	3.6	5.8	Single	397.5 MCM (IBIS)	1

Source: MOEP, 2014

6.2.3 Development Plan for Substations

The development plan for substations through 2015 is shown in Table 6.2-3 to Table 6.2-5 below.

Table 6.2-3 Development Plan of Substations in 2013

No.	Name of Substation	Location	Voltage Level (kV)	Rated Capacity (MVA)	Nos; of Transformer	Shunt Reactor (MVAR)	Condenser (MVAR)	COD*
1	Bhamo	Kachin State, Bhamo	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
2	Nabar	Sagaing Division, Nabar	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
3	Ngapawdine	Sagaing Division, Ngapawdine	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
4	Myothit	Kachin State, Bhamo	66 / 11	2	1	-	-	2014
5	Dawponyan	Kachin State, Bhamo	66 / 11	2	1	-	-	2014
6	Phayarkone (Zartabyin)	Kayin State, Zartabyin	66 / 11	5	1	-	-	2014
7	Falam	Chin State, Falam	66 / 11	5	1	-	-	2014
8	Taingin	Chin State, Thinengin	66 / 11	5	1	-	-	2014
9	Mindat	Chin State, Mindat	66 / 11	5	1	-	-	2014
10	Ramree	Rakhine State, Ramree	66 / 11	5	1	-	-	2014
11	Thandwe	Rakhine State, Thandwe	66 / 11	5	1	-	-	2014
12	Taunggyi	Shan State, Taunggyi	132/ 66	60	1 (3ϕ)	-	-	2014
13	Mineshoe	Shan State, Taunggyi	66/ 11	5	1	-	-	2014
14	Kalay	Chin State, Kalay	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
		Chin State, Kalay	66/ 11	10	1	-	-	2015
15	Dawei	Tanintharyi Division, Dawei	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
		Tanintharyi Division, Dawei	66/ 11	10	1	-	-	2015
16	Ye	Tanintharyi Division, Ye	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	50	50	2015
		Tanintharyi Division, Ye	66/ 11	10	1	-	-	2015
17	Taungtwingyi	Magway Division, Taungtwingyi	132/ 66	100	1	-	-	2015
18	Mogok	Mandalay Division, Mogok	66/ 33	30	1	-	-	2014
19	Chaungthar	Ayeyarwady Division, Chaungthar	66/ 11	10	1	-	-	2014
20	Ngwesaung	Ayeyarwady Division, Ngwesaung	66/ 11	10	1	-	-	2014
21	Kamnee	Ayeyarwady Division, Pathein	66/ 11	10 + 10	2	-	-	2014
22	Kytelat	Ayeyarwady Division, Kytelat	230/ 66/ 11	100	1 (3ϕ)	-	-	2015
23	Dala	Yangon Division, Dala	230/ 33/ 11	100	1 (3ϕ)	-	50	2015

*COD : Commercial Operation Date

Source: MOEP, 2013

Table 6.2-4 Development Plan of Substations in 2014

No.	Name of Substation	Location	Voltage Level (kV)	Rated Capacity (MVA)	Nos; of Transformer	Shunt Reactor (MVAR)	Condenser (MVAR)	COD
1	Hpakant	Kachin State, Hpakant	66/ 11	10	1	-	-	2015
2	Mogaung	Kachin State, Mogaung	132/ 66	60/ 60	1 (3ϕ)	-	-	2015
3	Loikaws	Kayah State, Loikaw	132/ 66	50/ 50	2 (3ϕ)	-	-	2015
			132/ 33	50 /50	1 (3ϕ)	-	-	2015
4	Shadaw	Kayah State, Shadaw	66/ 11	5	1	-	-	2015
5	Bawlakhe	Kayah State, Bawlakhe	66/ 33	30	1	-	25	2015
6	Hpasawng	Kayah State, Hpasawng	66/ 33	30	1	-	25	2015
7	Kawkareit	Kayin State, Kawkareit	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	-	25	2016
8	Myawaddy	Kayin State, Myawaddy	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	-	25	2016
9	Hlinebwe	Kayin State, Hlinebwe	66/ 11	5	1	-	-	2015
10	Chaungzon	Mon State, Chaungzone	66/ 11	30	1	-	-	2015
11	Thanbuzayat	Mon State, Thanbuzayat	66/ 33	10	1	-	-	2015
			66/ 11	10	1	-	-	2015
12	Mawlamyaing	Mon State, Mawlamyaing	66/ 33	20	1	-	-	2015
			66/ 11	20	1	-	-	2015
13	Buthitaung	Rakhine State, Buthitaung	66/ 11	5	1	-	-	2015
14	Minbya	Rakhine State, Minbya	66/ 33	5	1	-	-	2015
			66/ 11	10	1	-	-	2015
15	Kyeintali	Rakhine State, Kyeintali	66/ 11	5	1	-	-	2015
16	Gwa	Rakhine State, Gwa	66/ 11	2	1	-	-	2015
17	Taungup	Rakhine State, Taungup	66/ 11	2	1	-	-	2015
18	Rathedaung	Rakhine State, Rathedaung	66/ 11	5	1	-	-	2015
19	Buthidaung	Rakhine State,Buthidaung	66/ 11	5	1	-	-	2015
20	Maungdaw	Rakhine State,Maungdaw	66/ 11	5	1	-	-	2015
21	Theinni	Shan State, Theinni	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	25	25	2015
22	Mansan (Ext;)	Shan State, Mansan	230/ 66/ 11	60 / 60	4 (1ϕ)	25	-	2015
23	Kutkhaing	Shan State, Kutkhaing	66/ 11	5	1	-	-	2015
24	Kyethe	Shan State, Kyethee	66/ 11	5	1	-	-	2015
25	Lashio	Shan State, Lashio	66/ 33	30	1	-	5	2015
26	Moemate	Shan State, Moemate (Mabein)	66/ 11	5	1	-	-	2015
27	Kalaywa	Chin State, Kalaywa	66/ 11	5	1	-	-	2015
28	Thinengin	Chin State, Thinengin	66/ 11	5	1	-	-	2015
29	Monywar (Aungchanthar) (Ext;)	Sagaing Division, Monywa	132/ 33	50 / 50	2 (3ϕ)	-	25	2015
30	500 kV Bago (Kamarnat)	Bago Division, Bago	500/ 230/ 33	500/ 500/ 166	7 (1ϕ)	100	100	2017
31	500 kV Taungoo	Bago Division, Taungoo	500/ 230/ 33	500/ 500/ 166	7 (1ϕ)	100	100	2017
32	Gangaw	Magway Division, Gangaw	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2016
33	Chauk (Ext;)	Magway Division, Chauk	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2016
			132/ 66	60/ 60	1 (3ϕ)	-	-	2016
34	Kyaunchaung	Magway Division, Kyunchaung	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2016
35	Aunglan	Magway Division, Aunglan	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2016
36	Thayet	Magway Division, Thayet	66/ 11	15	1	-	-	2015
37	Kanma	Magway Division, Kanma	66/ 11	5	1	-	-	2015
38	Mintone	Magway Division, Kanma	66/ 11	2	1	-	-	2015
39	Pauk	Magway Division, Pauk	66/ 11	5	1	-	-	2015
40	Saw	Magway Division, Saw	66/ 11	2	1	-	-	2015
41	Tharzi (Ext;)	Mandalay Division, Tharzi	132/ 33	50 /50	2 (3ϕ)	-	-	2016
42	Nyaung Oo	Mandalay Division, Tharzi	66/ 11	10	1	-	-	2015
43	500 kV Meikhtila	Mandalay Division, Meikhtila	500/ 230/ 33	500/ 500/ 166	7 (1ϕ)	100	100	2017
44	Ngazon	Mandalay Division, Ngazon	66/ 11	20	1	-	-	2015
45	Aungpinlae (Ext;)	Mandalay Division, Aungpinlae	132/ 33	50 /50	2 (3ϕ)	-	-	2016
46	Industry Zone	Mandalay Division, Mandalay	132/ 33	50 /50	2 (3ϕ)	-	-	2016
47	Hinthada	Ayeyarwady Division, Hinthada	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	-	25.00	2015
			66/ 11	10	2	-	-	2015
48	Phyarpone	Ayeyarwady Division, Phyarpone	66/ 33	10	1	-	-	2015
			66/ 11	10	2	-	-	2015
49	Bokalay	Ayeyarwady Division, Bokolay	66/ 11	10	1	-	-	2015
50	Laymyatnar	Ayeyarwady Division, Hinthada	66/ 11	5	1	-	-	2015
51	Danuphyu	Ayeyarwady Division, Danuphyu	66/ 11	5	1	-	-	2015
52	Mawlamyaing gyun	Ayeyarwady Division, Mawgyun	66/ 11	5	1	-	-	2015
53	Shwelinpanm	Yangon Division, Hlaingtharyar	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	-	25	2015
54	Myaukoakkalarpa Industrial Zone	Yangon Division, North Oakkalar	230/ 33/ 11	100/ 100/ 30	2 (3ϕ)	-	25	2015
55	Thida GIS	Yangon Division, Botataung	230/ 66/ 11	200/ 200/ 60	2 (3ϕ)	-	25	2015

Source: MOEP, 2013

Table 6.2-5 Development Plan for Substations in 2015

No.	Name of Substation	Location	Voltage Level (kV)	Rated Capacity (MVA)	Nos; of Transformer	Shunt Reactor (MVAR)	Condenser (MVAR)	COD
1	Matupe	Chin State, Matupe	66/ 11	2	1	-	-	2016
2	Beelin	Mon State, Beelin	66/ 11	10	1	-	-	2016
3	Mabain	Shan State, Mabain	66/ 11	5	1	-	-	2016
4	Buddha Gone (Ext;)	Magway Division, Pakokku	132/ 66	60/ 60	1 (3ϕ)	-	25	2016
5	Bellin (Ext;)	Mandalay Division, Bellin	230/ 33/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2017
6	Meikhtila (Thapyawa) (Ext;)	Mandalay Division, Meikhtila	230/ 33/ 11	100/ 100/ 30	4 (1ϕ)	-	25	2017
7	Thilawa	Yangon Division, Thanlyin	230/ 33/ 11	100/ 100/ 30	1 (3ϕ)	-	25	2016
8	Dala	Yangon Division, Dala	230/ 33/ 11	100/ 100/ 30	1 (3ϕ)	25	25	2016

Source: MOEP, 2013

6.3 POWER SYSTEM OPERATION

6.3.1 Structure of Power System Operation

The structure for power system operation in Myanmar is shown in Fig. 6.3-1.

(1) LDC (Load Dispatch Center)

The LDC is in Yangon on the premises of YESB (Yangon City Electricity Supply Board); it controls and adjusts demand and supply for the entire power system.

The LDC develops a generation plan based on the demand forecast, requests to generate power from the GCC (Generation Control Center), and gives orders to jurisdictional TPPs (thermal power plants) (excluding coal-fired TPPs) and control power system.

Regarding demand and supply adjustments, a frequency meter is used, with LDC ordering individual power plants to control their generation and load shedding by phone as required. The LDC used to monitor the system using a monitoring board which gathered information from power plants and substations via radio communication; however, since the band frequency for radio waves has been assigned for telephone communication, the LDC is left with only the phone for communication.

(2) NCC (National Control Center)

The NCC is at Naypyitaw on the premises of MOEP (Ministry of Electric Power) and reports to MOEP regarding the power system operational situation. In addition, the NCC supports the LDC and the GCC (for example, the NCC assists in the restoration of services in case of massive outages).

(3) GCC (Generation Control Center)

The GCC issues orders to HPPs and coal-fired TPPs. The GCC controls the outputs of units for every power plant based on requests to decrease and increase generation from the LDC.

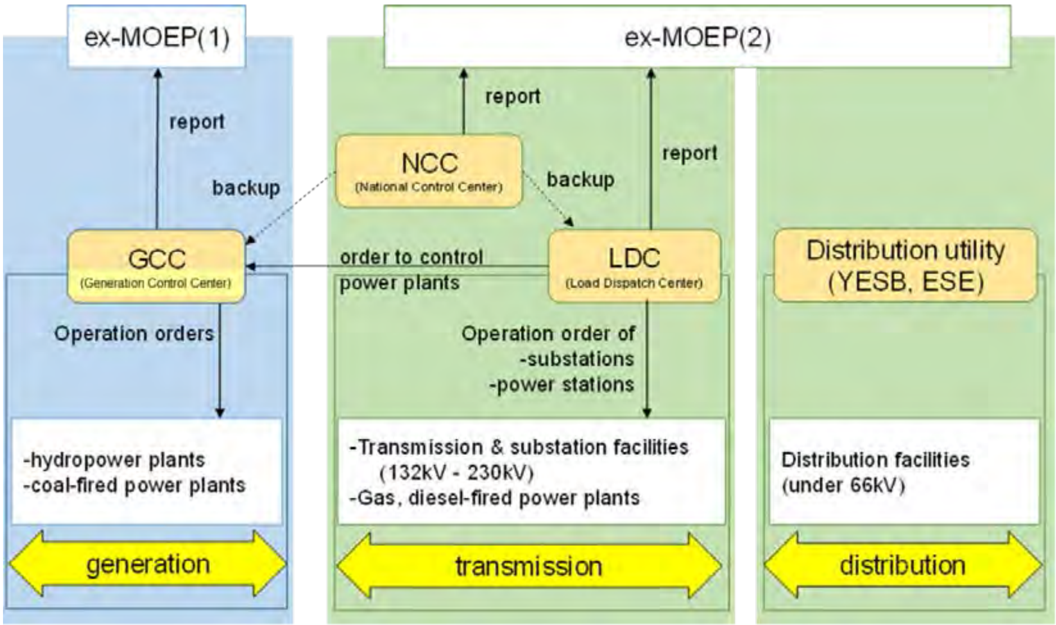
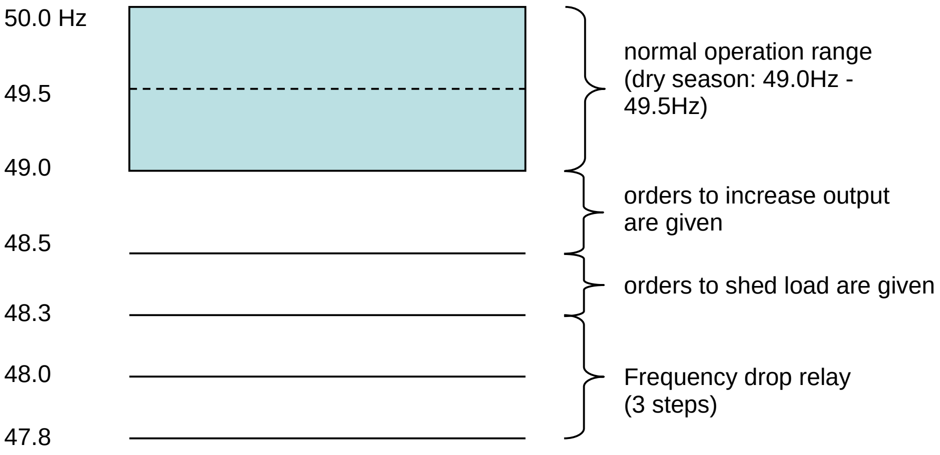


Fig. 6.3-1 Duty Structure of Power System Operations

6.3.2 Demand and Supply Control

The management criteria for daily operation of frequency control is shown in Fig. 6.3-2.

In normal situations, the frequency is controlled between 49.5Hz and 50.0Hz during the rainy season and between 49.0Hz and 49.5Hz during the dry season. When frequency is estimated to fall below its lower limit, orders to increase the output from power plants are given. During seasons when the frequency is anticipated to be out of control, load shedding is arranged on a monthly basis. Implementation of load shedding is approved by MOEP. If the frequency falls below 48.5Hz, the LDC implements load shedding under its own authority. Electricity consumers in Myanmar, however, mainly keen on if they have power or not. As such, there seems to be no complaints about effects to the equipment caused by frequency fluctuations.

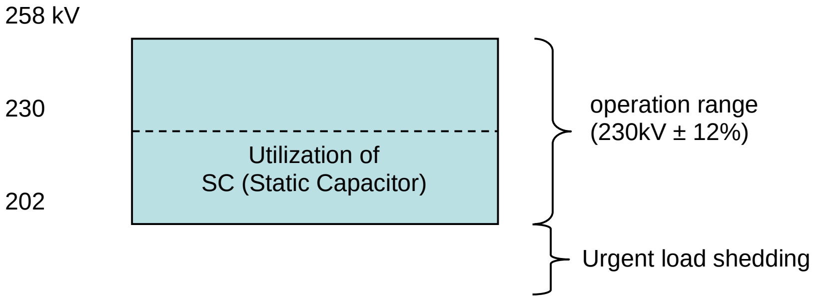


Source: Interview from LDC

Fig. 6.3-2 Management Criteria for Frequency Control

6.3.3 Voltage Control

The management criteria applied in daily operations for voltage control is shown in Fig. 6.3-3.



Source: Interview from LDC

Fig. 6.3-3 Management Criteria for Voltage Control

Voltage is controlled within 230kV ± 28kV (12%). In general, voltages in the north, where many HPPs are located, are higher than those around Yangon. When voltages fall below its lower limit, load shedding is implemented in substations around Yangon to maintain it within its normal operating range. During the rainy season, when output from TPPs around Yangon fall to between 250MW and 200MW, voltage problems become obvious.

6.3.4 Introduction of the SCADA System

Introduction of the SCADA (Supervisory Control And Data Acquisition) system is shown in Table 6.3-1.

Table 6.3-1 Introduction of the SCADA System

	Timing of introduction	Targeted facilities	Functions
Phase 1	2014 - 2015	Introduce control system of Naypyitaw LDC, Yangon RCC[*1], and Mandalay RCC in NCC (Equipment for RCC are to be installed at Naypyitaw as the temporary ones, and then those will be relocated to Yangon and Mandalay in the future) SCADA system will be introduced in 55 substations including 8 substations equipped with function of remote control. Substations(8): Belin, Thapyaywa, Pyinmana, Taungoo, Kamarnat, Taungdwgyi, Hlawga, Thaketa	- Communication: PLC[*2] method - Data collection of 230kV and 132kV facilities from targeted power stations and substations - for the meantime: remote control will not be operated - Operation will be controlled by Yangon LDC continuously
Phase 2	2016 onward (Not decided)	(Connection) -Connection between hydropower stations and their nearby substations -Interface connection for communication and control between hydropower stations and NCC and/or RCC (Communication) -Implementation of SDH[*4] (Control) -Implementation of control panel complied with IEC61850	- Communication: OPGW[*3] or PLC method - Remote monitoring/control - NCC will adjust demand and supply and operates bulk power system. - RCC will be planned to operate targeted local power system

*1 RCC : Regional Control Center
*2 PLC: Power Line Carrier
*3 OPGW: Optical Fiver Ground Wire
*4 SDH: Synchronous Digital Hierarchy

Source: Interview from NCC

6.3.5 Implementation of the SCADA System (Phase 1)

Progress of implementation of the SCADA system (Phase 1) is as follows (as of July 2014).

