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
SUMMARY

December 2014

Japan International Cooperation Agency

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

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- SUMMARY -

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Abbreviations

Symbol	English
ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BOD	Biochemical Oxygen Demand.
BOO	Build Own and Operate
BOT	Build Operate and Transfer
BS	Balance Sheet
CAGR	Compound Average Growth Rate
CCT	Clean Coal Technology
CF	Cash Flow
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
ECD	Environmental Conservation Department
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
FERD	Foreign Economic Relation Department
FESR	Framework of Economical and Social Reform
FGD	Flue Gas Desulfurization
FIT	Feed-in Tariff
FOB	Free on Board
FSRU	Floating Storage Regasification Units
FSU	Floating Storage Unit
GCC	Generation Control Center
GCV	Gross Caloric Value
GDC	Gas Distribution Center
GE	Gas Engine
GECC	Gas Engine Combined Cycle
GoM	Government of Myanmar
GOT	Government of Thailand
GPSA	Gas Purchase Sales Agreement

Symbol	English
GSA	Gas Sales Agreement
GT	Gas Turbine
GTA	Gas Transportation Agreement
GTCC	Gas Turbine Combined Cycle
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
IRR	Internal Rate of Return
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 Poverty 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
LRAIC	Long Run Average Incremental Cost
MDB	Multilateral Development Bank
MEPE	Myanma Electric Power Enterprise
MES	Myanmar Engineering Society
METI	Ministry of Economy, Trade and Industry
MIC	Myanmar Investment Committee
MOA	Memorandum of Agreement
MOAI	Ministry of Agriculture and Irrigation
MOBA	Ministry of Border Affairs
MOC	Ministry of Cooperation, Ministry of Construction
MOE	Ministry of Energy
MOECAF	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 Affairs
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

Symbol	English
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
NEDO	New Energy and Industrial Technology Development Organization
NEMC	National Energy Management Committee
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	Organization for Economic Co-operation and Development
OGP	Oil, Gas, Petrochemicals
OPGW	Optical fiber Ground Wire
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
PPP	Public Private Partnership
PSC	Product Shearing Contract
RAP	Resettlement Action Plan
RCC	Regional Control Center
SC	Super Critical
SCADA	Supervisory Control And Data Acquisition
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
TNB	Tenaga Nasional Berhad
TPD	Thermal Power Department
TPDC	Township Peace and Development Council
TPP	Thermal Power Plant
UNDP	United Nations Development Programme
UNHSR	The UN Refugee Agency
UNICEF	United Nations Children's Fund
USC	Ultra Super Critical

Symbol	English
WASP	Wien Automatic System Planning
WB	World Bank
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 OUTLINE OF THE STUDY

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, the 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's (Japan International Cooperation Agency) support of the National Electricity Mater 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 concept 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 to Myanmar
Target Facility	Electric power generation facilities and power system facilities of not less than 66kV transmission and substation systems owned by MEPE
Implementation Agency	MOEP
Scope of Work	1) Formulation of a middle/long term optimum National Electricity Master Plan to realize a strategic power generation and transmission system 2) Analysis and recommendations on organization, policy and legal legislation in the electric power sector

CHAPTER 2 PRESENT STATE AND ISSUES OF POWER SECTOR

2.1 PRESENT STATE OF POWER POLICY IN MYANMAR

(1) Energy Policy

The GoM established the NEMC in January 2013 for overall matters relating to the energy sector of the State and to implement the National Energy Plan for short and long term objectives (in compliance with the National Energy Policy). The GoM will implement projects in oil, natural gas and coal after drafting the National Energy Plan.

As of June 2014, based on discussions with the NEMC, a draft of the National Energy Policy (Burmese version) was compiled and submitted to the President's Office in April 2014. An English version was drafted with ADB (Asian Development Bank) support in May 2014. Authorization procedure of the National Energy Policy will be issued from the President's Office.

(2) Electricity Policy

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

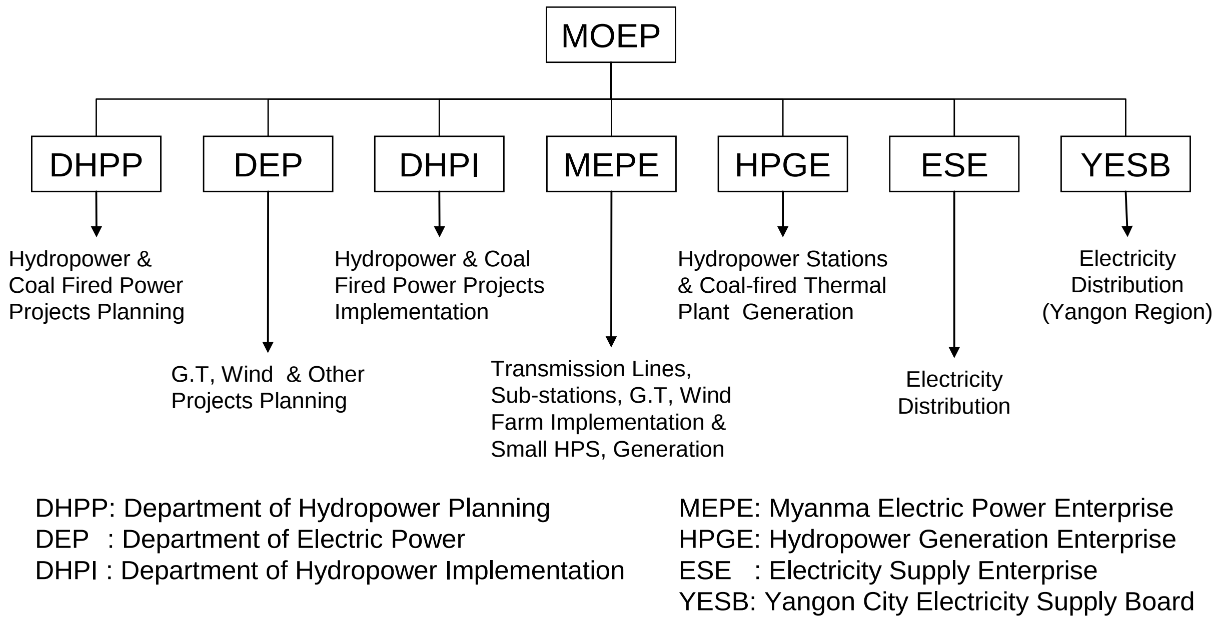
2.2 STATUS AND ISSUES OF POWER SECTOR

(1) Organization and System of Power Sector

In 2006, the power sector in Myanmar was reformed from vertical integration by MEPE to four enterprises as shown in Fig. 2-1:

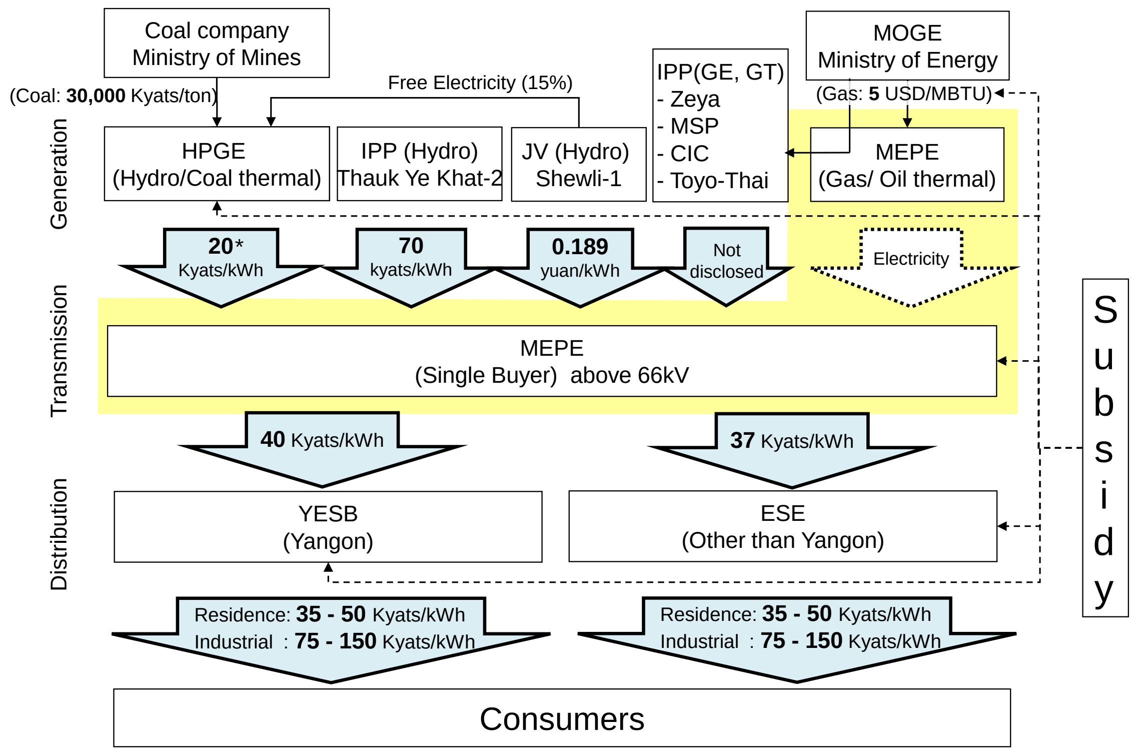
- Generation by HPGE (Hydropower Generation Enterprise), MEPE and IPPs;
- Transmission by MEPE; and
- Distribution by YESB and ESE.

MEPE plays the role of a single buyer similar to the power sectors of Thailand and Indonesia as shown in Fig.2-2. The unit prices to buy and sell electricity (kWh) between enterprises are also indicated in Fig.2-2.



Source: MOEP

Fig. 2-1 Organization and Function of MOEP (April 2014)



* 18 Kyat/kWh as of August, 2014

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

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

(2) Points to be reformed in Present Power Sector

After MOEP (1) and MOEP (2) were consolidated into MOEP in September 2012, the re-organization of MOEP has not been carried out. Function of governmental departments and SOEs (State Owned Enterprise(s)) should be clearer, and items to be improved and studied are as follows:

- In the present Myanmar power sector, it is recommendable that governmental departments should make a power development policy, give approvals and licenses for new power development, regulate the periodical inspection of the existing power plants. SOEs should implement power generation, transmission and distribution services following government policy and regulations. Two planning departments - DEP (Department of Electric Power) and DHPP (Department of Hydropower Planning) - in MOEP should be integrated into a single department.

- Presently, MEPE implements not only transmission service as a single buyer (who is defined as a governmental entity or public power company who buys all electricity generated by private companies and sells the electricity to a distribution company), but also gas-fired thermal power generation. In order to make MEPE a more efficient entity as a single-buyer, MOEP should better control all TPPs (thermal power plant(s)) via a new SOE, in 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 the electricity supply to the national grid, one option is that MEPE owns reservoir type HPPs (hydropower plant(s)) such as Yeywa and Paunglaung, which have a 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 there, the GoM should study how to better control the power sector by further reinforcement of governmental organization or establishment of an electricity regulatory authority which is a politically and financially independent organization.

- For planning of a PDP (Power Development Plan), MOEP needs to implement and evaluate an F/S (Feasibility Study) for all power development projects in advance, and to study development priorities and the ratio between MOEP's sole development and IPPs' development.

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

- MOEP is developing gas-fired thermal IPP projects. The procurement price of gas for IPPs and the wholesale price from IPPs will affect retail electricity tariffs. Though MOEP procures gas for power generation with subsidy price from MOE (Ministry of Energy), this subsidy will be decreased and wholesale prices will increase. MOEP expects to make up for any shortage of gas by procuring LNG (Liquid Natural Gas) via international bidding; its procurement price is forecasted to be high, which will affect the wholesale price and/or financial state of MEPE. Since MOEP requires power development by IPPs because of lack of finance, MOEP should study the future effect to the electricity tariff of power sources of each IPP type such as hydro, gas, and coal while the reserved margin of power supply is kept constant to prevent excess capital investment.

- The GoM currently subsidies the power sector for procurement of power fuel and wholesale prices to keep the retail electricity tariff at low level. To reduce the amount of governmental subsidies and stabilize financial conditions for generation, transmission and distribution enterprises, an appropriate cost-pass-through system is necessary, with the retail electricity tariff properly including the construction cost of power facilities, fuel costs, purchase cost from IPPs, O&M (Operation and Maintenance) costs, etc.

- Since wholesale prices from IPPs largely affect electricity tariffs, MOEP should fix a PPA (Power Purchase Agreement) before giving construction permission to developers. Provision of rules and procedures for PPAs 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 the domestic and import fuel amount to have bargaining power for price negotiation, while keeping stable procurement for fuel demand. Since coal-fired thermal power will be necessary to meet expected power demand going forward, adoption of CCT (Clean Coal Technology) should be studied for reduction of the environmental burden in line with growing international concerns. Moreover, introduction of USC (Ultra Supercritical) plants, which have a relatively high initial cost but lower running fuel costs with higher power efficiency, should be studied to reduce emissions 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 their organization and arrange rules and manuals via O&M guidelines, and implement continuous capacity building for management of power plants.

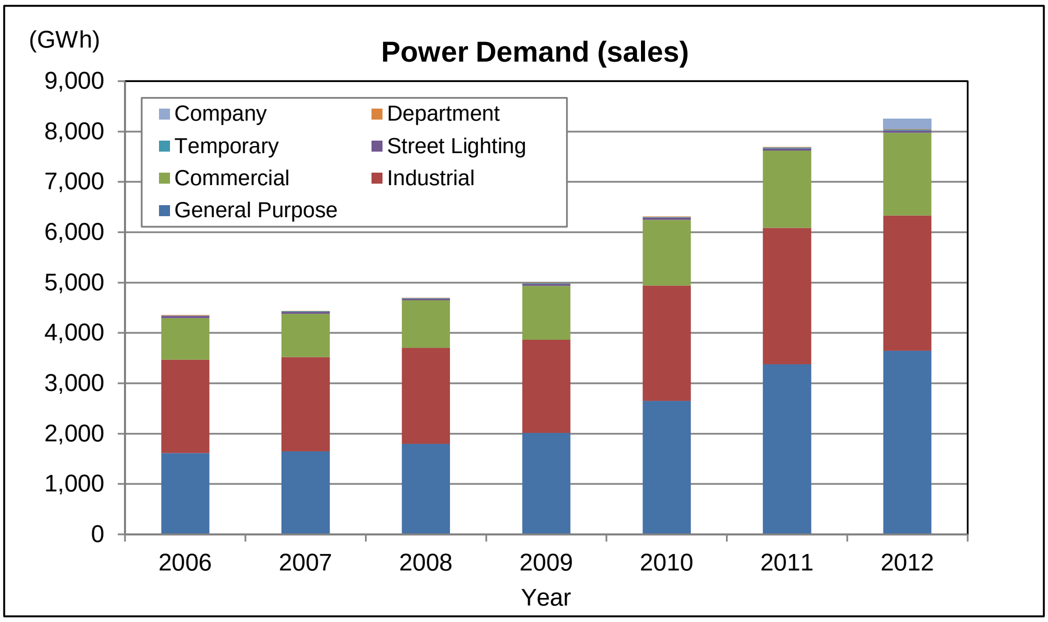
- Given the changing circumstance of the Myanmar power sector, it is urgent to strengthen human resource development and capacity building of MOEP staff so as to better handle the introduction of IPP (international bidding, PPA negotiation), environmental laws and regulations [EIA (Environmental Impact Assessment) and accountability], corporatization of SOEs (pricing policy, subsidy), establishment of electricity regulatory commission (the national electricity policy, the electricity tariff policy), etc.

CHAPTER 3 POWER DEMAND FORECAST

3.1 CURRENT POWER DEMAND AND FORECAST OF MYANMAR

(1) Current Power Demand Trend of Myanmar

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



Source : MEPE Administration Internal Data

Fig. 3-1 Power Consumption Trends in Myanmar

Table 3-1 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

The demand for power in Myanmar is also increasing along with recent rapid economic growth. However, this trend cannot be quantified into future projections as it is difficult to estimate. In addition, it cannot be said that the present value fully represents the current state unless frequent planned power outages and suspension in power supply and significant supply restrictions towards industrial districts are added. The potential demand estimates for power consumption is around 4.4% based on current power consumption amounts.

(2) Industrial Complex

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

3.2 POWER DEMAND FORECAST

(1) Our Methodology of Power Demand Forecast

In this analysis, top line forecasting methodology based on macro trend analysis is applied. It is believed this is most appropriate when compared to other methodologies such as accumulated forecasting requiring various assumptions for analysis which presently in Myanmar are unavailable due to inadequate data and lack of concrete future plans. This methodology could be reviewed in the future when the various statistical data are updated and validated.

(2) Premise of Power 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 and lack of concrete future plans. Nearby countries of Thailand and Vietnam are referred to due to their similar composition of population and geography.

Demand growth is calculated by future GDP (Gross Domestic Product) estimates and value of elasticity (power demand growth rate / GDP growth rate). Since the approximately 1.49 value of elasticity that the MOEP is using for its PDP is considered to be valid when compared with other countries with similar circumstances, the same value is used in this study.

When making a future forecast, two 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 calculated based on the IMF forecast (10.1%).

(3) Power Consumption Forecast (Consuming End)

Given the conditions mentioned above, estimated power consumption is shown below.

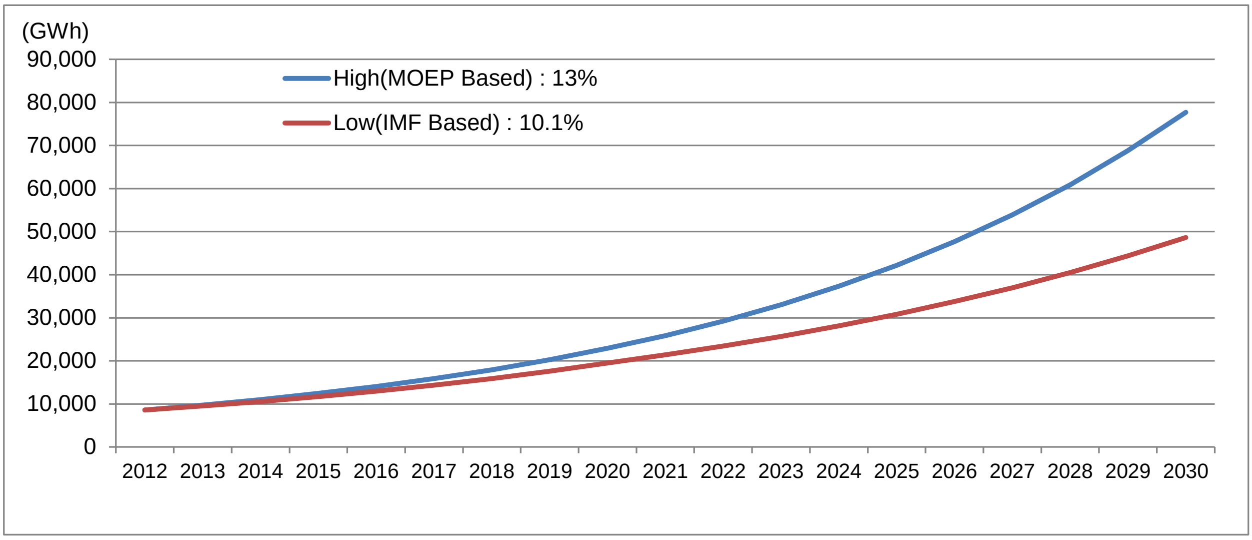


Fig. 3-2 Power Consumption Forecast of Myanmar

Although power consumption in 2012 was 8,254 GWh, it is projected to be 8,613 GWh when including the potential power demand due to aforementioned load shedding and suspension in power supplies. When projecting 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 value, and more than five times the current rate at 48,639 GWh in 2030 for the low case (high case: 77,730 GWh).