- Request for bidding : May 2012
- Contract : March 2013
- Supplier of SCADA system : Siemens
- Implementation as of July 2014 : 1 power station and 12 substations.
- Number of implementations until end of October, 2014 (Accumulated total) : 1 power station and 26 substations.
- Completion of implementation : end of July 2015

A diagram of the communication system between the NCC and substations - including connections within NCC is shown in Fig. 6.3-4. PLC (Power Line Carrier) is adopted as communication method between NCC and each substation with PLC communication panels. Within NCC, the server and each control panel for operators are connected with dual LAN types.

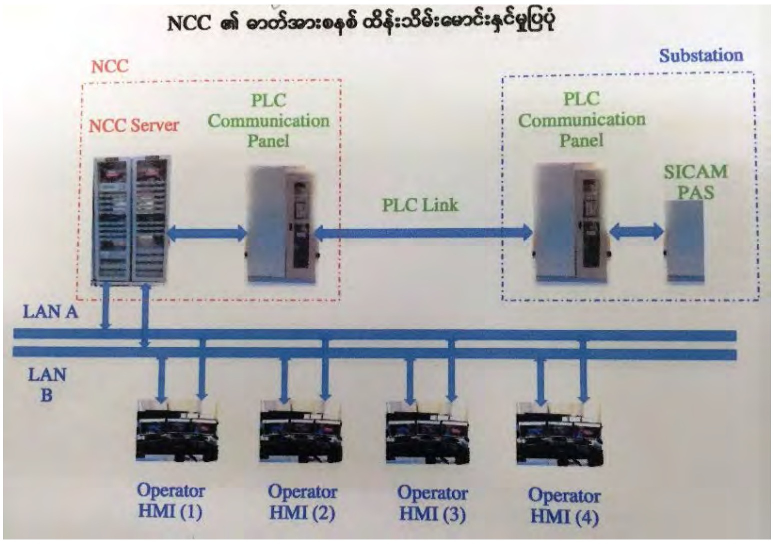


Fig. 6.3-4 Image of the Communication System among related Facilities

A diagram of the communication system between NCC and RCC (Regional Control Center) is shown in Fig. 6.3-5 below. PLC is adopted as the communication method for each server via PLC communication panels. This RCC server also has buckup functions.

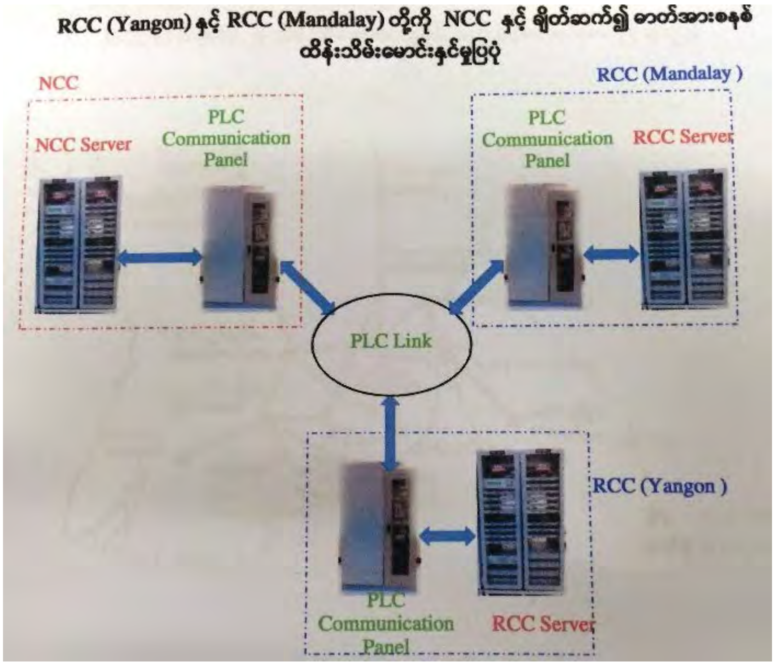


Fig. 6.3-5 Communication System between NCC and RCC

An image of the control room in NCC and its layout are shown in Fig. 6.3-6.

Fig. 6.3-6 Image of the Control Room in NCC and its Layout

6.3.6 Recommendations for Planning of Optimum Power System Operation

As described in Section 6.3.1, power plant operations are carried out through the two different organizations. For the HPPs and coal TPPs, the GCC is in charge of operations. For the gas TPPs and other power plants, the LDC is in charge of operations.

To establish the optimal power system operating planning, it is necessary to supervise power generation in all plants in order to ensure adequate reserve margin and to make suitable adjustments for periodical plant inspections (to better control the economic efficiency of the overall system). Therefore, a new organization that unites GCC and LDC is required.

The introduction of SCADA in major substations and the NCC is currently underway. However, HPPs that have already been developed also require the implementation of SCADA. This is a negative consequence of the dueling operating schemes. Therefore, the control center and the HPPs need to be slated for SCADA systems in a second phase of SCADA introduction projects in order to establish a new control organization. That would lead to more effective operations overall.

After the completion of SCADA rollouts, the NCC in Naypyitaw will become the central control center and two RCCs will be placed to Yangon and Mandalay respectively. Responsibilities would include:

NCC : Demand forecast, generation plans, demand and supply adjustments, power system operation planning, restoration planning during serious accidents, support of RCC and capacity building for operators.

RCC : Power system operation in northern areas (Mandalay RCC) and southern areas (Yangon RCC), adjustment of planned outages for maintenance, protection scheme for the power system, and back-up of NCC in case of emergency.

6.4 TECHNICAL PROBLEMS OF THE TRANSMISSION POWER SYSTEM

In this Section, technical problems of the transmission power system are covered.

(1) Weak Bulk Power System

As for main 230kV bulk power system in Myanmar, there are many sections that have only a single circuit. Normally, an extra high voltage power system is composed of two circuits. This is in order to keep transmitting power in case of failure of the single circuit due to accidents or scheduled outages for maintenance. As the power system in Myanmar developed under a peculiar historical background, the reliability is exceptionally low.

In Fig. 6.4-1 below, the number of large scale black outs of the bulk power system from 2010 to 2013 is shown. In 2010, most blackouts were due to a lack of power supply; after 2011, blackouts were mainly caused by accidents. Myanmar as a whole is completely blacked out for over twenty minutes more than ten times a year on average. Possessing a tropical climate where thunderstorms occur frequently, the power system is better composed of two circuits rather than one.

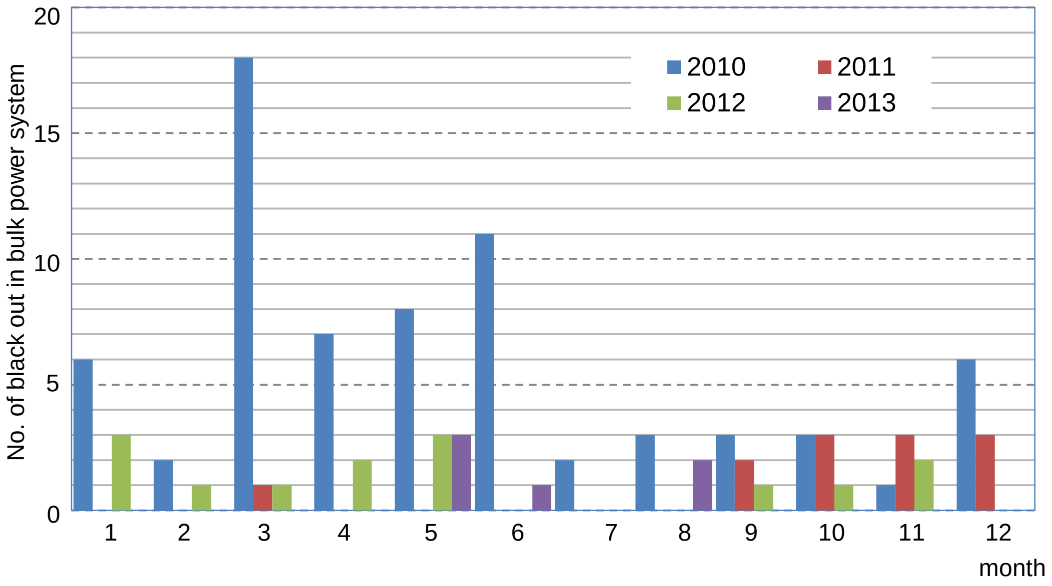


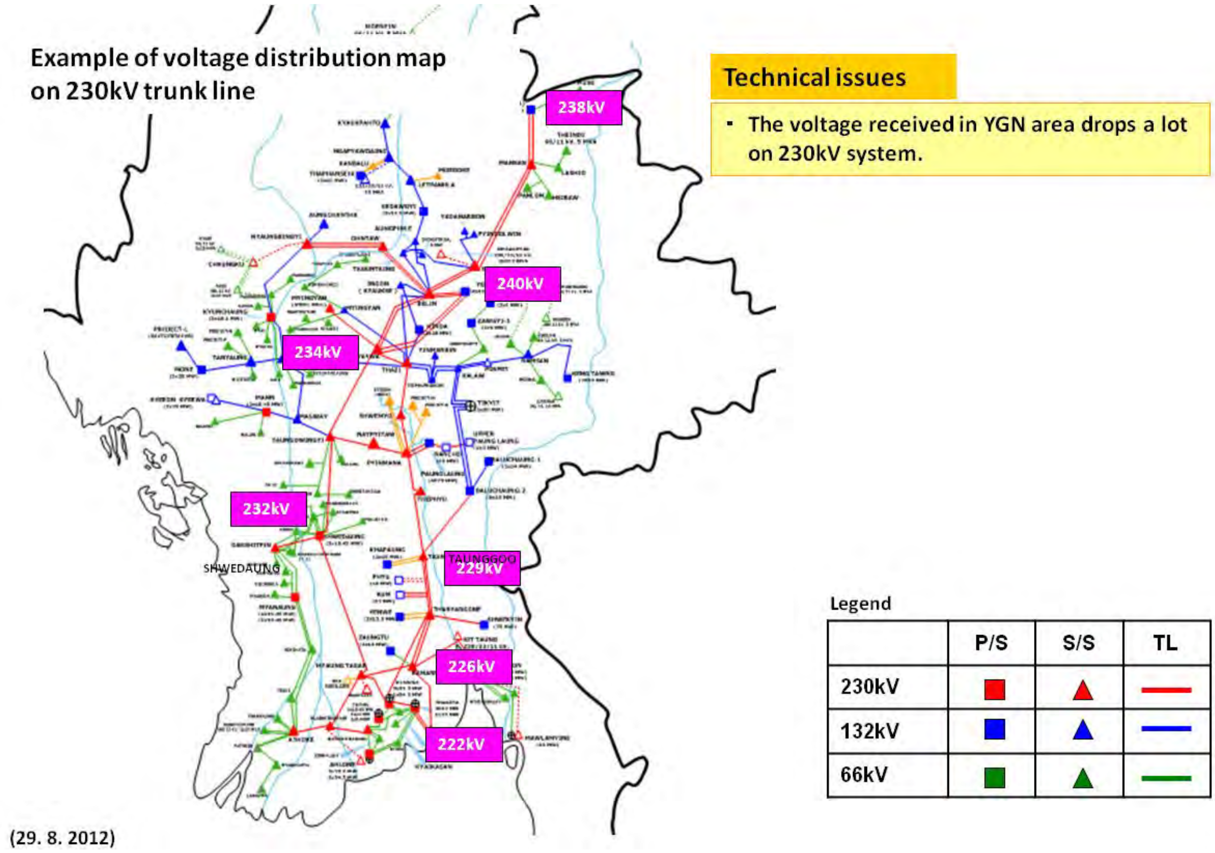
Fig. 6.4-1 Number of Black Outs in the Bulk Power System (January 2010 to August 2013)

Source: prepared by data provided from Power System Department

(2) Voltage Drop

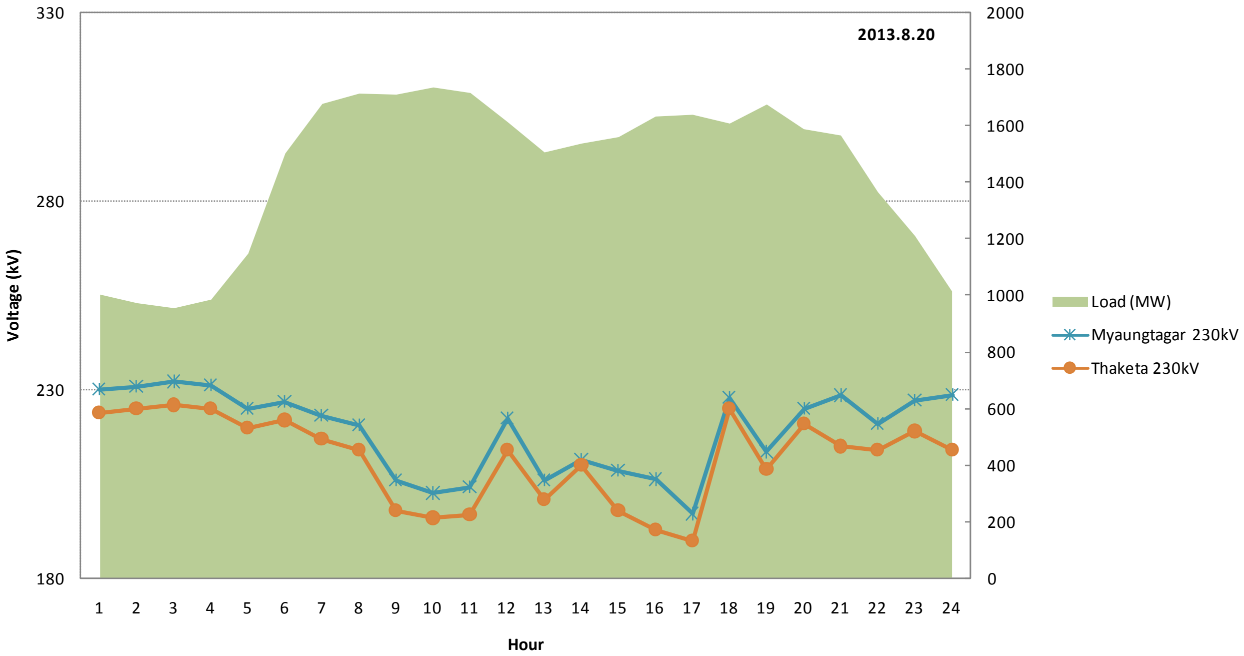
In Myanmar, electric power is transmitted from the north to the south. This eventually leads to a voltage drop, which is a major problem for the country. Fig. 6.4-2 shows the voltage distribution for the 230kV power system. In the figure, about 10% of voltage is dropped while transmitting electrical power from the northern power plants to the southern demand area. Fig. 6.4-3 shows voltage for the Myaungtagar and Thaketa substations in Yangon as well as demand for the whole of Myanmar. According to the figure, the voltage operated under 230kV throughout the day. Particularly when the power output from TPPs around Yangon are low (under 250MW), voltage is significantly dropped during peak demand hours because of heavy power flow from the north and middle areas of the country. Excessive voltage drops not only make it difficult to maintain voltage for the under 132kV power system, but also increases transmission losses. Further excessive voltage drops leads to voltage collapse, and a massive blackout occurs.

Whole capacitor banks around Yangon are already utilized to maintain voltage during the day. In addition, as a temporary measure, load shedding is initiated to prevent further voltage drops. There are several ways to supply stable power, including reduction of impedance of the transmission lines by multiple circuits and installation of capacitor and reactor banks.



Source: MOEP

Fig. 6.4-2 Voltage Distribution of 230kV Power System



Source: MEPE

Fig. 6.4-3 Voltage of 230kV Substations around Yangon

(3) Transmission Loss

Transmission loss in Myanmar is about 7%. Improving this is an urgent issue to be solved for countries like Myanmar, where the power supply situation is already tight. Reduction of transmission losses can be initiated by taking measures as previously mentioned above.

(4) Tight Transmission Capacity between North and South

Power plants are still planned for construction in the north, while demand is expected to increase mainly in the Yangon area. As such, increasing power transmission capacity between the north and the south is necessary.

In 2013, the limits for power transmission reached its capacity. During the rainy season, though HPPs can produce plenty of power, power plants are having their operations limited due to bottle necks in power transmission capacity. Reinforcement of power transmission facilities is necessary to transmit power from new HPPs in the north of the country to demand areas around Yangon.

Immediate countermeasures to eliminate limitations in transmission capacity are being implemented by replacing the current transformers with larger capacity ones as the power transmission capacity is limited by the capacity of the current transformers. This has already been carried out on the 230kV Pyinmana-Thephyu-Taungoo-Tharyargone route in the east.

(5) Aged Facilities due to Maintenance Issues

As stated above, facilities in Myanmar lack redundancy, even in the case of the bulk power system. This makes it necessary to cease supplying power when inspecting power transmission facilities. This contributes to a lack of appropriate maintenance. Facilities are basically under operation until they are completely damaged. As the number of aged facilities increases, the power supply reliability decreases.

In addition, TPPs around Yangon controlled by MEPE are now under constant operation as the base power generation source throughout the year. If there is enough capacity to transmit power from the north to the south, TPPs can stop their operations during the rainy season for inspection and required maintenance. Currently, this necessary time for maintenance is kept to a minimum, with degradation of facilities being one of the prime reasons for reductions in power output.

6.5 REVIEW OF THE SHORT TERM POWER SYSTEM DEVELOPMENT PLAN

System stability analysis performed by data provided by MEPE is as follows. The power flows of the bulk power system over a timeframe of several years were studied. Fig. 6.5-1 to Fig. 6.5-3 shows the power flow diagram through 2015 in the case of demand increases without reinforcement of the system. Fig. 6.5-4 shows the power flow diagram for the case of demand increases with reinforcement of the power system (planned to be constructed by 2015).

For this system stability analysis, the following five new HPPs will have been connected to the system as a precondition:

- Nancho HPP (40MW)	connected as of 2014;
- Baluchaung HPP (52MW)	connected as of 2014;
- Upper Paunglaung HPP (140MW)	connected as of 2014;
- Upper Baluchaung HPP (30MW)	connected as of 2015;
- Phyu HPP (40MW)	connected as of 2015.

Results of the analysis for the 230kV Thapyaywa power system (in the south) are shown below.