It is assumed that demand from industry in both the high case and low case will keep firm for the short term, and that a difference will not appear for both cases until 2020.

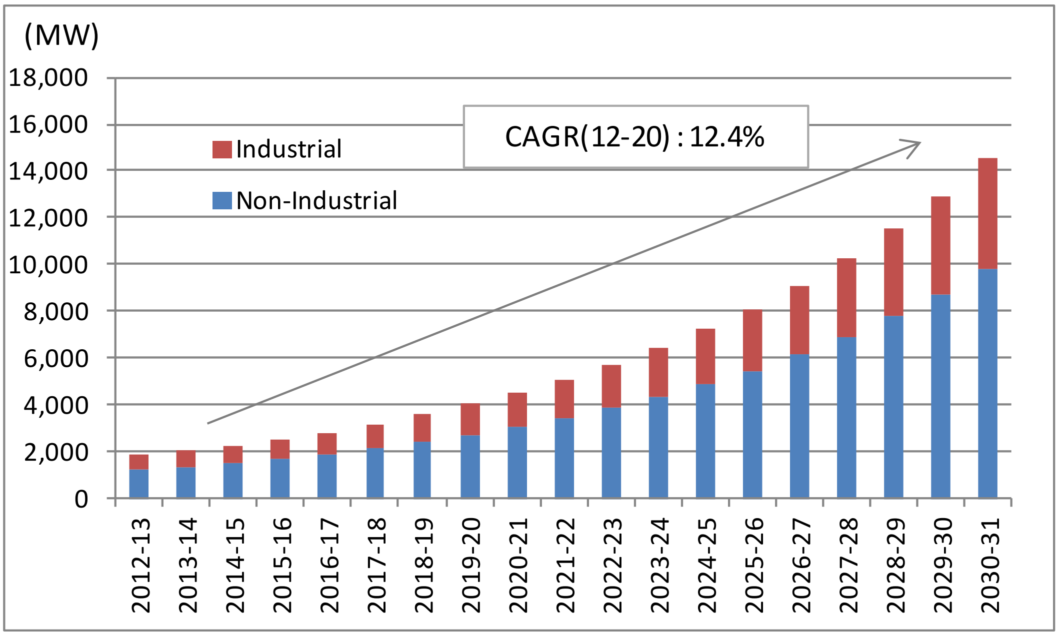
(4) Maximum Power Demand Forecast (Generating End)

Maximum power is calculated with 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 reached 72.1% in 2011 and decreased slightly to 68% the two years following. In this study, JICA Study Team assumes the future load factor in Myanmar at 68.9%, which is the actual figure in 2012. The annual load factor in Thailand, a neighboring country, was 71% to 72% from 1996 to 2006, indicating no change trend regardless of varying dispersion in some years.

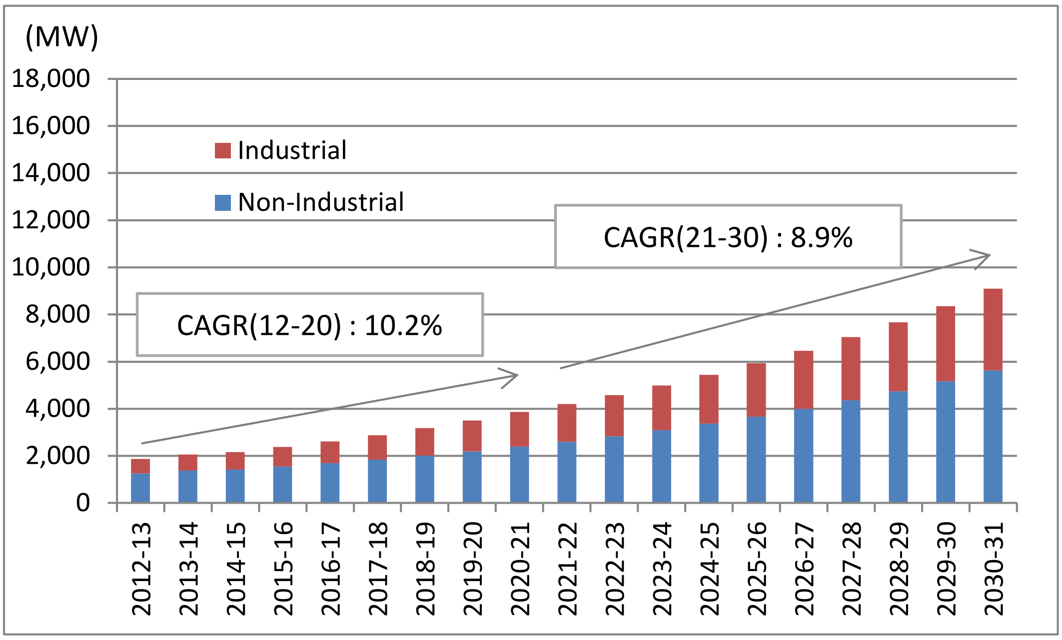
The future power transmission and distribution loss is assumed to gradually improve to the 12% standard of Thailand since 2000. On the other hand, the internal use rate should not significantly change in the future, and the current standard of a little less than 1% is expected to continue.

Based upon the above conditions, the maximum power demand forecast is estimated below.



*CAGR : Compound Average Growth Rate

Fig. 3-3 Maximum Power Demand Forecast (High-case)



*CAGR : Compound Average Growth Rate

Fig. 3-4 Maximum Power Demand Forecast (Low-case)

Based on the conditions mentioned above, it is estimated that the maximum power demand in Myanmar will be 14,542MW and minimum 9,100MW by 2030.

When making PDPs, both high and low cases should be taken into account to best prepare for an unpredictable future. In the implementation phase, the high case scenario should be chosen to avoid supply shortages, which is currently the most serious problem in Myanmar's power sector.

In the power forecast by MOEP prepared prior to this study, it is estimated to be 19,217MW in 2030. It is possible that this forecast is high as 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 important issues to be solved by MEPE and their effort to reduce it is expected to continue in the future. Therefore it may be a higher estimate than reality without considering these factors. In addition, as previously mentioned, this estimate is calculated on the condition that the current high growth rate will continue into the future, and the viability of that is uncertain.

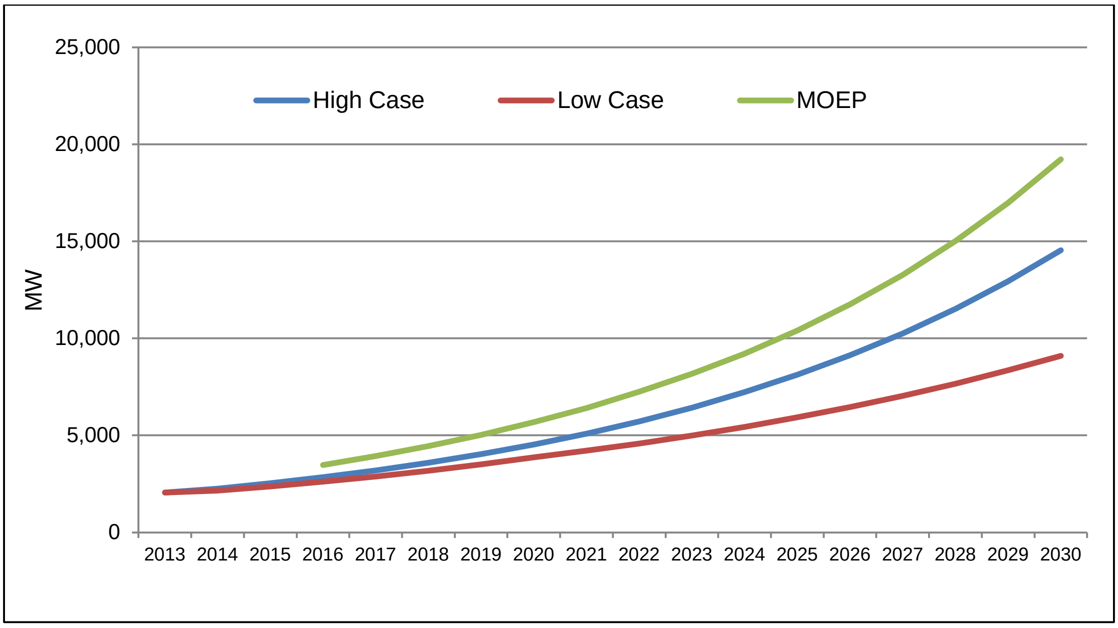


Fig. 3-5 Results of Demand Forecast

Table 3-2 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

(5) Demand Forecast by Region

In this study, a power demand forecast is estimated in total for the entire country from a macro approach. Thus, the PGDP (Power Generation Development Plan) is also drafted on a country-wide basis. 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.

Table 3-3 Power Demand Forecast by Region/State

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

CHAPTER 4 PRIMARY ENERGY

4.1 HYDROPOWER

4.1.1 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 wet season in the PDP.