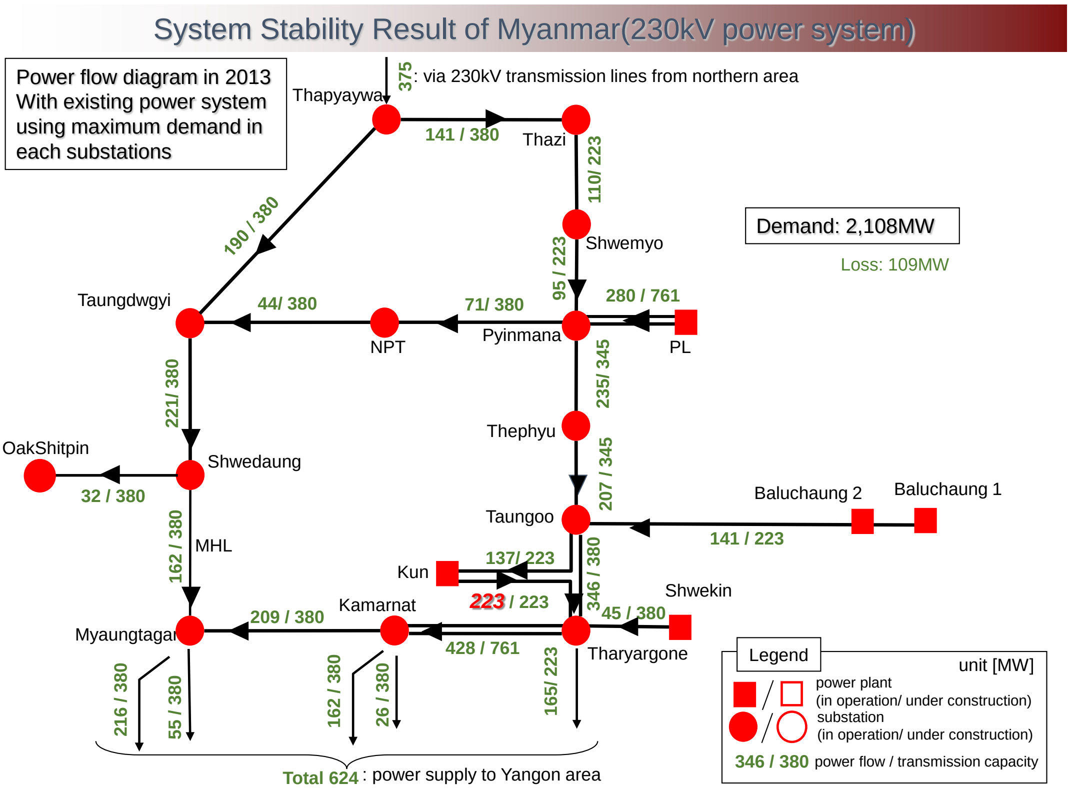


Fig. 6.5-1 Power Flow Diagram for Existing Power System (2013)

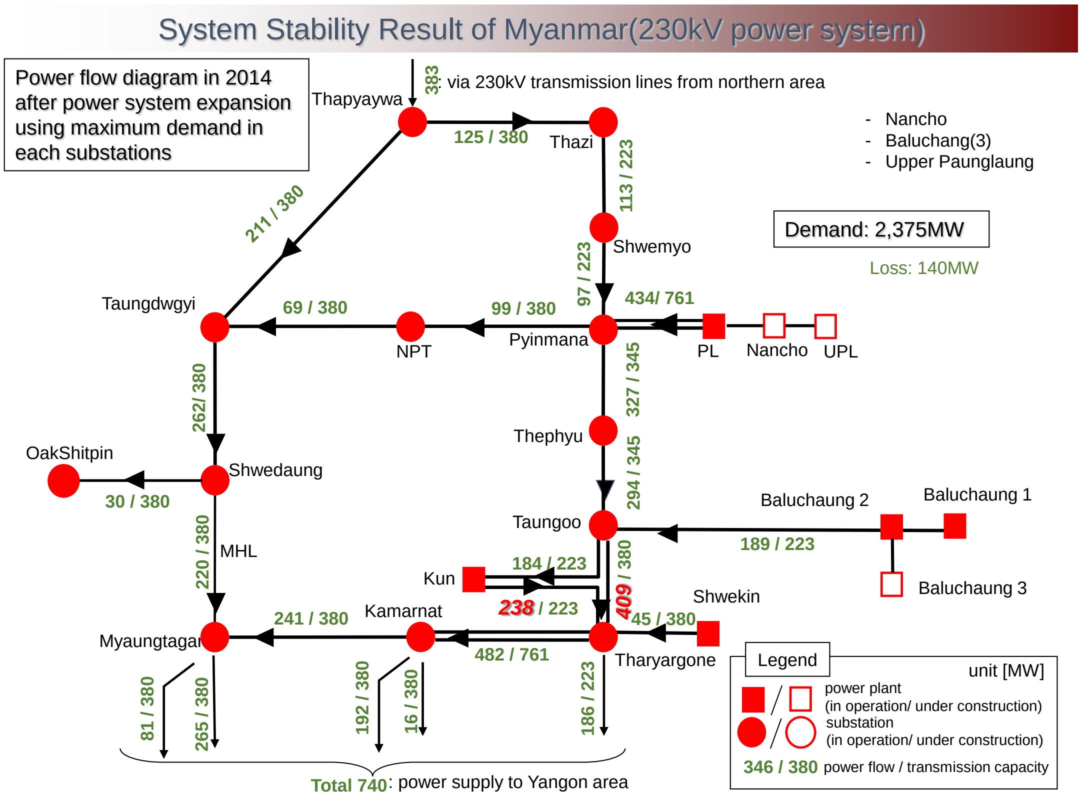


Fig. 6.5-2 Power Flow for Existing Power System (2014)

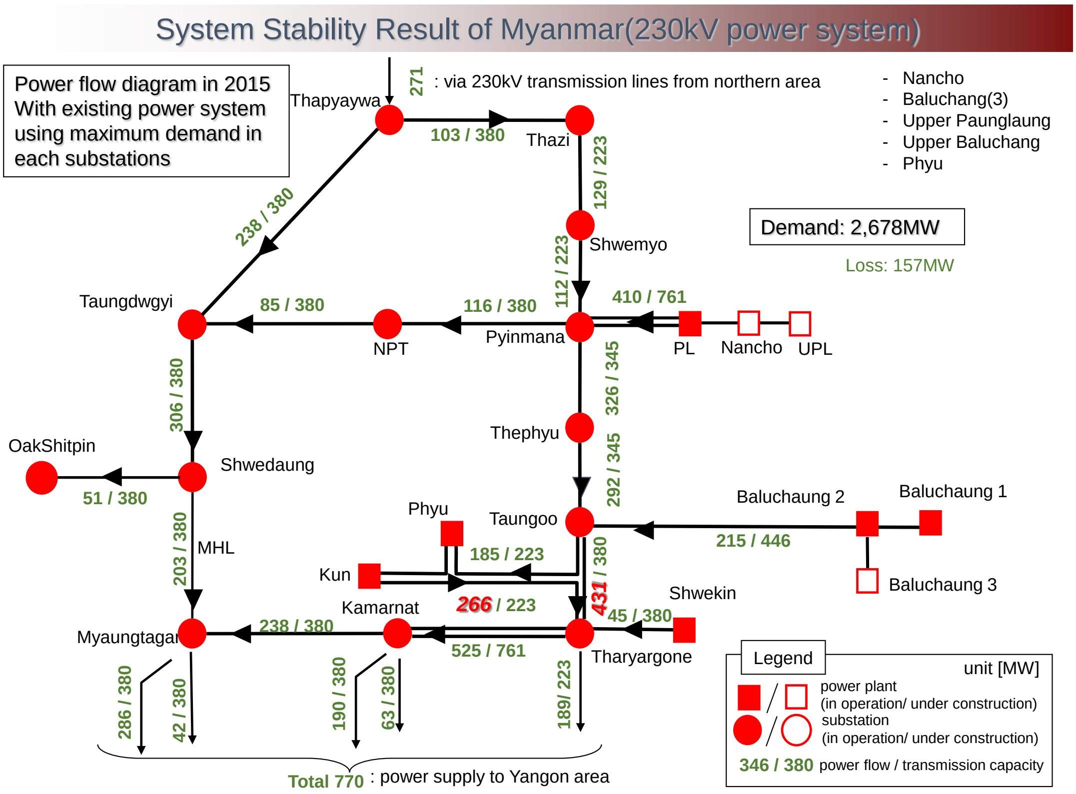


Fig. 6.5-3 Power Flow for Existing Power System (2015)

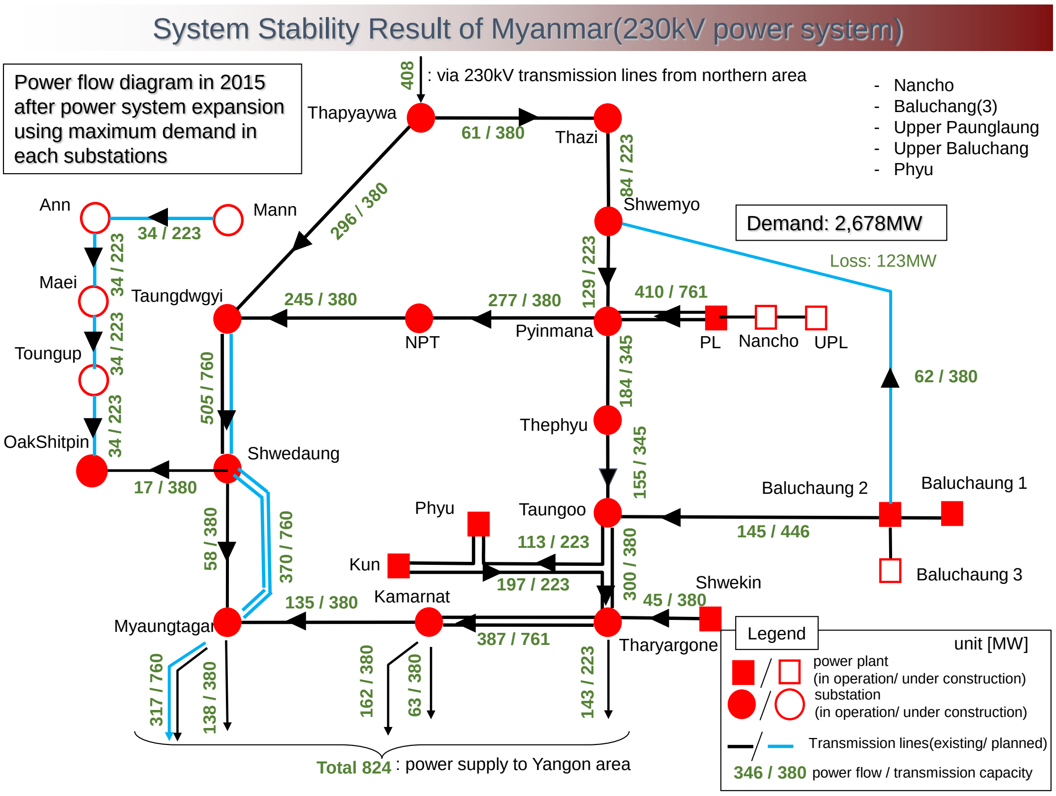


Fig. 6.5-4 Power Flow Diagram after Power System Expansion (2015)

It can be seen that if the power system is not reinforced, power flow for some sections - such as between Taungoo and Tharyargone - will exceed their transmission capacity limit. In actual operation, power output from the HPPs in the north must be suppressed so as not to exceed the transmission lines' capacity limits. In such a case, if there were no power plants that could generate power in the Yangon area, planned outages would become mandatory.

On the other hand, if planned reinforcements have been carried out as per Fig. 6.5-4, there would be no transmission line where the power flow could exceed its capacity (based on the demand forecast for 2015). Thus, over for the next several years, it is crucial to carry out the planned reinforcements of transmission lines and substations.

6.6 PRELIMINARY MIDDLE AND LONG TERM POWER SYSTEM DEVELOPMENT PLAN

6.6.1 Demand Setting for Substations in the Bulk Power System

Demand forecasts for all of Myanmar, as well as for every state and region, were carried out in Chapter 3. Based on the forecasts, JICA (Japan International Cooperation Agency) Study Team allocated the demand based on the high case for each substation in the bulk power system for 2020 and 2030. Demand was allocated to each substation according to a demand rate. The allocation results are shown in Table 6.6-1.

Table 6.6-1 Result of Demand Allocation for Each Substations in the Bulk Power System

Location	Substation	Voltage (kV)	2020 high case (MW)	2030 high case (MW)
Mandalay	Pyin-O-Lwin	132	24.62	100.22
	Aungpinlae	132	35.64	145.10
	Inngone	132	24.34	99.07
	Letpanhla	132	16.54	67.33
	Myin Gyan	132	21.80	88.73
	Tagundaing	132	42.44	172.77
	Yatanarbon	132	1.55	6.32
	Yinmarbin	132	0.33	1.36
	Yepaungsone	132	5.51	22.44
	Belin	230	20.00	81.42
	Shwemyo	230	16.31	66.39
	Shwesaryan	230	55.13	224.44
	Naypyidaw	230	31.30	127.41
	Thapyaywa	230	48.15	195.99
	Pyinmana	230	76.93	313.17
	Thazi	230	25.52	103.87
	Thephyu	230	27.67	112.64
	Myin Gyan (Stell Mill)	230	53.85	219.22
	Myaukpyin	230	123.12	501.18
	sub-total		**650.75**	**2,649.07**
Sagaing	Monyawa	132	31.75	97.53
	Kyaukpatoe	132	17.55	53.92
	Ngyapyadaing	132	14.46	44.43
	Nyaungbingyi	230	23.90	73.43
	Ohntaw	230	21.94	67.40
	Chaungku	230	0.59	1.81
	sub-total		**110.20**	**338.53**
Magway	Chauk	132	39.36	87.22
	Saytoattayar	132	1.21	2.68
	Tanyaung	132	3.92	8.69
	Magway	132	21.65	47.97
	Mann	132	2.66	5.89
	Kyunchaung	132	38.37	85.04
	Taungdwgyi	230	21.08	46.72
	sub-total		**128.25**	**284.21**
Shan	Kalaw	132	43.39	133.29
	Namsan	132	8.96	27.52
	Mansan	230	23.76	72.98
	Aungthapyay	66	36.00	110.57
	sub-total		**112.10**	**344.35**
Ayeyarwady	Athoke	230	77.38	286.41
	Myanaung	66	29.02	107.41
	sub-total		**106.40**	**393.82**
Bago	Kamarnat	230	40.34	148.65
	OakShitpin	230	31.60	116.43
	Shwedaung	230	58.56	215.80
	Taungoo	230	23.02	84.81
	Tharyargone	230	16.53	60.93
	sub-total		**170.05**	**626.62**
Yangon	Myaungtagar	230	246.08	771.33
	Thanlyin	230	166.87	523.04
	Hlawga	230	581.43	1,822.50
	Ahlone	230	316.79	992.96
	Bayintnaung	230	183.10	573.92
	Hlaingtharyar	230	228.75	717.00
	Thaketa	230	537.61	1,685.13
	Thida	66	159.63	500.35
	Ywama	33	285.36	894.46
	sub-total		**2,705.60**	**8,480.71**
Mon	Thaton	230	97.57	359.00
	Mawlamyaing	66	12.63	46.46
	sub-total		**110.20**	**405.46**
Kachin	Bhamo (Banmaw)	132	22.80	58.20
	sub-total		**22.80**	**58.20**
Kayar	Lawpita2 (Baluchaung-2)	132	13.30	23.28
	sub-total		**13.30**	**23.28**
Kayin	Kawkareik	230	45.60	117.37
	sub-total		**45.60**	**117.37**
Chin	Gantgaw	230	8.55	15.52
	sub-total		**8.55**	**15.52**
Tanintharyi	Meik (Myeik)	230	91.20	281.30
	sub-total		**91.20**	**281.30**
Rakhine	Taungup	230	28.50	87.30
	sub-total		**28.50**	**87.30**
TOTAL			**4,303.50**	**14,105.74**

6.6.2 Preliminary Review of the Middle Term Power System Development Plan

Three scenarios are reviewed from the viewpoint of power system development, respectively: Scenario 1 - priority on the Domestic Energy Consumption (Large Scale Hydro Oriented); Scenario 2 - priority on Least Cost; and Scenario 3 - priority on Power Resources Balance. To prepare a power system development plan based on demand forecasts and a corresponding power development plan, it is essential to have a rough idea of the demand and supply balance for the whole country. JICA Study Team divided Myanmar into five blocks - Northern, Middle, Western, Southern, and Yangon Area - then reviewed the power flow among and between the blocks.

To analyze the effect of decreases and increases of output by HPPs, JICA Study Team reviewed the power flow in during the rainy and dry seasons. Table 6.6-2 shows the output rates from HPPs during the dry and rainy seasons, respectively. As covered in Chapter 5, the rate of output on the rated capacities of HPPs are 50% during the dry season and 70% during rainy season. Output from TPPs is set to compensate for inadequate amounts of power.

Table 6.6-2 Output of HPPs (2020)

	Rainy Season	Dry Season
Output of HPPs (based on domestic supply capacity)	70%	50%

There are no significant differences for PGDPs (Power Generation Development Plan(s)) among the three scenarios until 2020. As such, JICA Study Team estimated the block balance of power flow that is common across all scenarios. The results are shown in Fig. 6.6-1.

The results showed that the main power flow feature in Myanmar is a large power flow from the north and middle areas of the country to Yangon Area until 2020. During the rainy season, the power flows from north to the middle areas and from middle areas to Yangon Area are approximately 1,500MW and 2,100MW, respectively. Power flows from the north and middle area, where HPPs are concentrated, to Yangon Area are reduced during the dry season when compared to the rainy season. This reduction in power supply is mostly compensated by TPPs from Yangon Area and the west.

The existing 230kV transmission line cannot adequately transmit this large power flow. Considering the continuous increase in demand for power, it will be necessary to implement a higher voltage power system in order to enable a larger power flow to be transmitted to Yangon Area. Currently, 500kV transmission line projects connecting the north to the south are planned. It is expected that when these projects are completed, the required transmission capacity will be ensured even during the rainy season (when the power flow from the north to the south is larger). At this time it is not deemed necessary to prepare 500kV transmission lines for western and southern areas where large power plants have yet to be planned.

This is only a simple case study carried out and presented for preliminary review; a detailed study is presented in Section 6.8.