Overall hydropower 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 of China or Thailand, and a half of electrical generation will be exported to these countries.

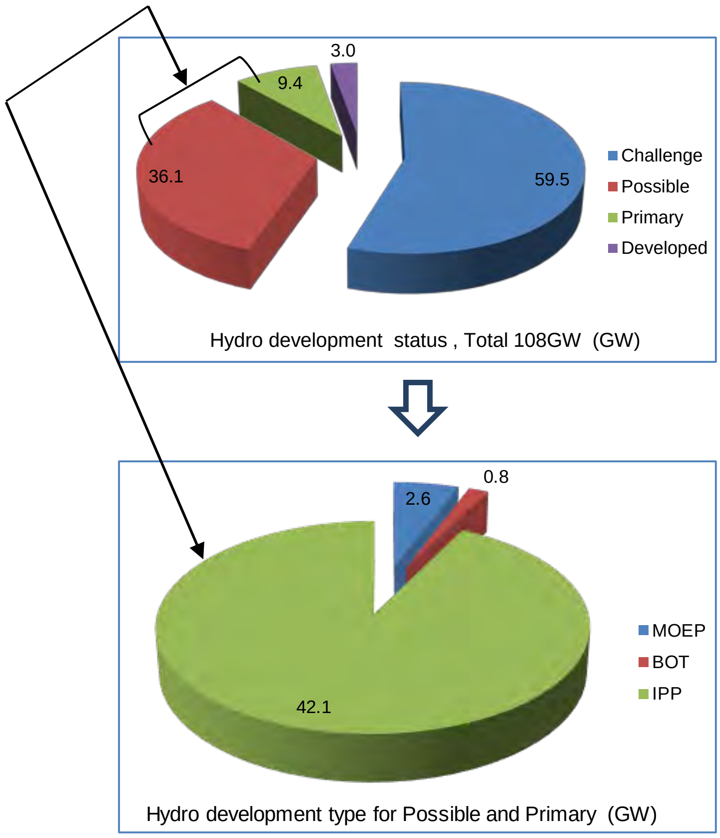


Fig. 4-1 Status of Hydro Development

4.1.2 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.

4.2 NATURAL GAS

4.2.1 Status and Outlook of Gas Supply

The Gas Supply and Demand Balance (~2030) table below is based on the following:

a) Gas supply from new fields will start in 2020-2021.
b) Gas shortage until 2019-2020 is solved by imported fuel oil and/or LNG.
c) LNG can supply from 2016-2017 until expected new gas yield come online (2020-2021).
d) Fuel oil can supply from 2014-2015.
e) Domestic gas supply ratio to Power Sector is 65%.

Table 4-1 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

The main points of gas supply prediction based on the table above are as follows:

1) To address the gas shortage from 2014-2015 to 2019-2020, LNG and/or fuel oil has to be purchased. The required maximum quantity of LNG only for the power sector is 84 mmcfd (marked in green), and that of fuel oil only as HSD (High Speed Diesel oil) 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.

2) Gas shortage from 2020-2021 to 2030-2031 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 at 715 bbtud (797 mmcfd based on Zawtika's calorific value). 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 only for domestic use. Graphic view of above table is shown below:

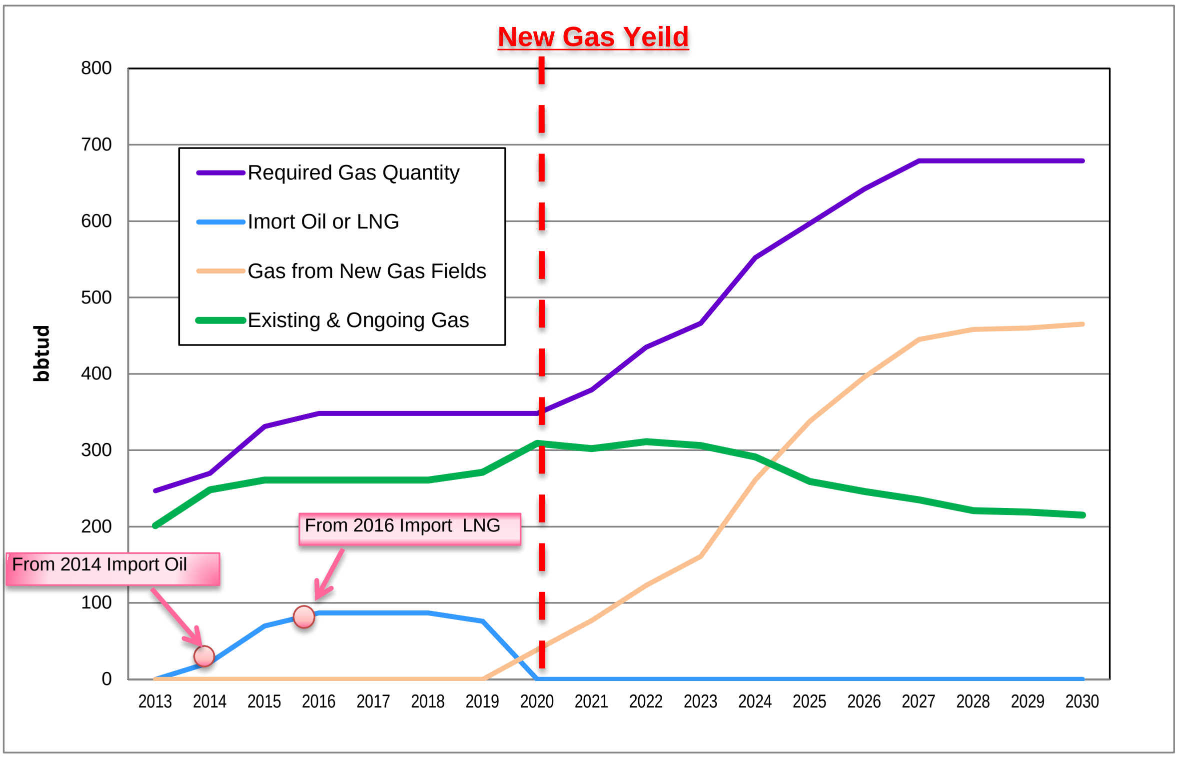


Fig. 4-2 Gas/Liquid Fuel Supply Plan (~ 2030)

4.2.2 Measures of Gas Supply

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

   If the negotiations on gas repurchase are difficult or takes time, as the second best solution, JICA Study Team recommends the MOEP consider liquid fuel (HSD) firing in existing and ongoing GTs (gas turbine(s))/GTCCs (gas turbine combined cycle(s)) where gas shortages are forecasted in the very short run.

   The reasons are as follows:

   a) Realization of LNG purchases is not clear to date, and even if realized, it takes 2~3 years minimum to supply LNG to 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 will need 2~3 years' lead time to complete.

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

3) As gas shortages are expected in the future, JICA Study Team recommends that MOEP consider specifying dual firing for future gas firing plants (GE (gas engine), GECC (gas engine combined cycle), GT, GTCC) in the new tenders[1].

4) As for the future gas-fired TPPs of Ayeyarwady/Yangon (500 MW), Hlaingtharyar (400 MW) and UREC 2 (400 MW), JICA Study Team recommends adopting GTCC with high efficiency GTs (where the combustion temperature is more than 1,500°C). MEPE can reduce gas consumption by around 13% due to the increase in efficiency.

   With regards to system frequency stability, in case of failure of 400 ~ 500 MW GTCC - as the gas-fired TPPs are planned to be put into operation after 2024-2025 - predicted peak loads reach 7,000 MW. Thus, a frequency drop of 400 ~ 500 MW is well within the allowable range.

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

   It is recommended that to avoid "Take or Pay", gas-fired TPPs that use Yadana gas and Zawtika gas reduce load factors or stop 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 that the MOE study the construction of a new gas pipelines in parallel with development of new gas fields.

1 for GE, GECC: Gas and heavy fuel oil/crude oil, for GT, GTCC: Gas and HSD

4.3 COAL

4.3.1 Status and Outlook of Coal Supply

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. The coal supply and demand balance (~2030) table is prepared on the following conditions:

a) Domestic coal is assumed to be supplied for the power sector up to 60%.
b) Shortages of domestic coal will be solved by imported coal from Indonesia, Australia, South Africa, and elsewhere.

1) To realize the operation of the all future coal-fired TPPs until 2030-2031, a maximum of 20 million tons of coal needs to be imported annually.

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

Table 4-2 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

	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31
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

3) With regards 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 a coal terminal will be required.

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

a) Coal mine group

As there is already a coal mine group in Kalewa Region, IPPs can contract a CSA (Coal Sales Agreement) with the group to enable bulk coal purchases. A coal mine group in Shan State that could supply coal to Keng Tong coal-fired TPPs, however, does not exist. As Keng Tong coal-fired TPPs will consume bulk coal, private coal mine companies cannot deal with the required large amounts of coal independently. A coal mine group must set up before implementation of the Keng Tong coal-fired TPP project.

b) Increase of domestic coal production

Present coal production in Kalewa Region and Shan State is far from the quantities required to supply Kalewa and Keng Tong coal-fired TPPs. Increased coal production is an imperative demand.