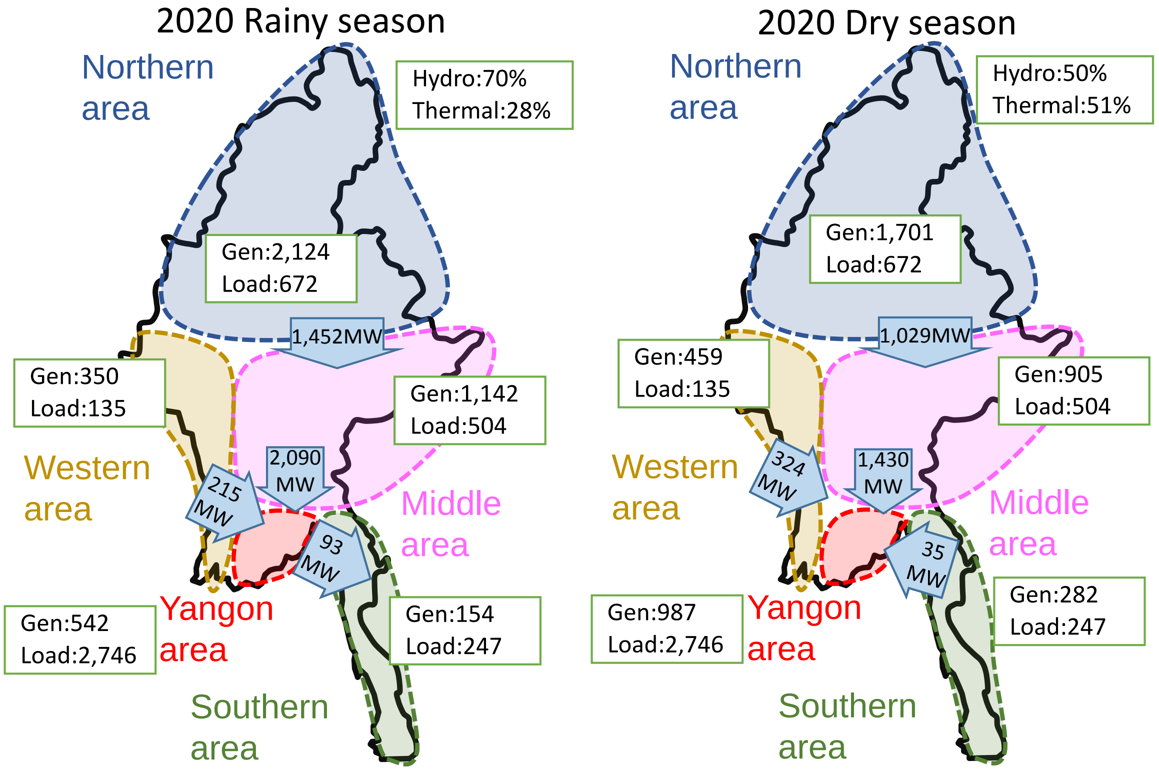


Fig. 6.6-1 Block Balance Diagram for High Case Demand in 2020

6.6.3 Preliminary Review of the Long Term Power System Development Plan

(1) Three Scenarios

As presented in Section 6.6.2, power flow among the blocks during the rainy and the dry seasons in 2030 has been reviewed. The preconditions for this review are the same as for the review in 2020.

The three scenarios can be classified into two groups: one group consisting of Scenarios 1 and 2 and the other consisting of Scenario 3. From the viewpoint of power system development planning, large hydro power development located in the north and northeast has great impact. These HPPs are generally located far away from Yangon, where main demand center is, in addition to their large scale of capacity. As mentioned in the generation development plan, additional 1,000MW class HPPs will be developed in Scenarios 1 and 2; on the other hand, middle and small scale HPPs are mainly planned in Scenario 3. Therefore, two case studies were carried out: one based on Scenarios 1 and 2, which includes large scale hydro development; and the other based on Scenario 3, with middle and small scale hydro development.

Results for the reviews of Scenarios 1 and 2, and Scenario 3 are shown in Fig. 6.6-2 and Fig. 6.6-3 respectively.

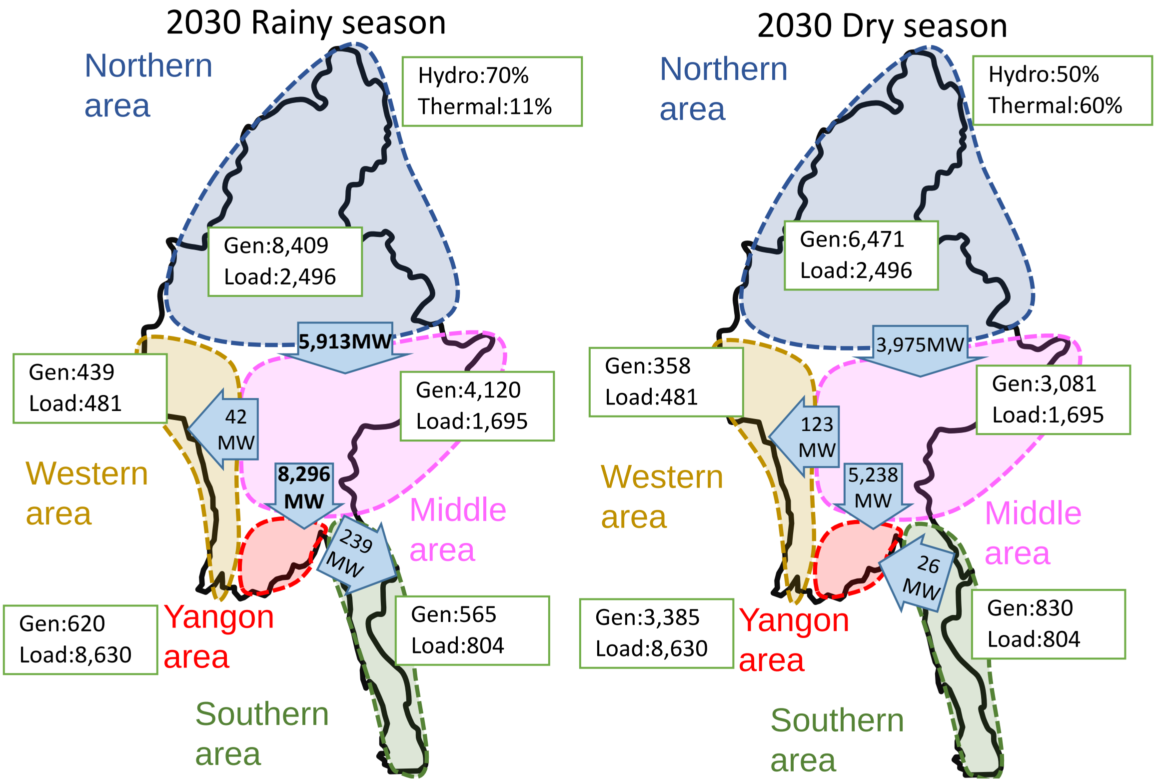


Fig. 6.6-2 Block Balance Diagram for High Case Demand in 2030 (Scenarios 1 and 2, Rainy and Dry Seasons)

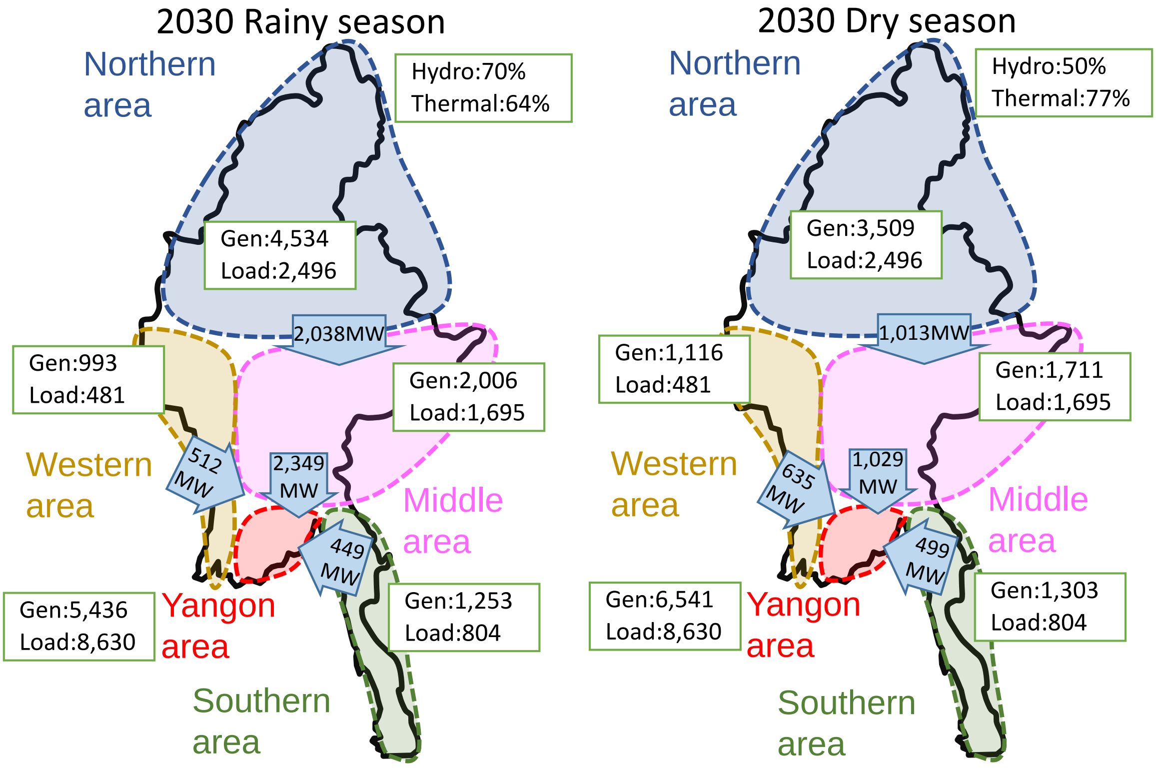


Fig. 6.6-3 Block Balance Diagram for High Case Demand in 2030 (Scenario 3, Rainy and Dry Seasons)

In Scenarios 1 and 2, transmission capacities of approximately 5,900MW from the north to the middle of the country and 8,300MW from the middle to Yangon are necessary during the rainy season. Considering a transmission length of approximately 1,000km from the HPPs in the north to Yangon, development of two DC (Direct Current) 500kV transmission routes (from the north to Yangon) and one AC (Alternating Current) 500kV transmission route from the middle of the country to Yangon are considered as necessary countermeasures. As for DC 500kV transmission lines, capacity is approximately 2,500MW in ± 500kV. It would be unnecessary to construct other 500kV transmission lines to connect blocks as there are no other blocks that show heavy power flows in both the rainy and dry season.

In Scenario 3, the power flow from the north to the south is smaller when compared with Scenario 1 and 2. Fig. 6.6-3 shows that during the rainy season, a transmission capacity of 2,100 - 2,200MW is necessary to transmit power from the north to the middle of the country and then on to Yangon. During the dry season, the power flow between the south and the north is relatively small. On the other hand, the power flow from the west and south to Yangon is increasing; however, the total amount is still less than 600MW.

(2) Alternative Plan

Considering the above results, there are two possible plans for bulk power transmission lines that connect the north and the south. The first plan consists of not constructing a second 500kV transmission route and instead restricting the output of HPPs by allocating the power output from TPPs during rainy season. The second plan is to construct a second 500 kV transmission route and utilize HPPs to their utmost limits.

However, it doesn't seem effective for Myanmar - where the demand for power is expected to grow rapidly - to select the option which limits the utilization of its abundant hydro resources. From this viewpoint, an additional 500kV transmission line development plan is recommended in Section 6.8.2.

6.6.4 Result of Preliminary Study of the Middle and Long Term System Plan

A system configuration outline and its development cost calculated until 2030 based on the preliminary study results and transmission line development plan provided by MOEP are shown in Fig. 6.6-4 and Table 6.6-3, respectively.

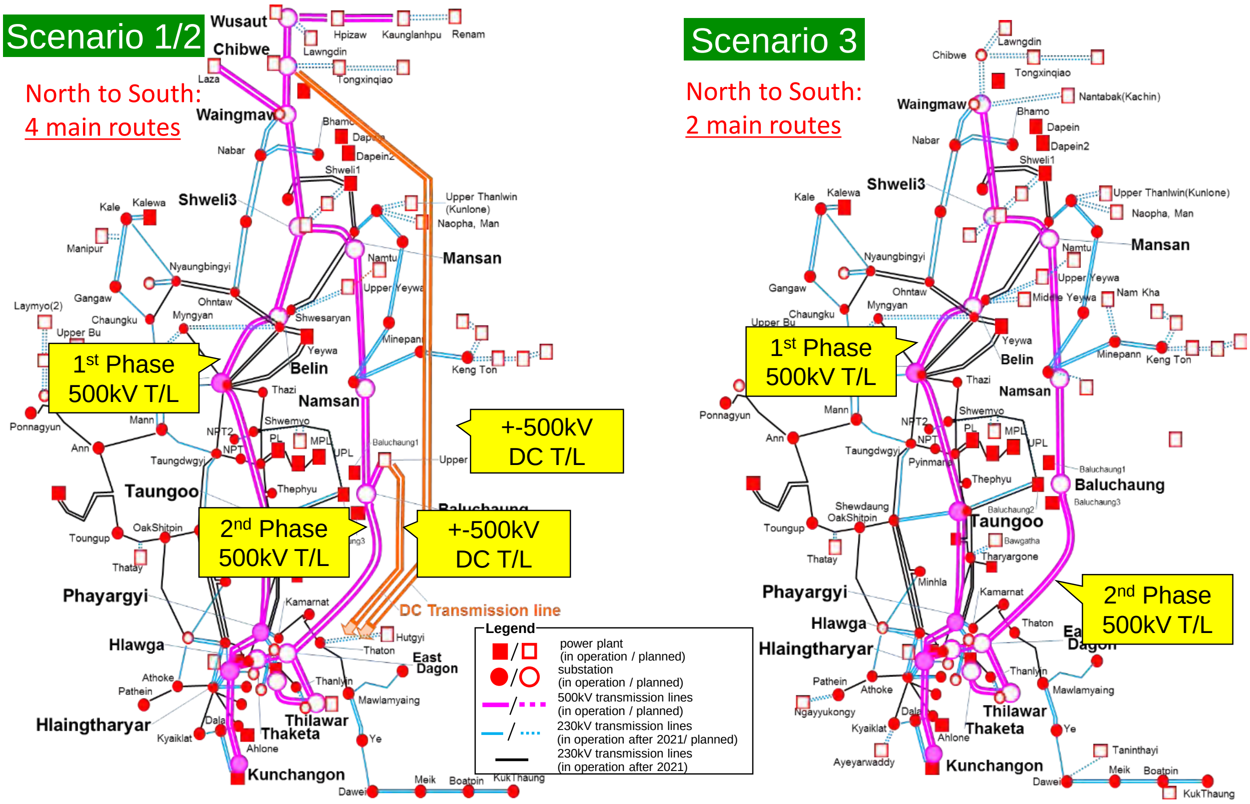


Fig. 6.6-4 *Preliminary Bulk Power System Development Plan (2020, Scenario 3)*

Table 6.6-3 *Preliminary Development Cost for Scenarios*

Scenario		No 1	No 2	No 3
Priority of PGDP		Domestic Energy Consumption (Large Scale Hydro Oriented)	Least Cost	Power Resources Balance
Middle term (2016 ~ 2020)	Main projects	500kV T/L	500kV T/L	500kV T/L
	500kV Cost	710 MUSD (570km, 5,000MVA)	710 MUSD (570km, 5,000MVA)	710 MUSD (570km, 5,000MVA)
	230-132kV Cost	1,660 MUSD (4,160km, 8,770MVA)	1,660 MUSD (4,160km, 8,770MVA)	1,660 MUSD (4,160km, 8,770MVA)
	Total	2,370 MUSD	2,370 MUSD	2,370 MUSD
Lon term (2021 ~ 2030)	Main projects	DC T/L 500kV T/L	DC T/L 500kV T/L	500kV T/L
	500kV Cost	4,680 MUSD	4,680 MUSD	2,480 MUSD
	230-132kV Cost	900 MUSD	900 MUSD	900 MUSD
	Total	5,580 MUSD	5,580 MUSD	3,380 MUSD

6.6.5 Coordination of the PGDP with MOEP

As described in Chapter 5, Scenario 3 -Power Resources Balance- is the optimum plan for Myanmar (as confirmed with MOEP through a series of workshops). As such, a detailed study was carried out based on Scenario 3.

6.7 MIDDLE AND LONG TERM POWER SYSTEM DEVELOPMENT PLAN

6.7.1 Power System Development Plan Policy

There is not firm standard for a power system development plan in Myanmar. Anticipating international connects in the future, the following standards were developed for this study with reference to the policies of neighboring countries.

(1) Basic Conditions

Under regular conditions:

- Facilities are not to exceed their rated capacity unnecessarily.
- System voltage is to be maintained within its variation range.

Under irregular conditions:

- Under contingency (N-1) criteria, supply failures will not occur until 2030.
- System voltage is to remain within its possible variation range under irregular conditions.
- Considering the effects of accidents and restoration after accidents, the operational limit for healthy facilities in irregular cases should be set at 110%.
- Considering the impact on lower voltage levels when severe accidents occur in higher voltage level systems, a loop system between different voltage levels should not be configured.

(2) Transmission Capacity of Conductors

The transmission capacity for each conductor per circuit is assigned as shown in Table 6.7-1.

Table 6.7-1 Transmission Capacity per Circuit

Conductor type	MCM	Ampere	MW (PF 0.85)		
			132kV	230kV	500kV
Ibis	397	433	84	-	-
Duck	605	562	109	190	-
Drake	795	660	128	223	485

(3) Voltage Variation Range

The allowable variation range for voltage is shown in Table 6.7-2.

Table 6.7-2 Allowable Variation Range for Voltage

	Allowable variation range of the nominal voltage
Normal Condition	± 5%
Abnormal Condition (Contingency (N-1) Criteria)	± 10%

(4) Fault Current

The maximum allowable fault current is shown in Table 6.7-3.

Table 6.7-3 Maximum Allowable Fault Current

Voltage Level (kV)	Maximum Allowable Fault Current (kA)
500	40 – 50
230	40 – 50
132	25 - 31.5

6.7.2 Middle Term Power System Development Plan

(1) Preconditions

Considering the geographical features of Myanmar, where power flows from the north to the south, the output for power plants is based on the case during the rainy season. A MEPE study of transmission lines and substation plans under 230kV for the whole country was provided as a basis.

(2) Outline of the Middle Term Power System

The bulk power transmission system development plan (2020) for Scenario 3 is shown in Fig. 6.7-1. In the figure, dashed lines represent new transmission lines developed after 2016, while bold and fine lines represent 500kV and 230kV transmission lines, respectively. The main features of this development plan is to locate 500kV transmission lines in the center of Myanmar as a framework for the transmission system, to develop transmission lines required to connect power plants listed in the generation development plan, and to expand transmission lines planned by MOEP. Regarding the 500kV system, new transmission lines between Shweli 3 - Belin - Meikhtila are considered crucial (transmission lines for Meikhtila - Taungoo - Phayargyi - Hlaingtharyar are already underway) to transmit power from Shweli-3 (a new HPP), which is planned to have a capacity of 1,000MW.

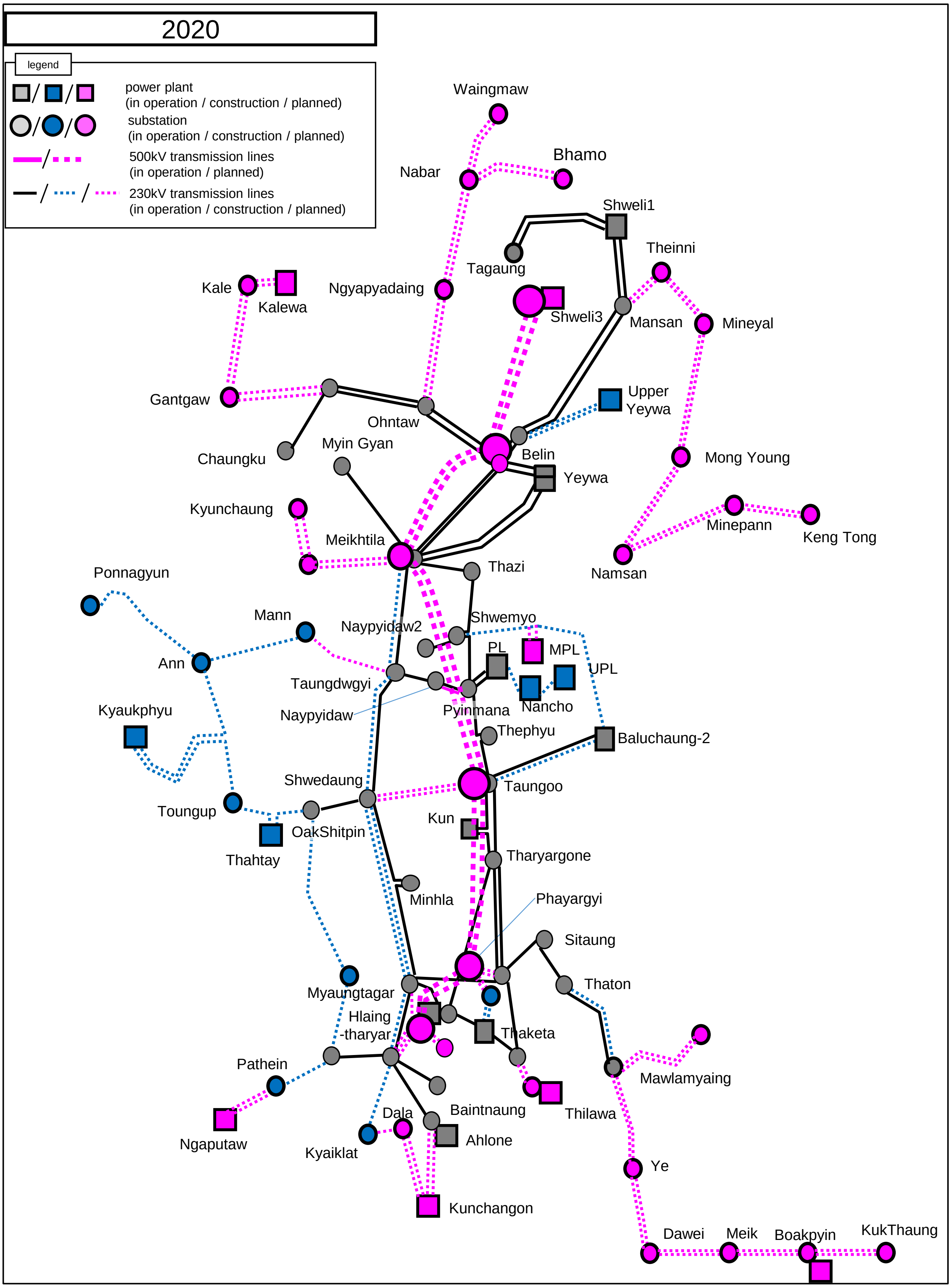


Fig. 6.7-1 ***Bulk Power System Development Plan (2020, Scenario 3)***

(3) Results of Power System Study

1) Power Flow Analysis

According to the development plan, a power flow study was conducted for Scenario 3. As shown in Fig. 6.7-2, the overall trend for power flows is that power generated by hydropower in the north is transmitted to south to high demand areas such as Yangon thorough 500kV transmission lines.

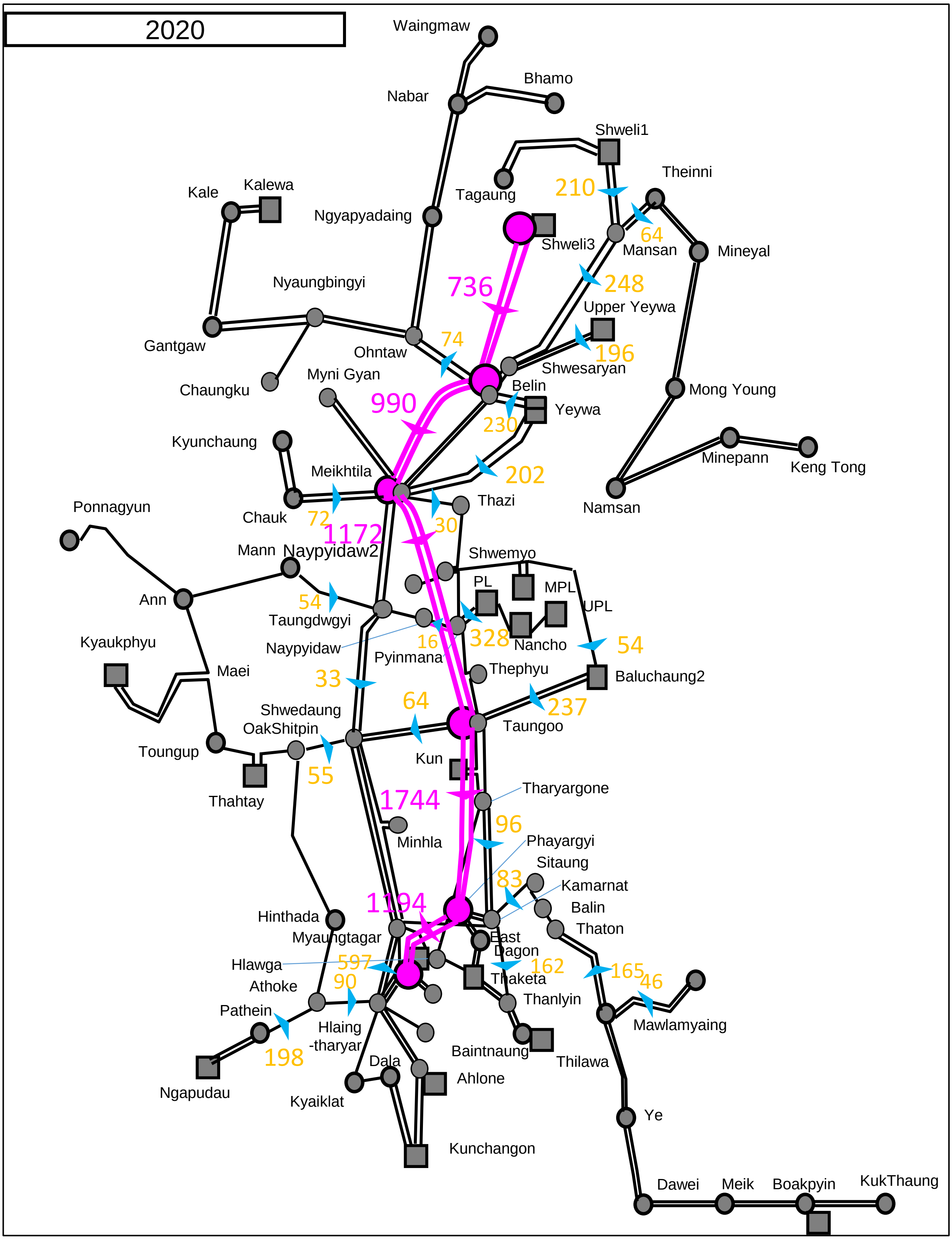


Fig. 6.7-2 Power Flow Diagram
(2020, Scenario 3, Dry Season, Rate of Output from HPPs: 70%)

Voltage distribution for 500kV and 230kV substations are shown from Fig. 6.7-3 to Fig. 6.7-5. In each figures, voltage profiles are shown in line with the transmission routes from the north to the south. The voltage from 500kV and 230kV substations are confirmed to be controlled within ± 5% of nominal voltage in accordance with the preconditions previously mentioned. In order to maintain the voltage properly, required capacitors and reactor banks are assumed to be installed in appropriate location.

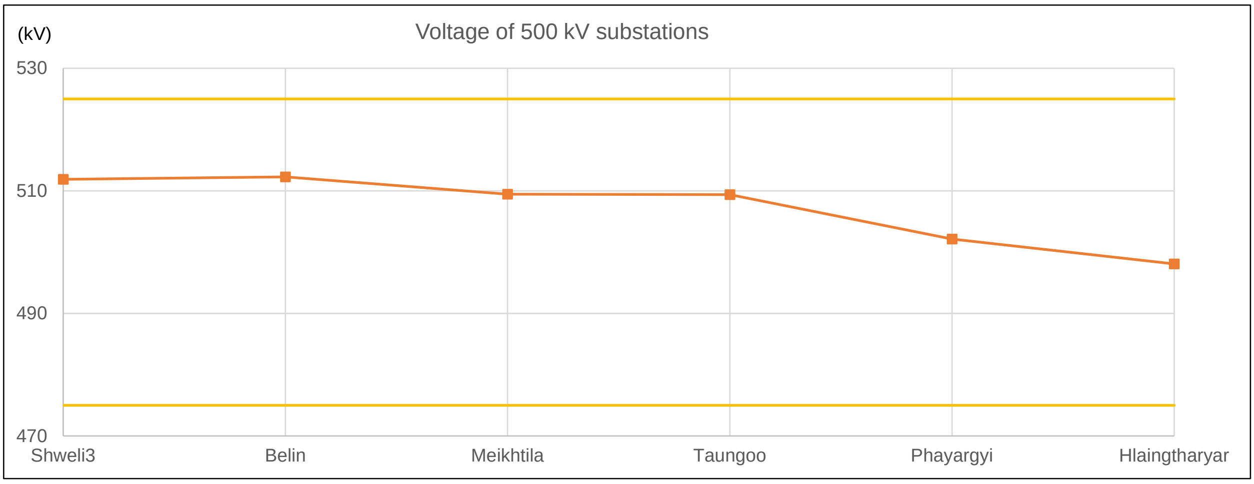


Fig. 6.7-3 Result of Voltage Distribution from 500kV Substations (2020, Scenario 3)

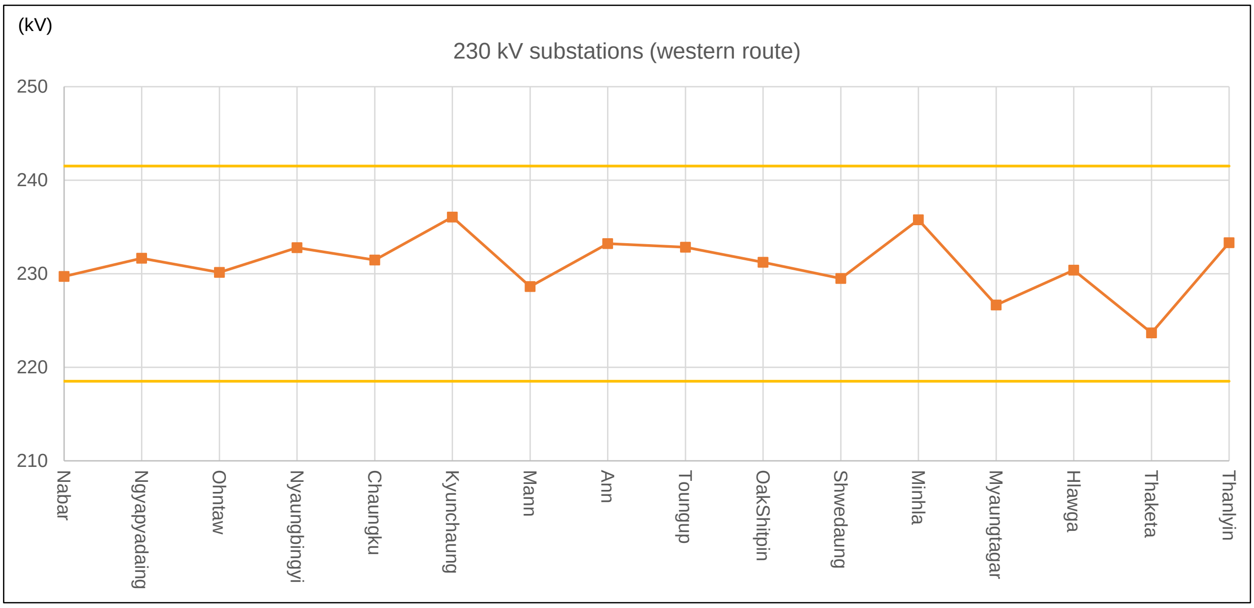


Fig. 6.7-4 Result of Voltage Distribution from 230kV Substations (2020, Scenario 3, Western Route)

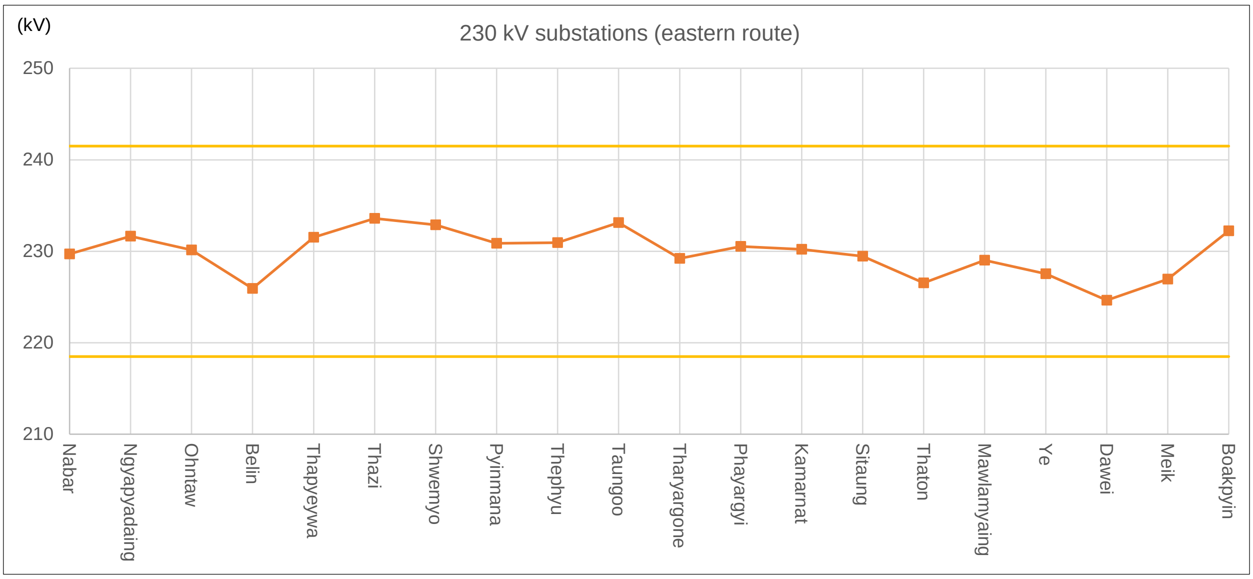


Fig. 6.7-5 Voltage Distribution Results for 230kV Substations (2020, Scenario 3, Eastern Route)

Results of short circuit current of 500kV and 230kV substations are shown in Fig. 6.7-6 and Fig. 6.7-7.

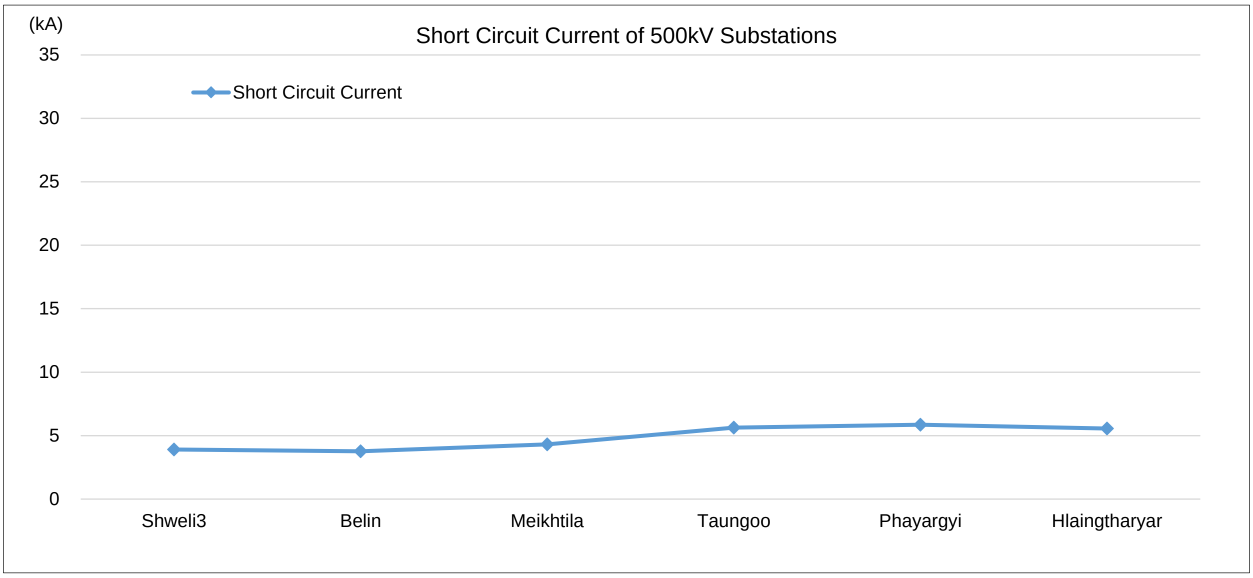


Fig. 6.7-6 Short Circuit Current Results for 500kV Substations (2020, Scenario 3)

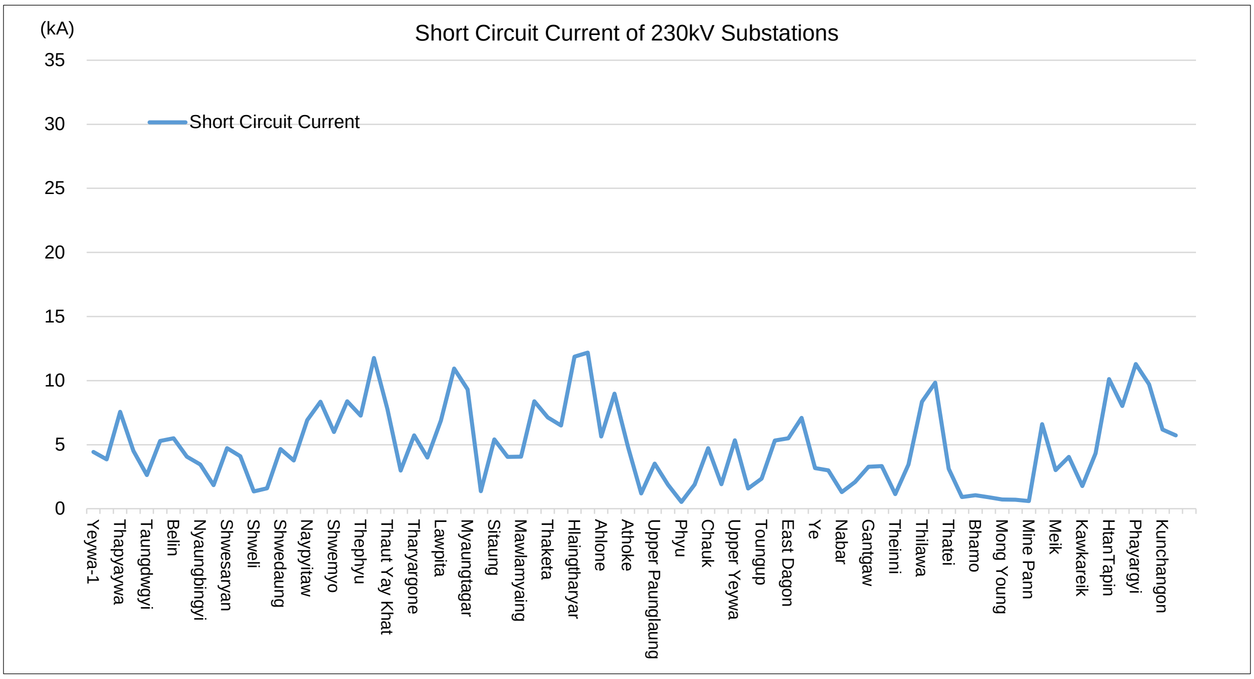


Fig. 6.7-7 Short Circuit Current Results for 230kV Substations (2020, Scenario 3)

The short circuit current for 500kV substations is estimated to be approximately 10kA. The short circuit current for 230kV substations is estimated to be approximately 20kA maximum. As a result, it can be confirmed that the short circuit current for all substations is estimated to be below the maximum allowable in this study.