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

A graphic view of the table above:

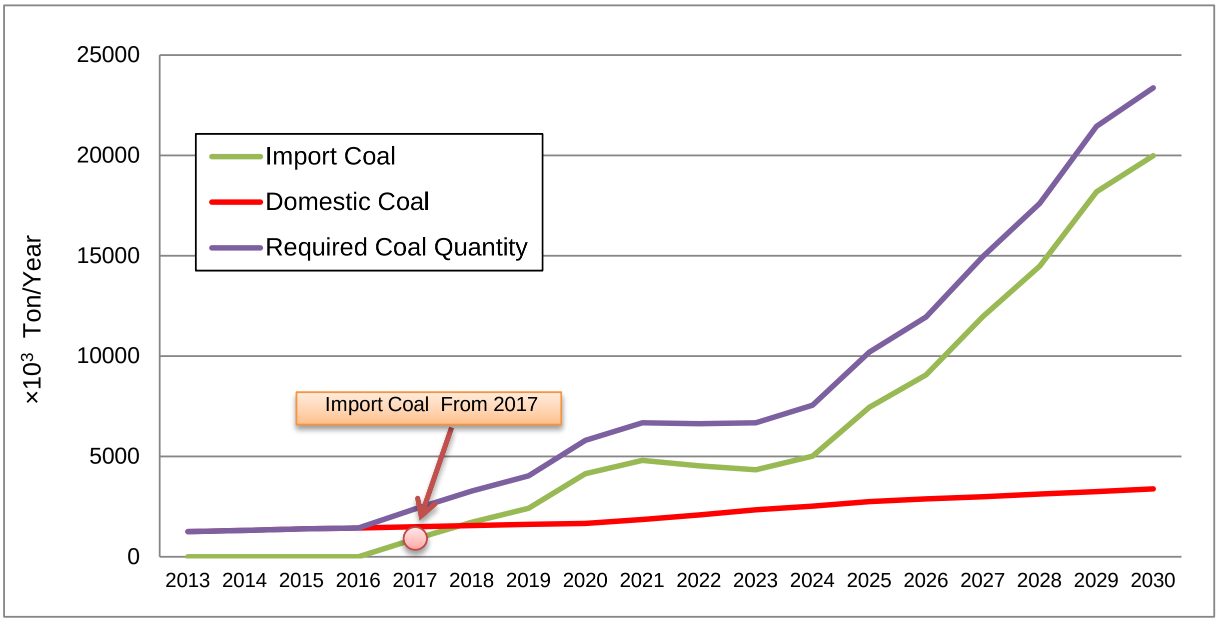


Fig. 4-3 Coal Supply Plan

4.3.2 Measures of Coal Supply

1) JICA Study Team recommends that the GoM takes initiative in developing a coal terminal in order to facilitate bulk coal imports to future coal-fired TPPs, especially in Yangon Area considering the development of several IPP projects there. A common coal terminal that other IPPs can use can also be developed by IPPs with construction of coal-fired TPPs jointly.

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

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

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

4.4 RENEWABLE ENERGY

4.4.1 Status and Expansion Plan

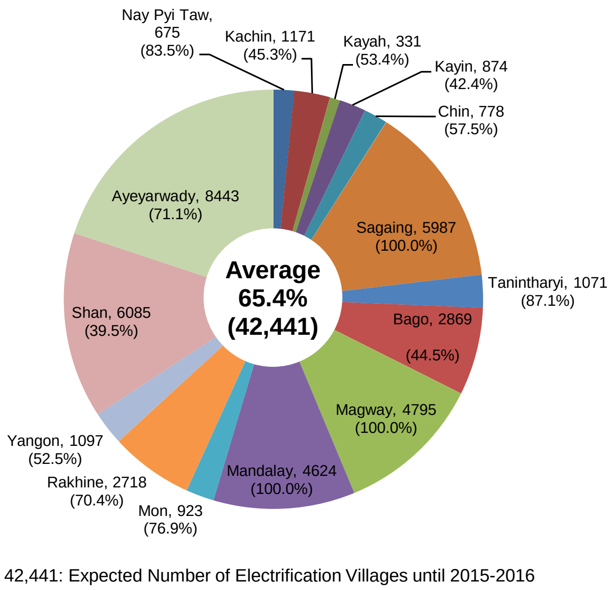
1) The overall responsibility to promote rural electrification has recently transferred from MOI (Ministry of Industry) to MOLFRD (Ministry of Livestock, Fisheries, and Rural Development).

2) The roles and responsibilities regarding rural electrification and promotion of renewable energy in Myanmar are summarized as follows:

Type of Energy	Research & Education	Production				
		Off-Grid/Mini-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/GE)	-	ESE/MOI*2	○	○	MOEP	○
Geothermal Power	-	-	-	-	MOEP*3	○
Tidal Power	MES	Under study stage				

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

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



Source: DRD as of January 2014

Fig. 4-4 Forecast on Rural Electrification until 2015-2016

4.4.2 Measures of Renewable Energy

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.

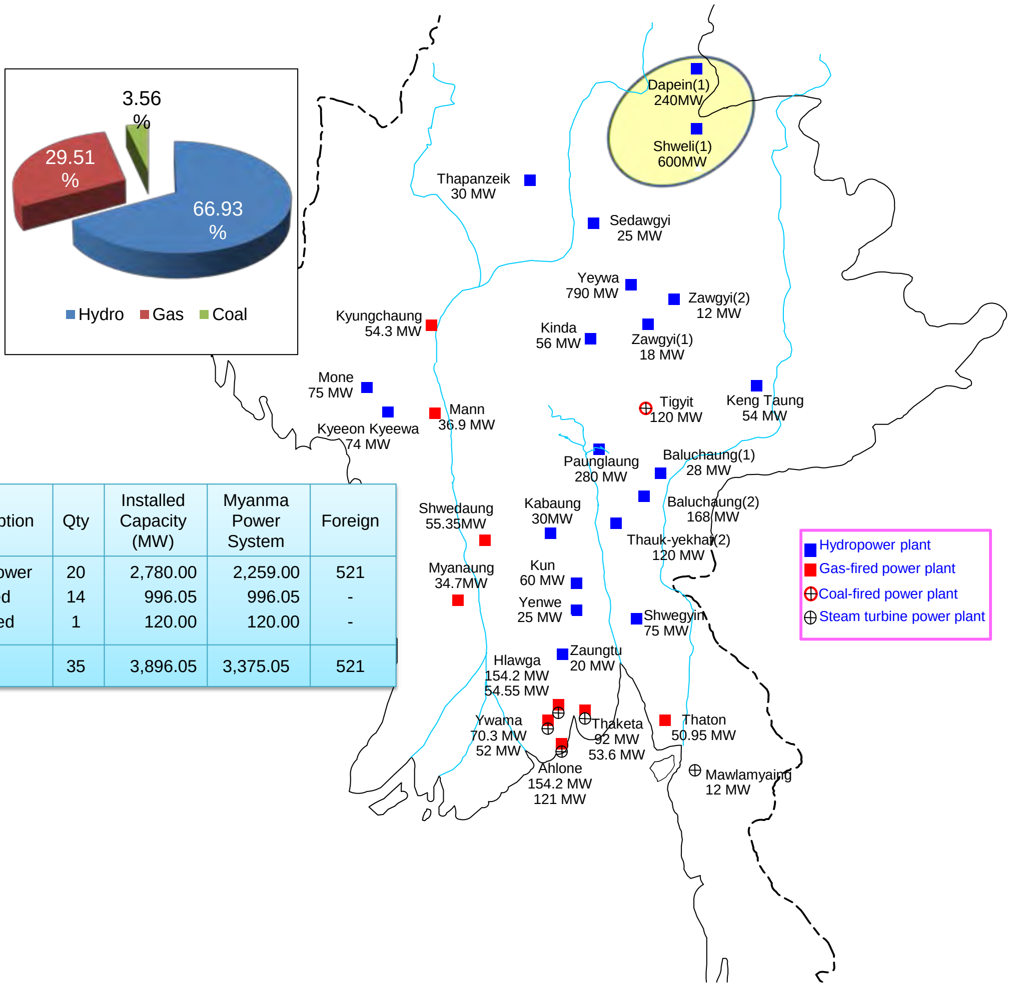
2) JICA Study Team also recommends that the GoM reflects the study results by WB (World Bank) and ADB on the Five-Year Plan and a future plan as much as possible with regard to the feasible rural electrification system, programmatic sector-wide approach and planning of the financial model on long term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

CHAPTER 5 POWER GENERATION DEVELOPMENT PLAN

5.1 SITUATION OF EXISTING POWER STATIONS

(1) Summary of Existing Power Plants

The total installed capacity of the existing power plants in Myanmar is 3,896.05MW according to the PDP in Myanmar (June 2013)[2], consisting of hydropower generation (2,780MW), gas-fired power generation (996.05MW) and coal-fired power generation (120MW). The location of power plants is shown in Fig. 5-1, with the installed capacity of each power plant shown in Table 5-1.



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

Fig. 5-1 Location of Existing Power Plants

2 PDP in Myanmar by MOEP (June, 2013)

Table 5-1 Power Stations 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)

According to study results by JICA Study Team, as of December 2013 HPPs' installed capacity was 2,780MW (20 plants), gas-fired TPPs' installed capacity was 796.9MW (10 plants) and coal-fired TPPs' installed capacity was 120MW. As a result, total installed capacity was 3,696.9MW (31 plants).

(2) PDP in Myanmar

A comprehensive list of power plants based on available documentation and information is presented in Table 5-2. This list includes existing, ongoing and future planned power plants (hydropower, gas & coal-fired power and renewable energy).

Additionally, power supply capacities are also described in Table 5-2 through 2030. Although the situation regarding power generation in Myanmar is continuously updated, this table is adjusted to correspond to the PDP as of June 2013.

Table 5-2 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 5-2 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 (Tuxzing ?)	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 5-2 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

5.2 BASIC CONDITIONS FOR FORMULATION OF THE PGDP

5.2.1 Planning Methodology for the PGDP

(1) Planning Methodology for Short term

The PDP in Myanmar presents new gas TPPs (mainly by IPP projects) as important for power supply in the short term (by 2016) because of their relatively short construction period. As the PDP in Myanmar is the base of this study, the plan has been reviewed considering variety of power supplies and delay of construction.