2) Stability Analysis

No issues were identified in a stability analysis carried out for the proposed power system (Scenario 3).

(4) Summary and Project List for Middle Term Power System Development

Based upon the review results, a summary and project list for required power system development from 2016 ~ 2020 are shown below. An outline of the power system development plan is shown in Table 6.7-4, and the project list for transmission lines and substations is shown in Table 6.7-5 and Table 6.7-6.

Table 6.7-4 Summary of Power System Development (2016 ~ 2020, Scenario 3)

	(Voltage)	Amount of Facility	Amount of Cost
Transmission Line	500kV	1,029 km	643 MUSD
	230kV	4,387 km	822 MUSD
	132 kV	280 km	27 MUSD
Substation	500kV	5,000 MVA	310 MUSD
	230kV	7,740 MVA	813 MUSD
	132 kV	830 MVA	111 MUSD
Total			**2,726 MUSD**

- *Installation of 500kV transmission line (Meikhtila - Hlaingtharyar)*

  An expansion of the transmission capacity between the north and the demand centers around Yangon will be achieved in order to solve the bottlenecks of this transmission route. The supply capacity will be significantly increased to meet power demand.

- *Installation of 500kV transmission line (Meikhtila - Shweli 3)*

  New transmission lines to connect the existing grid and Shweli-3 Hydropower station, which is planned to develop in 2020, will be required. As there is a large potential for hydropower in this area, 500kV for this new line should be selected.

- *Expansion of 230kV transmission line*

  As for the 230kV system, expansion of the existing grid is planned, mainly for the purpose of connecting new TPPs and better supplying power to northern and southern areas.

Table 6.7-5 Transmission Lines Projects List (2016 ~ 2020, Scenario 3)

No	Substation A	Substation B	Voltage Level (kV)	Length		No. of circuit	Conductor Type	No. of conductors /Phase
				Miles	km			
1	Meikhtila	Taungoo	500	146.0	235.0	Double	795MCM (Drake)	4
2	Taungoo	Phayargyi (Kamarnat)	500	117.0	188.3	Double	795MCM (Drake)	4
3	Shweli-3	Belin	500	135.0	217.3	Double	795MCM (Drake)	4
4	Belin	Meikhtila (Thapyaywa)	500	125.0	201.2	Double	795MCM (Drake)	4
5	Phayargyi (Kamarnat)	Hlaingtharyar	500	60.0	96.6	Double	795MCM (Drake)	4
6	Mawlamyaing	Kawkareik-Myawaddy	230	80.0	128.8	Double	605MCM (Duck)	2
7	Mawlamyaing	Ye	230	82.0	132.0	Double	605MCM (Duck)	2
8	Ye	Dawei	230	50.0	80.5	Double	605MCM (Duck)	2
9	Mansan	Theinni	230	60.0	96.6	Double	605MCM (Duck)	2
10	Shwelinpan	Hlaingtharyar-Bayintnaung	230	6.0	9.7	Single	605MCM (Duck)	2
11	Hinthada	Athoke	230	80.0	128.8	Single	605MCM (Duck)	2
12	Gantgaw	Nyaungbingyi	230	80.0	128.8	Double	605MCM (Duck)	2
13	Baluchaung-2	Taungoo	230	96.0	154.5	Single	795MCM (Drake)	2
14	MineWa(Mong Wa)	So Lue	230	23.0	37.0	Double	605MCM (Duck)	2
15	Taungoo	Shwedaung	230	110.0	177.0	Double	605MCM (Duck)	2
16	Gantgaw	Kale	230	80.0	128.8	Double	795MCM (Drake)	2
17	Minbu (Mann)	Taungdwgyi	230	85.0	136.8	Single	605MCM (Duck)	2
18	Meikhtila	Chauk	230	75.0	120.7	Single	605MCM (Duck)	2
19	Kalewa (Coal Plant)	Kale	230	10.0	16.1	Double	605MCM (Duck)	2
20	Namsan-Mine Pann	Keng Tong	230	138.0	222.1	Double	605MCM (Duck)	2
21	Dawei	Meik	230	60.0	96.6	Double	605MCM (Duck)	2
22	Upper Yeywa	Shwesaryan	230	80.0	128.8	Double	605MCM (Duck)	2
23	Shwesaryan	Myaukpyin	230	16.0	25.8	Single	605MCM (Duck)	2
24	Thahtay (In-Out)		230	7.0	11.3	Single	605MCM (Duck)	2
25	Middle Paunglaung	(In-Out)	230	7.0	11.3	Double	605MCM (Duck)	2
26	Kunchangon	Dala	230	35.0	56.3	Double	605MCM (Duck)	2
27	Ngayukong	Pathein	230	60.0	96.6	Double	605MCM (Duck)	2
28	Waingmaw	Nabar	230	140.0	225.3	Double	605MCM (Duck)	2
29	Theinni-Mineyal	MineNaung-Namsan	230	168.0	270.4	Double	605MCM (Duck)	2
30	Meik	Boakpyin-KukThaung	230	250.0	402.3	Double	605MCM (Duck)	2
31	Htantapin	Myaungtagar	230	12.0	19.3	Double	605MCM (Duck)	2
32	Htantapin	Hlaingtharyar	230	11.0	17.7	Double	605MCM (Duck)	2
33	Bhamo (Banmaw)	Nabar	230	85.0	136.8	Double	605MCM (Duck)	2
34	Nabar	Ngyapyadaing	230	95.0	152.9	Double	605MCM (Duck)	2
35	Ngyapyadaing	Ohntaw	230	84.0	135.2	Double	605MCM (Duck)	2
36	Meikhtila	Thapyaywa	230	6.5	10.5	Triple	605MCM (Duck)	2
37	Phayargyi	East Dagon	230	50.0	80.5	Double	605MCM (Duck)	2
38	Hlaingtharyar 500kVSS	Hlaingtharyar 230kVSS	230	6.5	10.5	Triple	605MCM (Duck)	2
39	Hlaingtharyar 500kVSS	Ywama (Shwelinpan)	230	19.0	30.6	Double	605MCM (Duck)	2
40	Boakpyin	Boakpyin	230	12.0	19.3	Double	605MCM (Duck)	2
41	Ngaputaw	Pathein	230	30.0	48.3	Double	605MCM (Duck)	2
42	Dawei	LongLon	230	15.0	24.1	Single	605MCM (Duck)	2
43	Dala	Kyaiklat	230	13.0	20.9	Double	605MCM (Duck)	2
44	Meikhtila	Taungdwgyi	230	80.0	128.8	Single	605MCM (Duck)	2
45	Kyause	Ohntaw	230	6.5	10.5	Single	605MCM (Duck)	2
46	Thilawa	Thanlyin	230	6.5	10.5	Double	605MCM (Duck)	2
47	Meikhtila	Chauk	230	75.0	120.7	Single	605MCM (Duck)	2
48	Chauk	Kyunchaung	230	25.0	40.2	Double	605MCM (Duck)	2
49	Meikhtila	Myin Gyan	230	69.0	111.0	Single	605MCM (Duck)	2
50	Pyinmana	Thephyu	230	70.0	112.7	Single	605MCM (Duck)	2
51	Thephyu	Taungoo	230	61.0	98.2	Single	605MCM (Duck)	2
52	Kunchangon	Ahlone	230	48.0	77.3	Triple	605MCM (Duck)	2
53	Kanpouk	Dawei	132	6.0	9.7	Single	605MCM (Duck)	2
54	Upper Keng Tong	Namsan	132	50.0	80.5	Single	397.5MCM (Ibis)	1
55	Ngotchaung	Lawpita (Baluchaung-1)	132	31.0	49.9	Single	605MCM (Duck)	2
56	Dapein-2	Dapein-1	132	3.0	4.8	Single	605MCM (Duck)	2
57	Upper Bu	Tayaung	132	85.0	136.8	Double	605MCM (Duck)	2

Table 6.7-6 Project List for Substations (2016 ~ 2020, Scenario 3)

No	Name of Substation	Voltage Level (kV)	Transformer Rated Capacity (MVA)	No. of Transformer	Substation Rated Capacity (MVA)
1	Meikhtila	500/ 230/ 33	500/ 500/ 166	2	1000
2	Phayargyi (Kamarnat)	500/ 230/ 33	500/ 500/ 166	2	1000
3	Taungoo	500/ 230/ 33	500/ 500/ 166	2	1000
4	Hlaingtharyar	500/ 230/ 33	500/ 500/ 166	2	1000
5	Belin	500/ 230/ 33	500/ 500/ 166	2	1000
6	Hinthada	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
7	Bhamo	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	400
8	Nabar	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
9	Ngyapyadaing (Shwebo)	230/ 33/ 11	100/ 100/ 30	4 (1ϕ)	400
10	Dawei	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
11	Ye	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
12	Thilawa	230/ 33/ 11	100/ 100/ 30	1 (3ϕ)	100
13	Dala	230/ 33/ 11	100/ 100/ 30	1 (3ϕ)	100
14	Kawkareik	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	100
15	Myawaddy	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	100
16	Kale	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
17	Theinni	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
18	Mansan (Ext;)	230/ 66/ 11	60 / 60	4 (1ϕ)	240
19	Kyunchaung	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	400
20	Aungland	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
21	Gantgaw	230/ 66/ 11	100/ 100/ 30	4 (1ϕ)	400
22	Chauk (Ext;)	230/ 132/ 11	100/ 100/ 30	4 (1ϕ)	400
23	Belin (Ext;)	230/ 33/ 11	100/ 100/ 30	4 (1ϕ)	400
24	Meikhtila (Thapyaywa) (Ext;)	230/ 33/ 11	100/ 100/ 30	4 (1ϕ)	400
25	Shwelinpan	230/ 66/ 11	100/ 100/ 30	1 (3ϕ)	100
26	Myaukoakkalarpa Industrial Zone	230/ 33/ 11	100/ 100/ 30	2 (3ϕ)	200
27	Thida GIS	230/ 66/ 11	200/ 200/ 60	2 (3ϕ)	400
28	Dala	230/ 33/ 11	100	1 (3ϕ)	100
29	Waingmaw (Ext;)	230 / 132	100	1	100
30	Kyine Ton	230 / 66	100	1	100
31	Meik (Ext;)	230 / 66	100	1	100
32	Mine Pann	230 / 66	100	1	100
33	Namsan (Ext;)	230 / 132	100	1	100
34	Minenaung	230 / 66	50	2	100
35	Mineyal	230 / 66	50	2	100
36	Boakpyin	230 / 33	50	2	100
37	KukThaung	230 / 33	50	2	100
38	Loikaw s	132/ 66	50/ 50	2 (3ϕ)	100
39	Loikaw s	132/ 33	50 /50	1 (3ϕ)	50
40	Chauk (Ext;)	132/ 66	60/ 60	1 (3ϕ)	60
41	Aungpinlae (Ext;)	132/ 33	50 /50	2 (3ϕ)	100
42	Industry Zone	132/ 33	50 /50	2 (3ϕ)	100
43	Mogaung	132/ 66	60/ 60	1 (3ϕ)	60
44	Monywar (Aungchanthar) Sub; (Ext;)	132/ 33	50 / 50	2 (3ϕ)	100
45	Taungtwingyi	132/ 66	100	1	100
46	Buddha Gone (Ext;)	132/ 66	60/ 60	1 (3ϕ)	60
47	Thazi (Ext;)	132/ 33	50 /50	2 (3ϕ)	100

6.7.3 Long Term Power System Development Plan

(1) Preconditions

The output from power plants is based on the rainy season generation in the preliminary review; the same as for the middle term consideration. Transmission lines and substations less than 230kV in each area are set according to MEPE planning. The 500kV transmission lines are set for two routes.

(2) Outline of Long Term Power System

The bulk power system development plan for Scenario 3 through 2030 is shown in Fig. 6.7-8. Transmission lines depicted as dashed line indicate new construction projects after 2021, with the bold and fine lines representing 500kV and 230kV transmission lines, respectively.

The second route of the 500kV transmission line located in the east runs from Shweli-3 to Thaketa, via Mansan, Namsan and Baluchaung. Corresponding 500kV substations, such as Mansan and others are also installed.

The main feature of this power system is a loop configuration formed by the existing 500kV power system (until 2020) and the second 500kV power system (through 2030) in order to transmit power generated in the north and east to the Yangon areas via several 500kV substations.

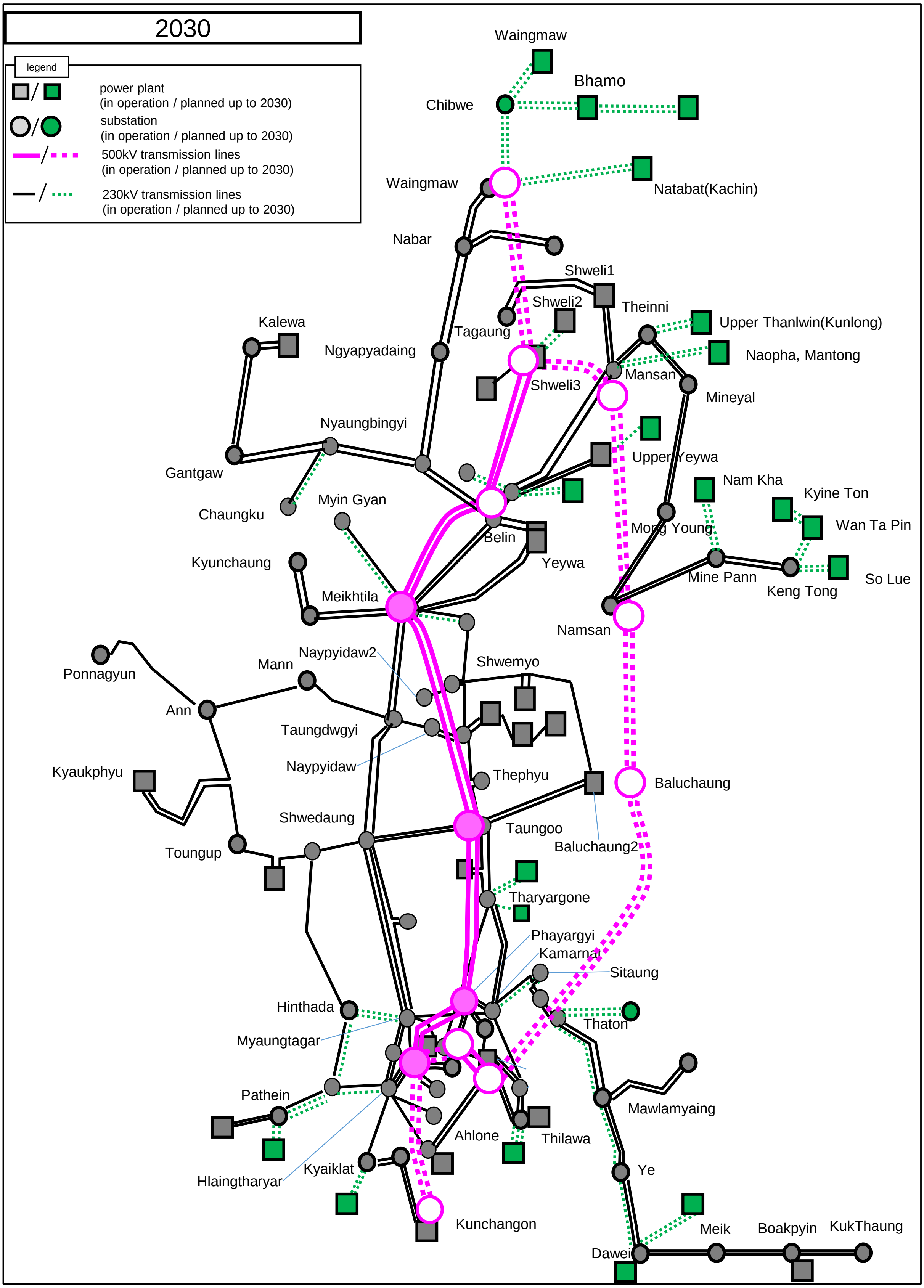


Fig. 6.7-8 Bulk Power System Development Plan (2030)

(3) Results of the Power System Study

1) Power Flow Analysis

As with the review of the middle term power system development plan, a power flow analysis was carried out. The result is shown in Fig. 6.7-9. It was found that both 500kV routes enable the transmission of large power flows to Yangon Area properly.

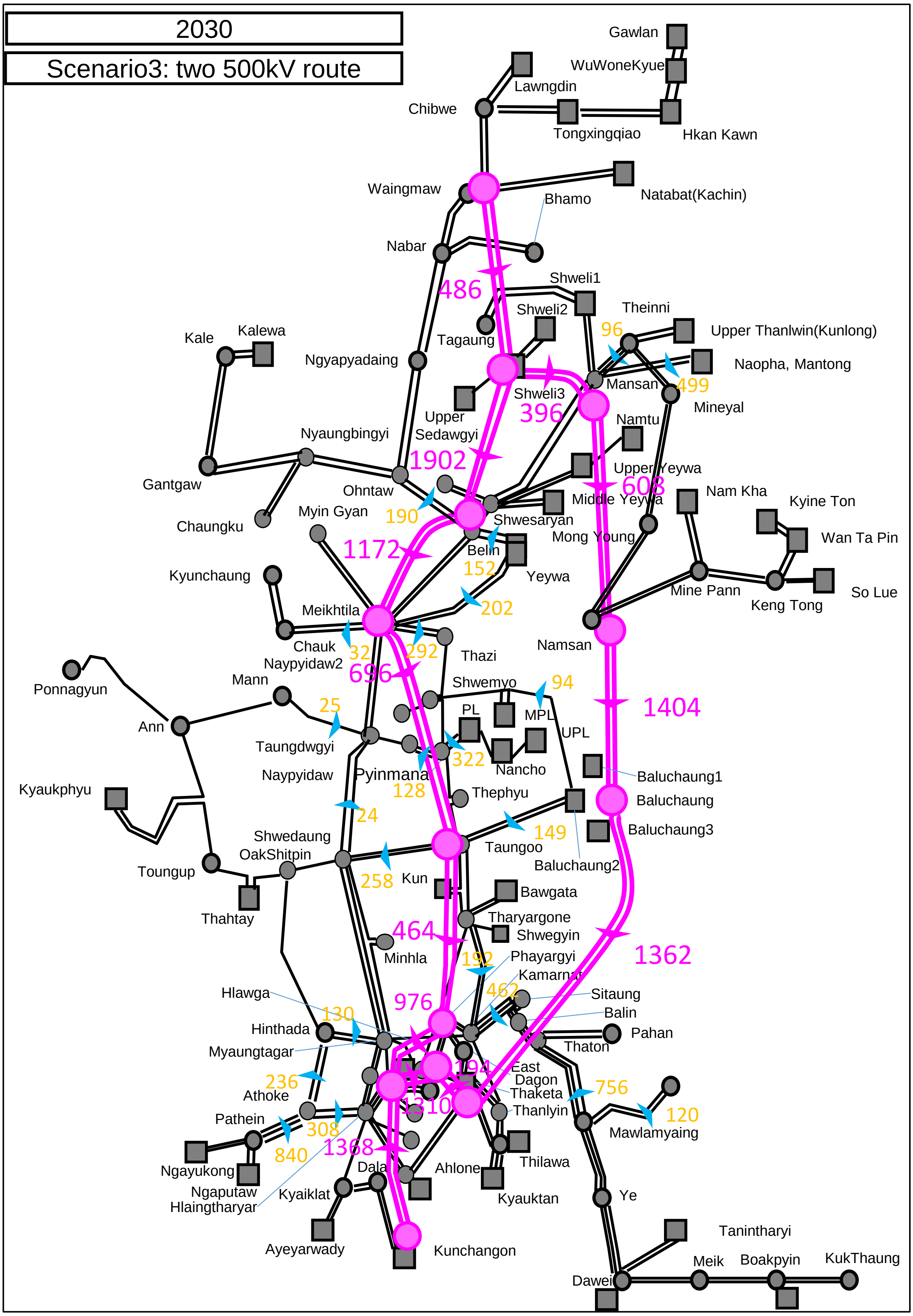


Fig. 6.7-9 Power Flow Diagram (2030)

Voltage distribution for the 500kV and 230kV substations is shown from Fig. 6.7-10 to Fig. 6.7-12. In each figure, voltage profiles are shown in line with the transmission route from the north to the south. In a steady state, voltage from the 500kV and 230kV substations is confirmed to be controlled within ± 5% of nominal voltage in accordance with preconditions. In order to maintain voltage properly, necessary capacitors and reactor banks are assumed to be installed in appropriate locations.

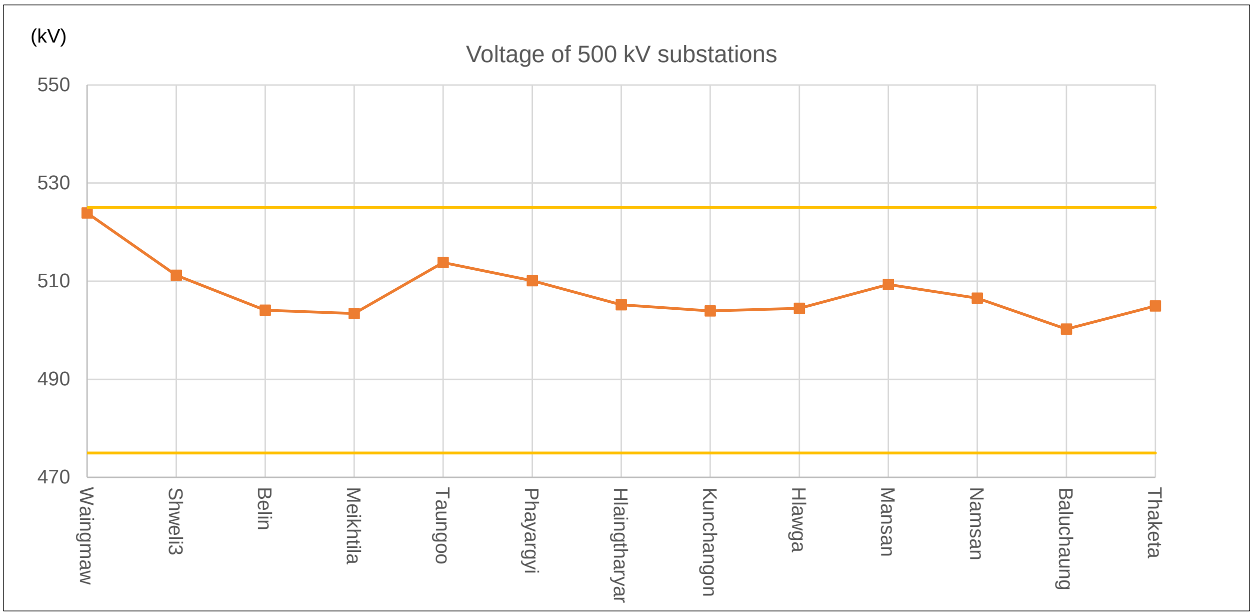


Fig. 6.7-10 Voltage Distribution from 500kV Substations (2030, Scenario 3)

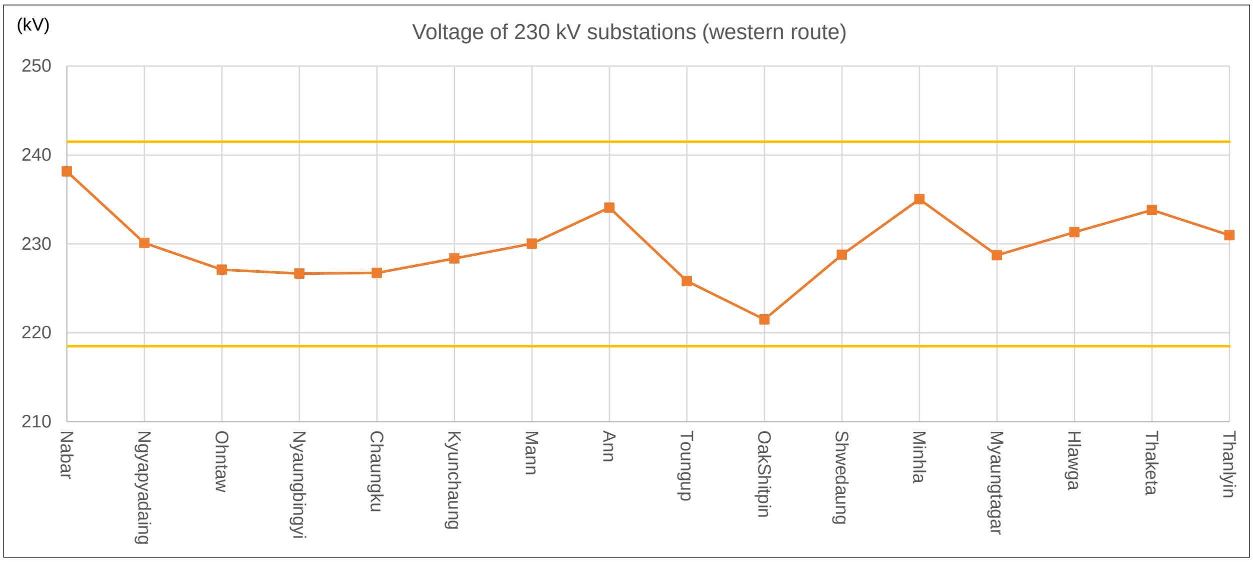


Fig. 6.7-11 Voltage Distribution from 230kV Substations (2030, Western Route)

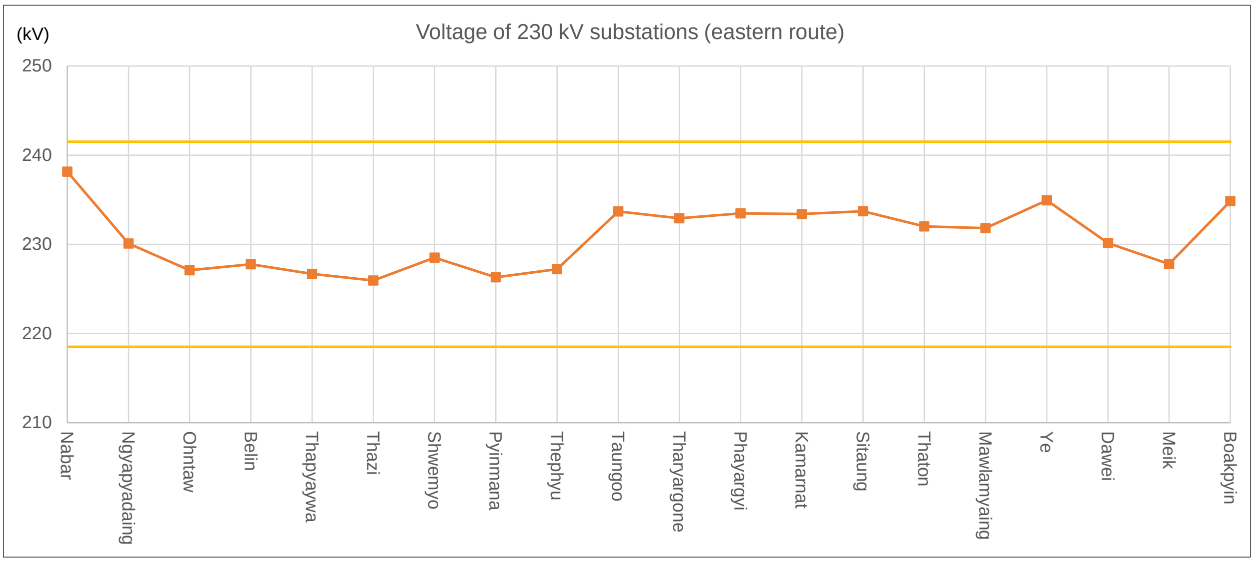


Fig. 6.7-12 Voltage Distribution from 230kV Substations (2030, Eastern Route)

Results of short circuit current from 500kV and 230kV substations are shown in Fig. 6.7-13 and Fig. 6.7-14.

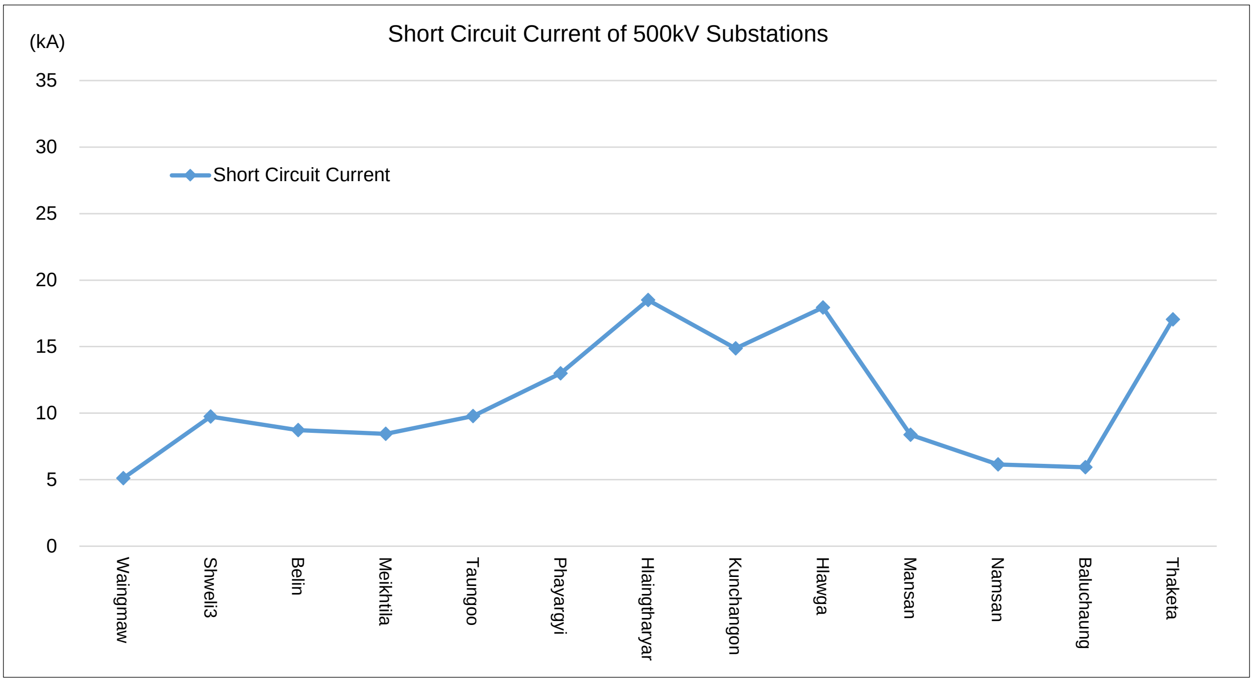


Fig. 6.7-13 Short Circuit Current for 500kV Substations (2030)

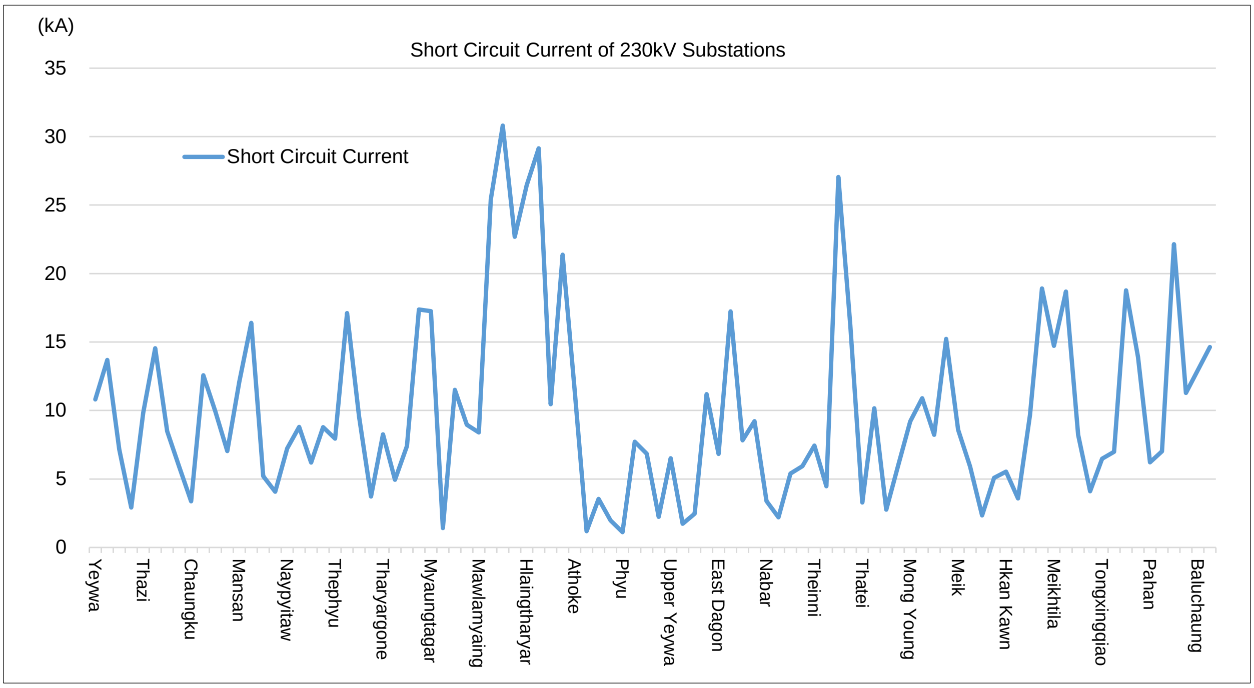


Fig. 6.7-14 Short Circuit Current for 230kV Substations (2030)

Short circuit current for 500kV substations is estimated to be less than 25kA. Short circuit current for 230kV substations is estimated to be less than 40kA, although the current of individual substations fluctuates to some degree. As a result, it can be confirmed that the short circuit current of substations is estimated to be below the maximum allowable until 2030.

2) Stability Analysis

No issues were identified in a stability analysis carried out for the proposed power system.

(4) Summary and Project List for Long Term Power System Development

Based on the results above, a summary and project list for required power system development from 2020 ~ 2030 are shown below. An outline of the power system development plan is shown in Table 6.7-7, and the project list for transmission lines and substations is shown in Table 6.7-8 and Table 6.7-9, respectively

Table 6.7-7 Summary of Power System Development (2020 ~ 2030, Scenario 3)

	(Voltage)	Amount of Facility	Amount of Cost
Transmission Line	500kV	1,630 km	1,019 MUSD
	230kV	2,190 km	401 MUSD
	132 kV	122 km	11 MUSD
Substation	500kV	12,500 MVA	941 MUSD
	230kV	4,530 MVA	476 MUSD
	132 kV	720 MVA	96 MUSD
Total			**2,944 MUSD**

- *Installation of 500kV transmission line (Shweli 3 - Mansan - Namsan - Baluchaung - Thaketa)*

  An expansion of the transmission capacity from generation plants to Yangon is a high priority project so as to increase the power supply. Moreover, as a 500kV loop configuration system is established by the completion of this project, the power supply from various plants is expected to be improved. Reliability against accidents is also improved by the loop configuration.

- *Installation of 500kV transmission line (Hlaingtharyar - Kunchangon)*

  Around Yangon, there are several plans for TPPs through 2030. Kunchangon, which is planned at 3,270 MW, has the largest generation capacity of all of the planned projects. Installation of a 500kV transmission line from Kunchangon to Hlaingtharyar is high priority in order to better deal with the high power demand in the Yangon area.