In short term planning, in order to mitigate the power supply shortage, the most present issues have been extracted and prioritized. The middle and long term plans have been recommended in view of economic performance and reliability.

As mentioned above, available power supply capacity has been reviewed considering a variety of power supplies and an optimal power generation planning program has been utilized.

(2) Planning Methodology for 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

Scenario 1 is the one in which the utilization of domestic power resources will be maximized based on the PDP. For example, hydropower including large scale ones and gas-fired plants are fully developed and the power supply deficit is compensated by coal-fired TPPs.

Scenario 2 is the one in which the overall generation cost will be minimized. Therefore, compared to the above scenario, power supply from coal-fired TPPs will increase and that from gas-fired plants will decrease in order to minimize costs.

Scenario 3 is the one in which the best mix of power resources is focused 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 up to completion and short distance to demand centers. Gas-fired plants will be fully developed as long as enough gas supply can be expected. However, the capacity of domestic energy such as hydropower, gas and renewable energy is insufficient for future demand and comprises some risks in the power supply. Coal-fired TPPs must also be developed to compensate for them. It is effective to balance power resources in regards to 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. Through this exercise, JICA Study Team has proposed the best-mixed power generation development from the viewpoints of economy and reliability for the middle and long terms.

5.2.2 Policy of the PGDP

The development policy of each scenario by power source for the short, middle and long term summarized in Table 5-3 below.

Table 5-3 Development Policy of each Scenarios by Power Source

<table>
<tr><th colspan="2" rowspan="2">Power Source</th><th colspan="3">2015</th><th colspan="3">2020</th><th colspan="3">2030</th></tr>
<tr><th>S1</th><th>S2</th><th>S3</th><th>S1</th><th>S2</th><th>S3</th><th>S1</th><th>S2</th><th>S3</th></tr>
<tr><td colspan="2">Gas-fired</td><td colspan="3">Development based on MOEP's Plan</td><td colspan="3">Development based on MOEP's Plan</td><td>Development of plants based on the gas supply forecast after 2022, commissioning of new gas fields</td><td>-</td><td>Development of plants based on the gas supply forecast after 2022, commissioning of new gas fields</td></tr>
<tr><td rowspan="2">Hydro-power</td><td>Medium and Small Scale (~1,000MW)</td><td colspan="3">Development based on MOEP's Plan</td><td colspan="3">Development based on MOEP's Plan</td><td rowspan="2">Development of Large, Medium and Small scale hydropower plants based on MOEP's Plan</td><td rowspan="2">Development of Large, Medium and Small scale hydropower plants based on MOEP's Plan</td><td>Development of Medium and Small scale hydropower plants based on MOEP's Plan</td></tr>
<tr><td>Large Scale (1,000MW~)</td><td colspan="3">-</td><td colspan="3">-</td><td>-</td></tr>
<tr><td colspan="2">Coal-fired</td><td colspan="3">-</td><td colspan="3">Development based on MOEP's Plan</td><td>Development to compensate the shortage of gas and all hydropower plants</td><td>Development to compensate the shortage of all hydropower plants</td><td>Development to compensate the shortage of gas and Medium and Small hydropower plants</td></tr>
<tr><td colspan="2">Renewable Energy</td><td colspan="3">-</td><td colspan="3">Development from 2019</td><td colspan="3">Development to aim at 10% in total power supply in 2030</td></tr>
</table>

S1 : Domestic energy consumption scenario (Large Scale Hydro Oriented)
S2 : Least cost scenario
S3 : Power resources balance scenario

5.2.3 Optimal Power Generation Development Program

The "optimal power generation development program: WASP (Wien Automatic System Planning)" used in this Study was developed by the IAEA (International Atomic Energy Agency) and has been used by various countries for power generation development optimization planning.

The power generation development analysis was carried out based on the above-mentioned principles and expectations. The basic plan with main analysis and conditions for the calculations are shown below based on discussions with MOEP.

✔ 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)

Demand forecast is based on the results of Chapter 3.

✔ Future power plants

<table>
<tr><th rowspan="2">Resource</th><th rowspan="2">Capital Cost (USD/kW)</th><th rowspan="2">Efficiency (%)</th><th rowspan="2">Fuel Cost ($/MMbtu)</th><th colspan="2">O&M COST</th><th rowspan="2">Remarks</th></tr>
<tr><th>Fixed ($/kW-month)</th><th>Variable ($/MWh)</th></tr>
<tr><td>Hydropower</td><td>2,000</td><td>-</td><td>0</td><td>0.6</td><td>0</td><td>- 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.</td></tr>
<tr><td colspan="7">Thermal</td></tr>
<tr><td>Gas-Turbine</td><td>1,100</td><td>31.1</td><td rowspan="3">11.19 (Gas)
18.0 (LNG)
19.4 (HSD)</td><td>1.9</td><td>2</td><td rowspan="3">- 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 Gas Turbine World 2013 that of GE is on Hlawga (55MW).</td></tr>
<tr><td>Gas Combined</td><td>1,200</td><td>50.6</td><td>2.3</td><td>1</td></tr>
<tr><td>Gas Engine</td><td>890</td><td>45.6</td><td>1.9</td><td>2</td></tr>
<tr><td>Coal-Fired</td><td>1,500 - 2,200</td><td>38 - 43</td><td>4.26</td><td>2.5</td><td>2</td><td>- 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</td></tr>
<tr><td colspan="7">Renewable Energy</td></tr>
<tr><td>Photovoltaic (PV)</td><td>3,600</td><td>-</td><td>0</td><td>0.6</td><td>0</td><td>- 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.</td></tr>
</table>

Basic conditions such as capital cost were prepared based on existing projects, reports, interviews with persons concerned from relevant departments and related publications such as “Gas Turbine World”.

5.3 COMPARISON OF THREE SCENARIOS

The overall objective of the PGDP is that the short, middle and long term PGDPs meet the demand forecasts. The high case demand estimate: 4.5 GW in 2020 and 14.5 GW in 2030. Three scenarios of the PGDP were formulated with a target that the power supply during the dry season exceeds the demand of the high case estimate with a reserve margin of 30%.

The annual transition of the power supply and installed capacity for Myanmar in each scenario is shown in Fig. 5-2. When estimating the same amount of power supply during the dry season across all Scenarios, the lowest capacity is realized in Scenario 3. Imported coal-fired power stations are substituted for large hydropower stations in Scenario 3. The possibility of gas capacity depends on new local gas supplies or imports.

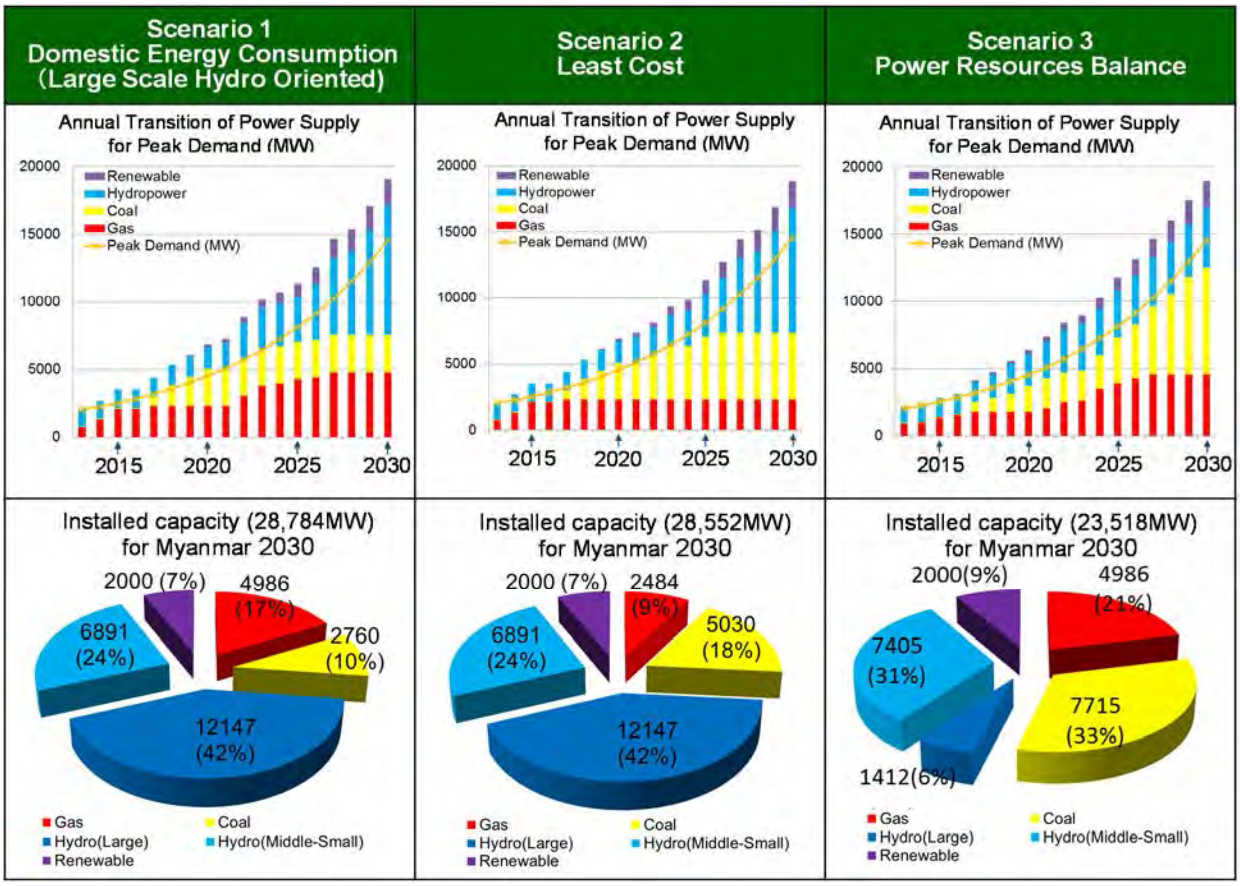


Fig. 5-2 Annual Transition of Power Supply and Installed Capacity for Myanmar in each Scenario

Comparison of LRMC (Long Run Marginal Cost) among three scenarios is shown in Fig. 5-3 and Unit Cost is shown in Fig. 5-4. For unit cost, HPP development indicates the lowest cost, with coal the second lowest and gas the highest.

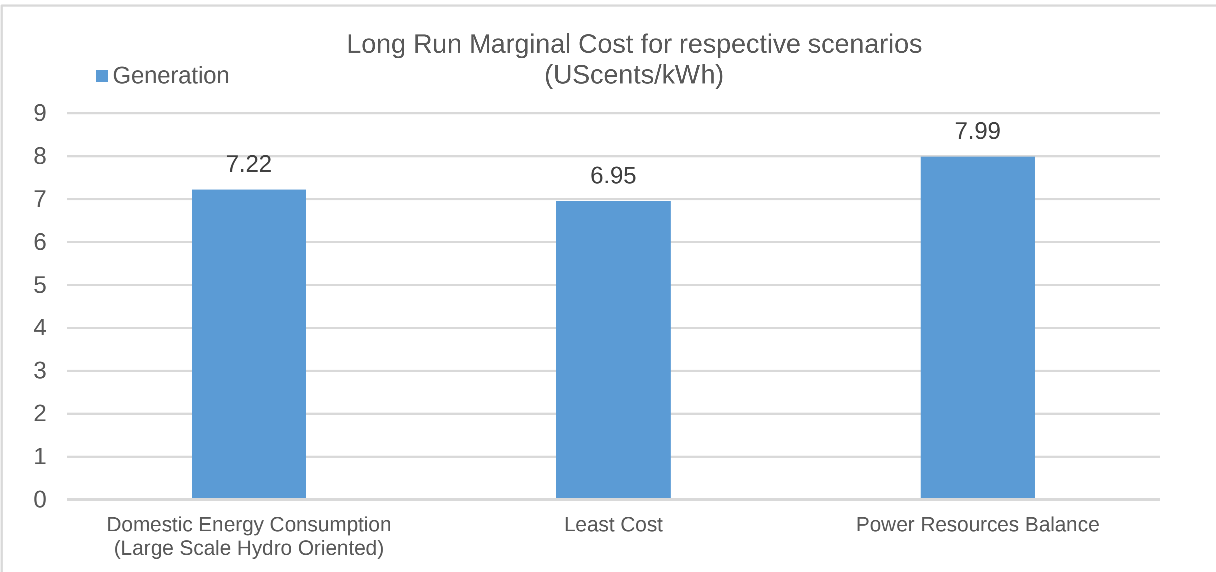
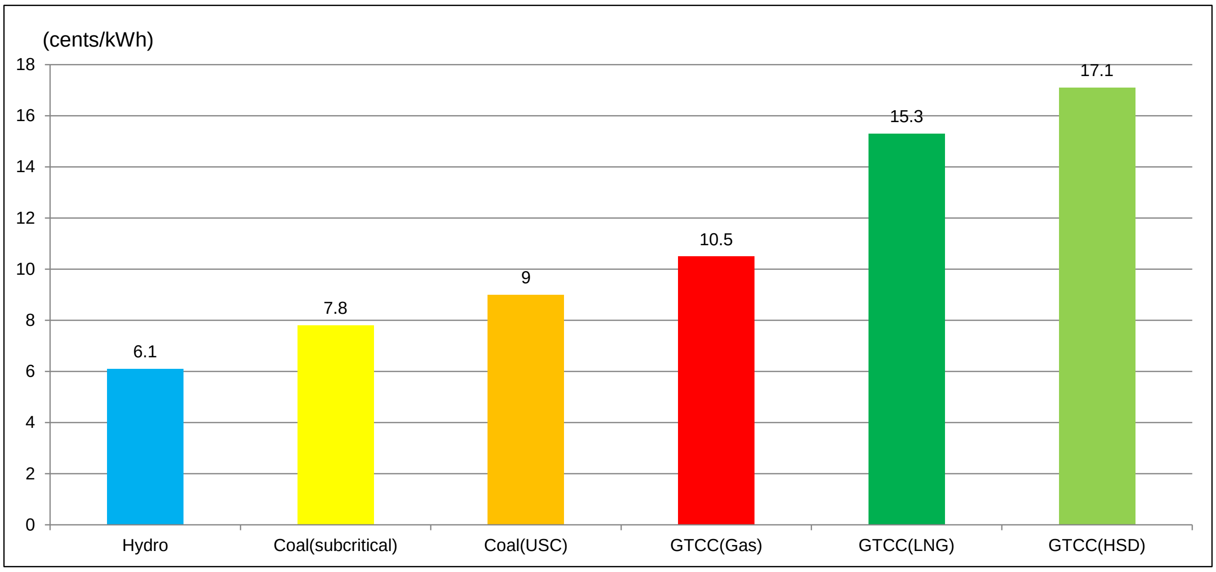


Fig. 5-3 Comparison of LRMC



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.

Fig. 5-4 Comparison of Unit Cost for each Power Resource

Close Discussion on the comparison of three Scenarios had been implemented between MOEP and JICA Study Team during this study. Finally, Scenario 3 "Power Resources Balance" is confirmed as the optimum one to be proceeded for the further study at the workshop on May 27, 2014, considering utilization of domestic energy, supply conditions of each primary energy and 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

Quantity of power supply and the operational year of power plants in Scenario 3 have been reviewed in recent interviews and discussions with MOEP.

(1) Revised Power Supply Composition for Scenario 3

The result of arrangements with MOEP is shown in Table 5-4 (supply planning), Fig. 5-5 (annual transition of power supply), Fig. 5-6 (power supply composition), Table 5-5 and Table 5-6 (operational year of HPPs and TPPs). The locations of new power plants are shown in Fig. 5-7 and Fig. 5-8.

Table 5-4 Supply Planning of the Revised Power 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	

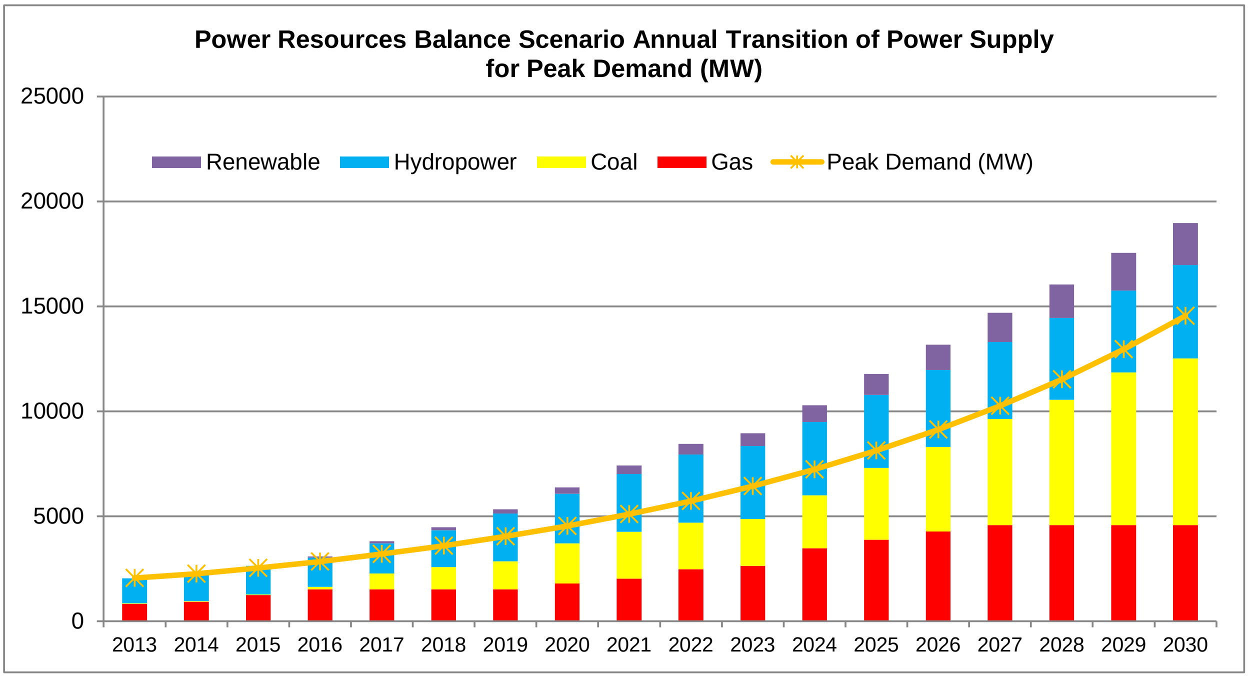


Fig. 5-5 Annual Transition of the Power Supply for the Revised Power Resources Balance Scenario