- *Expansion of 230kV transmission line*

  As for 230kV system, an expansion of transmission capacity from western and southern areas to Yangon Area is under consideration, as are new 230kV transmission lines from planned HPPs to existing substations. Moreover, JICA Study Team recommends that the 230kV transmission lines containing only a single circuit be upgraded to double circuits in order to avoid supply failure (through 2030) as a contingency (N-1).

Table 6.7-8 Transmission Lines Projects (2020 ~ 2030, Scenario 3)

No	Substation A	Substation B	Voltage Level (kV)	Length		No. of circuit	Conductor Type	No. of conductors /Phase
				Mile	km			
1	Hlawga 500	Hlaingtharyar 500	500	9.0	14.5	Double	795MCM (Drake)	4
2	Hlaingtharyar 500	Kunchangon	500	35.0	56.3	Double	795MCM (Drake)	4
3	Shweli-3	Waingmaw	500	261.0	420.0	Double	795MCM (Drake)	4
4	Mansan 500	Shweli-3	500	93.0	149.7	Double	795MCM (Drake)	4
5	Baluchaung 500	Namsan 500	500	186.0	299.3	Double	795MCM (Drake)	4
6	Namsan 500	Mansan 500	500	186.0	299.3	Double	795MCM (Drake)	4
7	Baluchang 500	Thaketa 500	500	212.0	341.2	Double	795MCM (Drake)	4
8	Thaketa 500	Hlawga 500	500	37.0	59.6	Double	795MCM (Drake)	4
9	Gawlan	WuWoneKyue	230	30.0	48.3	Double	605MCM (Duck)	2
10	WuWoneKyue	Hkan Kawn	230	10.0	16.1	Double	605MCM (Duck)	2
11	Hkan Kawn	Tongxingqiao	230	20.0	32.2	Double	605MCM (Duck)	2
12	Tongxingqiao	Chibwe	230	40.0	64.4	Double	605MCM (Duck)	2
13	Shweli-3	Shweli-2	230	20.0	32.2	Double	605MCM (Duck)	2
14	Kunlong	Theinni	230	53.0	85.3	Double	605MCM (Duck)	2
15	Bawgata	Tharyargone	230	20.0	32.2	Double	605MCM (Duck)	2
16	Kyauktan	Thilawa	230	10.0	16.1	Triple	605MCM (Duck)	2
17	Naopha, Mantong	Mansan	230	50.0	80.5	Double	605MCM (Duck)	2
18	Hinthada	Myaungtagar	230	80.0	128.8	Double	605MCM (Duck)	2
19	Thaton	Pahan	230	25.0	40.2	Double	605MCM (Duck)	2
20	Middle Yeywa	Shwesaryan	230	31.0	49.9	Double	605MCM (Duck)	2
21	Keng Ton	Wan Ta Pin	230	28.0	45.1	Double	605MCM (Duck)	2
22	So Lue	Keng Tong	230	25.0	40.2	Double	605MCM (Duck)	2
23	Wan Ta Pin	Kyine Ton	230	22.0	35.4	Double	605MCM (Duck)	2
24	Natabat	Waingmaw	230	40.0	64.4	Double	605MCM (Duck)	2
25	Nam Kha	Mine Pann	230	32.0	51.5	Double	605MCM (Duck)	2
26	Lawngdin	WuSauk	230	9.0	14.5	Double	605MCM (Duck)	2
27	Thazi	Thapyaywa	230	15.0	24.1	Single	605MCM (Duck)	2
28	Ayeyarwady	Kyaiklat	230	31.0	49.9	Double	605MCM (Duck)	2
29	Upper Sedawgyi	Shweli-3	230	31.0	49.9	Single	605MCM (Duck)	2
30	Namtu	Upper Yeywa	230	6.0	9.7	Single	605MCM (Duck)	2
31	Mong Young	Namsan	230	12.0	19.3	Single	605MCM (Duck)	2
32	Tanintharyi	Dawei	230	20.0	32.2	Double	605MCM (Duck)	2
33	Hlaingtharyar	Bayintnaung	230	7.0	11.3	Double	605MCM (Duck)	2
34	Shwesaryan	Myaukpyin	230	16.0	25.8	Single	605MCM (Duck)	2
35	Hlaingtharyar	Shwelinpan	230	19.0	30.6	Single	605MCM (Duck)	2
36	Dala	Kyaiklat	230	13.0	20.9	Single	605MCM (Duck)	2
37	Hlaingtharyar	Kyaiklat	230	30.0	48.3	Double	605MCM (Duck)	2
38	Thilawa	Thanlyin	230	6.0	9.7	Single	605MCM (Duck)	2
39	Thilawa	Thida	230	15.0	24.1	Double	605MCM (Duck)	2
40	Shwesaryan	Belin	230	17.0	27.4	Single	605MCM (Duck)	2
41	Athoke	Pathein	230	40.0	64.4	Double	605MCM (Duck)	2
42	Phayargyi(Kamarnat)	Sitaung	230	37.0	59.6	Double	605MCM (Duck)	2
43	Sitaung	Balin	230	31.0	49.9	Double	605MCM (Duck)	2
44	Balin	Thaton	230	31.0	49.9	Double	605MCM (Duck)	2
45	Thaton	Mawlamyaing	230	48.0	77.3	Double	605MCM (Duck)	2
46	Mawlamyaing	Ye	230	82.0	132.0	Single	605MCM (Duck)	2
47	Ye	Dawei	230	50.0	80.5	Single	605MCM (Duck)	2
48	Athoke	Hlaingtharyar	230	71.0	114.3	Single	60 MCM (Duck)	2
49	Athoke	Hinthada	230	80.0	128.8	Single	605MCM (Duck)	2
50	Kunchangon	Ahlone	230	30.0	48.3	Triple	605MCM (Duck)	2
51	Tarbin(1)	Tarbin-2	132	5.0	8.1	Single	605MCM (Duck)	2
52	Keng Yang	Minewa(Mong Wa)	132	31.0	49.9	Single	605MCM (Duck)	2
53	He kou	Minewa(Mong Wa)	132	40.0	64.4	Single	605MCM (Duck)	2

Table 6.7-9 Substation Projects (2020 ~ 2030, Scenario 3)

No	Name of Substation	Voltage Level (kV)	Transformer Rated Capacity (MVA)	No. of Transformer	Substation Rated Capacity (MVA)
1	Hlawga	500/ 230/ 33	500/ 500/ 166	4	2000
2	Thaketa	500/ 230/ 33	500/ 500/ 166	4	1500
3	Hlaingtharyar (Ext;)	500/ 230/ 33	500/ 500/ 166	2	1000
4	Mansan	500/ 230/ 33	500/ 500/ 166	3	1500
5	Baluchaung	500/ 230/ 33	500/ 500/ 166	2	1000
6	Namsan	500/ 230/ 33	500/ 500/ 166	3	1500
7	Kunchangon	500/ 230/ 33	500/ 500/ 166	4	2000
8	Waingmaw (Ext;)	500 / 230/ 33	500/ 500/ 166	2	1000
9	Shweli-3	500/ 230/ 33	500/ 500/ 166	2	1000
10	Thaton (Ext;)	230 / 66	100	2	200
11	Myin Gyan (Ext;)	230 / 33	80	1	80
12	Pahan	230 / 66	50	1	50
13	LaungLone	230 / 33	100	2	200
14	Kamarnat	230 / 33	100	1	100
15	MyaukOo	230 / 66	100	1	100
16	Pathein (Ext;)	230 / 66	100	1	100
17	Naypyidaw	230 / 33	100	1	100
18	Meikhtila (Thapyaywa)	230 / 33	100	2	200
19	Myaukpyin	230 / 33	100	2	200
20	Shwesaryan (Ext;)	230 / 33	100	2	200
21	Shwemyo (Ext;)	230 / 33	100	3	300
22	Thida	230 / 66 / 11	300/ 200/ 100	3	900
23	Kyaikkasan	230 / 66 / 11	300/ 200/ 100	3	900
24	Okkalapa	230 / 66 / 11	300/ 200/ 100	3	900
25	Pyin-O-Lwin (Ext;)	132 / 33	50	2	100
26	Myin Gyan (Ext;)	132 / 66	60	1	60
27	Aungpinle (Ext;)	132 / 33	100	2	200
28	Sesaing	132 / 66	60	1	60
29	Nyaungbingyi (Ext;)	132 / 33	50	2	100
30	Industry Zone	132 / 33	100	2	200

6.8 DEMAND SUPPLY PLAN AROUND YANGON (THROUGH 2030)

In the high case demand, through 2030 the demand around Yangon is estimated to be approximately 8,500MW. This is equivalent to 60% of total national demand. It is expected that this demand bias will continue into the foreseeable future. As such, it is important to develop the overall power system in accordance with the elaborate plans already in place to ensure a stable power supply to and around Yangon.

A study regarding the 500kV substations around Yangon, which serve as the hub for demand supply, is described below.

The power generation capacity of thermal plants connected to the 230kV power system around Yangon is estimated to be about 5,600MW. Provided that these plants perform within 50% of operations, the power supply from the 230kV system is estimated to be approximately 2.800MW. In this case, the necessary power supply required from the 500kV system is considered to be approximately 5,700MW (equivalent to 6,000MVA based on apparent power). In the case that four main transformers, each with a capacity of 500MVA, are installed in the 500kV substation, three substations will be necessary in and round Yangon for a stable power supply.

It is the same for the 230kV substations around Yangon. In the case that two main transformers each with the capacity of 300MVA are installed in a 230kV substation, fifteen substations would be necessary in and round Yangon for a stable power supply.

Power supplied to this area is assumed to be transmitted from HPPs in the north and middle areas of the country via two 500kV transmission routes, along with gas and coal TPPs in and around Yangon. Moreover, in the future, additional power will be transmitted from western and southern areas of Myanmar. In consideration of the situation described above, the concept for a bulk power system in and around Yangon is shown in Fig. 6.8-1.

A 500kV power system is configured to surround Yangon, with power transmitted from 500kV substations to 230kV substations near the demand areas. Based on this, the power system around Yangon is shown in Fig. 6.8-2.

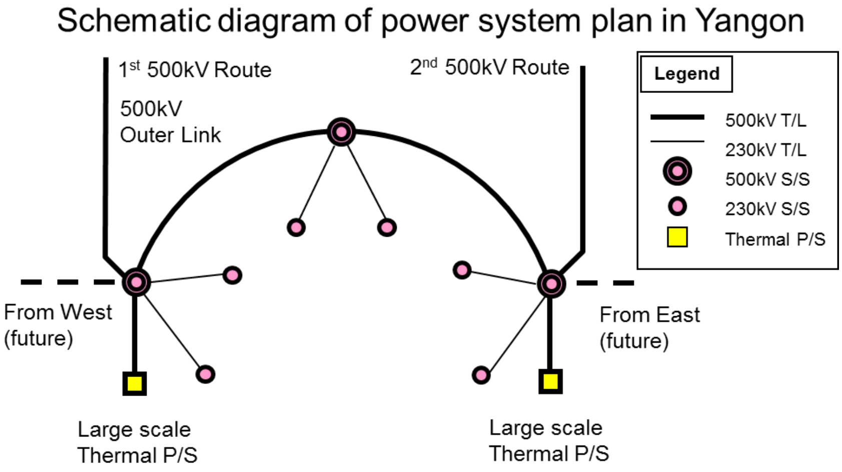


Fig. 6.8-1 Concept for a Bulk Power System around Yangon

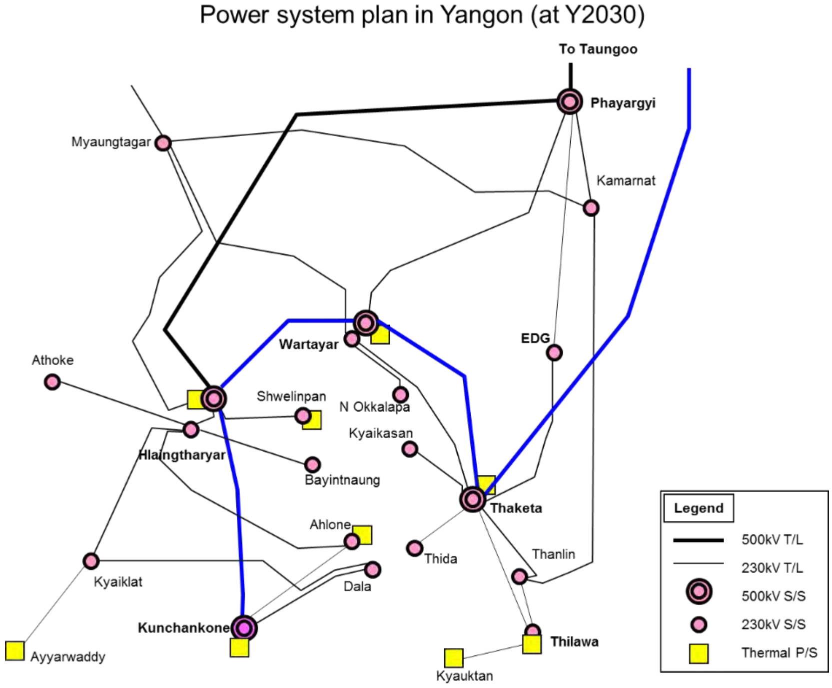


Fig. 6.8-2   Example of Configuration of Bulk Power System around Yangon

Additional investigation is required in order to develop a possible plan as new transmission routes and location selection for substations are not included in this study.

If construction of electric facilities is not implemented in a timely and appropriate manner, it may become difficult to proceed due to rapid urban expansion in Yangon. Therefore, it is important to coordinate with the GoM (Government of Myanmar) and other relevant organizations to carry out the construction of transmission lines and substations in coordination with other infrastructure development projects such as land, road and water.

6.9 INTERCONNECTION WITH NEIGHBORING COUNTRIES

6.9.1 Current Situation of International Connection

There are two (2) international connections in Myanmar.

- Dapein-1 HPP (240MW) - China
- Shweli-1 HPP (600MW) - China

These HPPs were developed by JV (Joint Venture) with Myanmar and China. Each plants transmit power with 500kV or 220kV transmission lines to China. They are to export from 50% to 90% of rated output.

6.9.2 Prospect of International Connections

MOUs (Memorandum of Understanding) and/or MOAs (Memorandum of Agreement) were signed by Myanmar and China or Thailand covering most of the potential locations for HPPs bordering China or Thailand. As these HPPs are to transmit power to either China or Thailand, international connections will have to be developed as part of the development of these power plants. However, those connections will not be connected to the power grid system in Myanmar. China or Thailand will construct their own transmission lines to their respective countries for allocated output of power.

If the Myanmar power grid was able to connect directly to the grids of surrounding countries, electricity exports driven by rich hydropower resources, reduction of backup generation, and electrification of areas currently without electricity could be realized. Demand for Myanmar's electricity is high during the dry season, when the outputs of HPPs in surrounding countries are relatively low as they are located in the same climate zone. However, for instance, the power generation of HPPs is only 5.1% (as of 2012) of total power generation in Thailand, thus largely mitigating the effects of the climate. It would be possible for Myanmar to export electricity during the rainy seasons and import it during the dry seasons. However, energy security could be affected by external factors in a power development plan based on import of electrical power.

Therefore, in this study, JICA Study Team will only highlight the possibility of international connections and power system development plan through 2030 based on an electric power supply generated only within Myanmar.

In addition, countries that belong to Greater Mekong Sub-region, including Cambodia, China, Laos, Myanmar, Thailand and Vietnam, are continuously exchanging information and discussing the establishment of a Regional Power Coordination Center with ADB (Asian Development Bank) support. The establishment of electricity trading among these countries in the future is expected.

6.10 CONCLUSION AND RECOMMENDATIONS FOR THE POWER SYSTEM DEVELOPMENT PLAN

6.10.1 Conclusion for the Power System Development Plan

In Myanmar, biased power demand areas and major power plants, mainly HPPs, are located far away one another. Transmission lines connecting these areas cover significantly long distances. Given the limitations of Governmental finances, the construction of the power system has not been carried out properly. As a result, shortages in power supply and transmission capacity have occurred and the country is faced with frequent blackouts due to transmission line faults.

It is thus crucial to install and reinforce the bulk power system connecting the north to the south, as well as the bulk power system in Yangon Area, in order to achieve continuous economic growth and enable a power supply that fully utilizes the abundant water resources available.

As an immediate countermeasure, the reinforcement of the 230kV bulk transmission line route connecting the north to the south is required. Thereafter, the installation of a 500kV bulk transmission line connecting Meikhtila to Hlaingtharyar is a priority (which is the first 500kV project planned for Myanmar). This project is quite important for Myanmar. Moreover, as large projects such as the Shweli-3 hydropower project and the Kalewa coal thermal power project are also under planning, adequate transmission lines are also required to be constructed. Particularly, in case of the Shweli 3 project, expansion of the 500kV transmission line route will need to be undertaken.

Until 2020, power from HPPs in the north and middle areas of the country and gas and coal thermal plants around Yangon will be transmitted to the major demand areas. In this case, major construction projects will include the 500kV transmission line project as to serve as the backbone of country’s power system, the 230kV transmission line project from plants to the grid, and the reinforcement project for the power system around Yangon.

The estimated power demand in 2030 will be three times the demand forecast in 2020. As for the 500kV transmission line, a second route running through the east will be installed in order to meet the required transmission capacity. As for the 230kV system, reinforcement of transmission capacity from western and southern areas to Yangon will be required according to the development plan for the large TPPs in Ayeyarwady and Tanintharyi.

As for the distribution system, it will be necessary to expand the local transmission lines with double circuits to better ensure supply security. It will also be necessary to reinforce the power system in and around Yangon in close conjunction with the distribution system and urban development plans.

6.10.2 Recommendations for Effective Development

(1) Preparation of action plan

Projects which are necessary for the middle and long terms are proposed in this study. In order to implement these projects according to the development plan, it is recommended to prepare an action plan considering the timing of the feasibility study and construction period for each project.

(2) Bulk power system development plan concentrated (Yangon Area)

As described in Section 6.8 “Demand Supply Plan around Yangon”, a rapid increase in the demand for power in Yangon is underway. As such, it will be necessary to prepare a detailed bulk power system development plan harmonized with the distribution system and the various urban planning schemes currently underway and planned for Yangon. Specific methods for system expansion and appropriate terms should be decided upon and updated in consideration of ongoing changes in the situation.

(3) Improvement of distribution lines

The improvement of distribution lines is important for the following reasons:

- To increase power supply reliability in Yangon and other major cities;
- To increase the amount of power supply due to decreases distribution losses.

These recommended improvements all increase the power supply capacity, which is crucial as it will be difficult to operationalize TPPs around Yangon until 2020 mainly due to fuel supply issue.

These recommendations are also described in Chapter 9 with additional information.