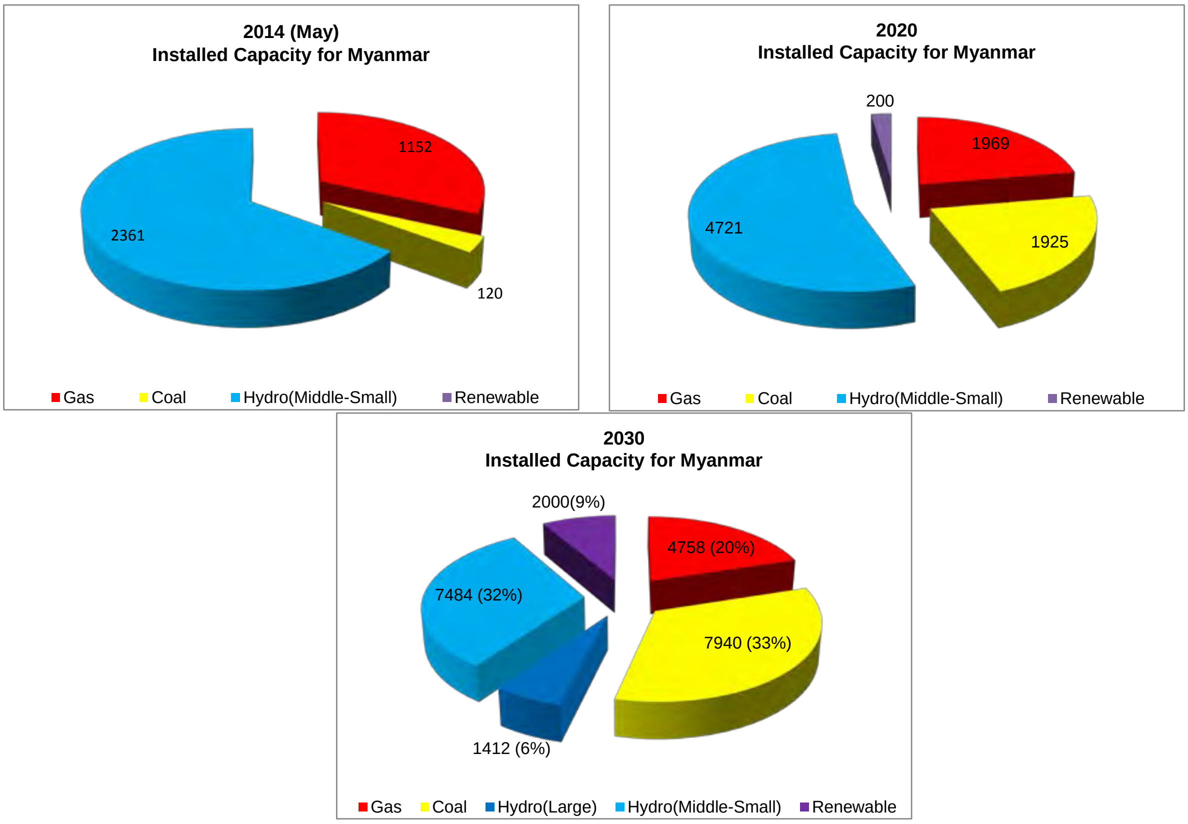


Fig. 5-6 Power Supply Composition of the Revised Power Resources Balance Scenario on 2014, 2020 and 2030

Table 5-5 Operational Start Plan of New HPPs: Revised Power Resources Balance Scenario (Final List)

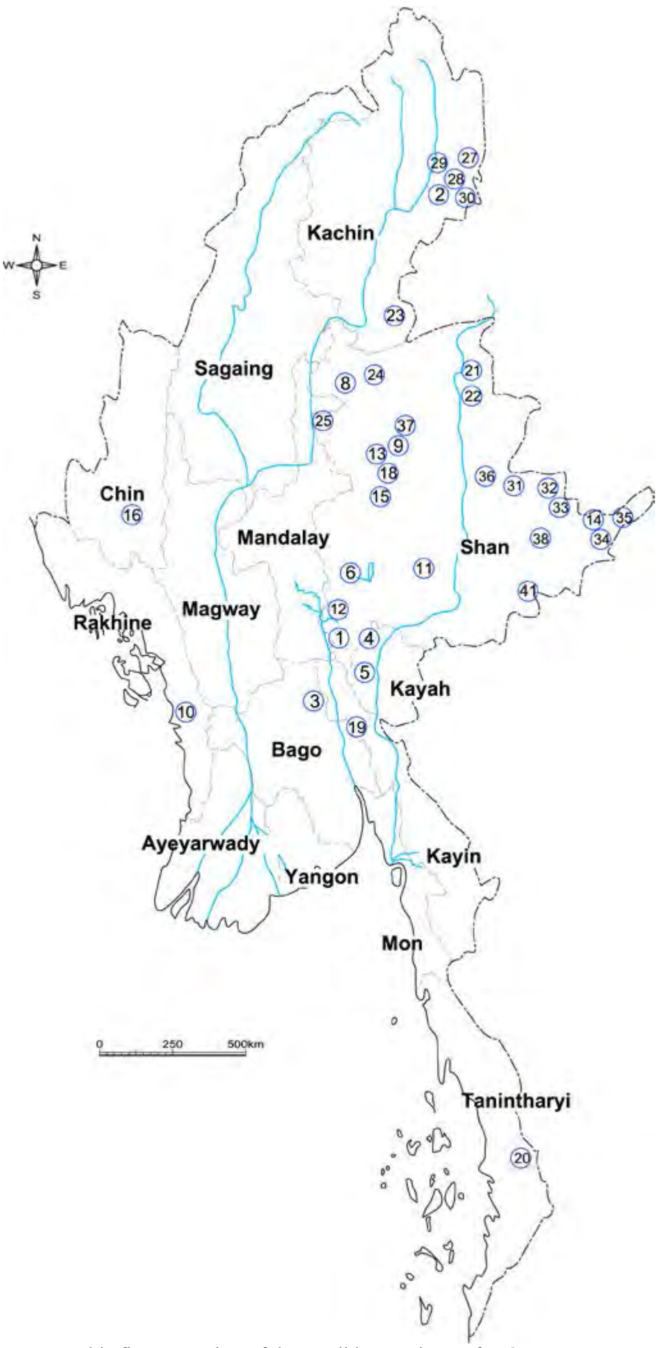
	Project	Installed Capacity (MW)	Proponent	Contraction Condition	COD by MOEP Plan	Available Capacity for Myanmar (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Remark
							2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	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	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		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 5-6 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*

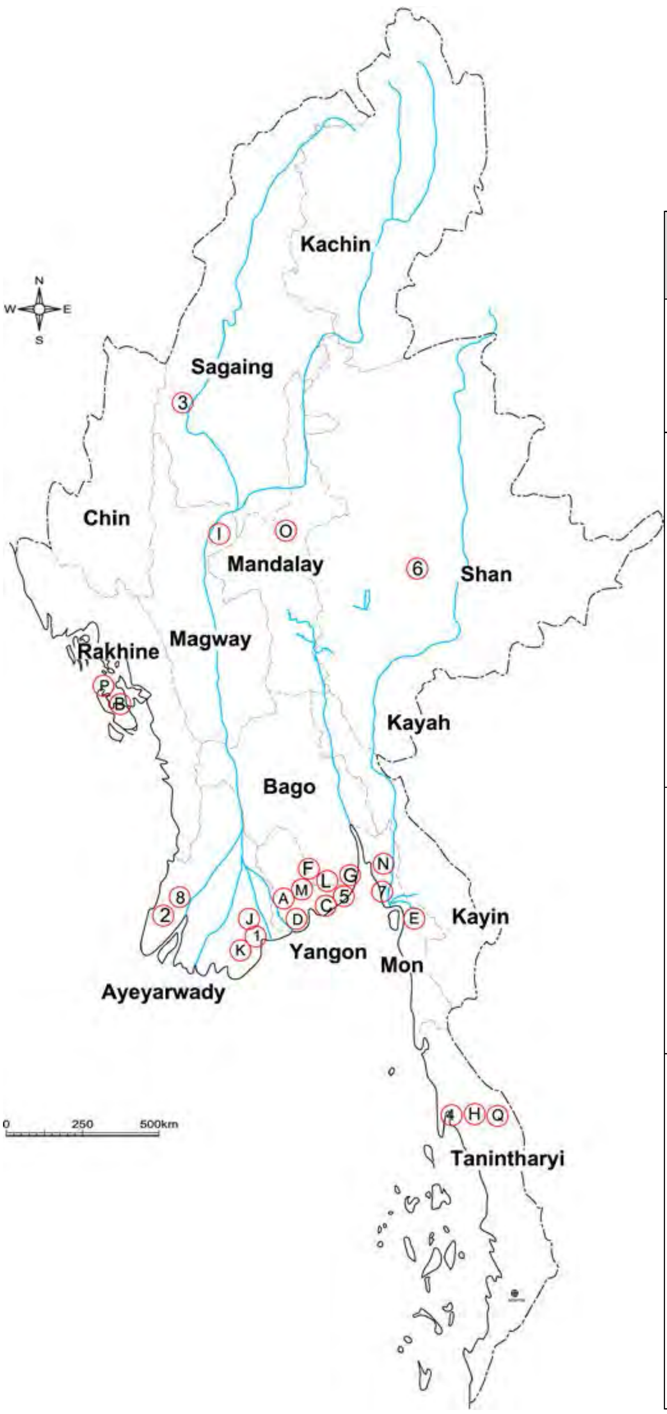
Note: This table consists of the candidate projects of MOEP.
As this plan is based on the provisional simulation, it may change in the future.



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. 5-7 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. 5-8 Location of New TPPs

(2) Revised Demand and Supply Balance for Scenario 3

As a result, in 2030 the total installed capacity will be 27.0GW, with the installed capacity for domestic use at 23.6GW and actual capacity during the dry season at 18.9GW (which includes the reserve margin (kW) of approximately 30% of the demand).

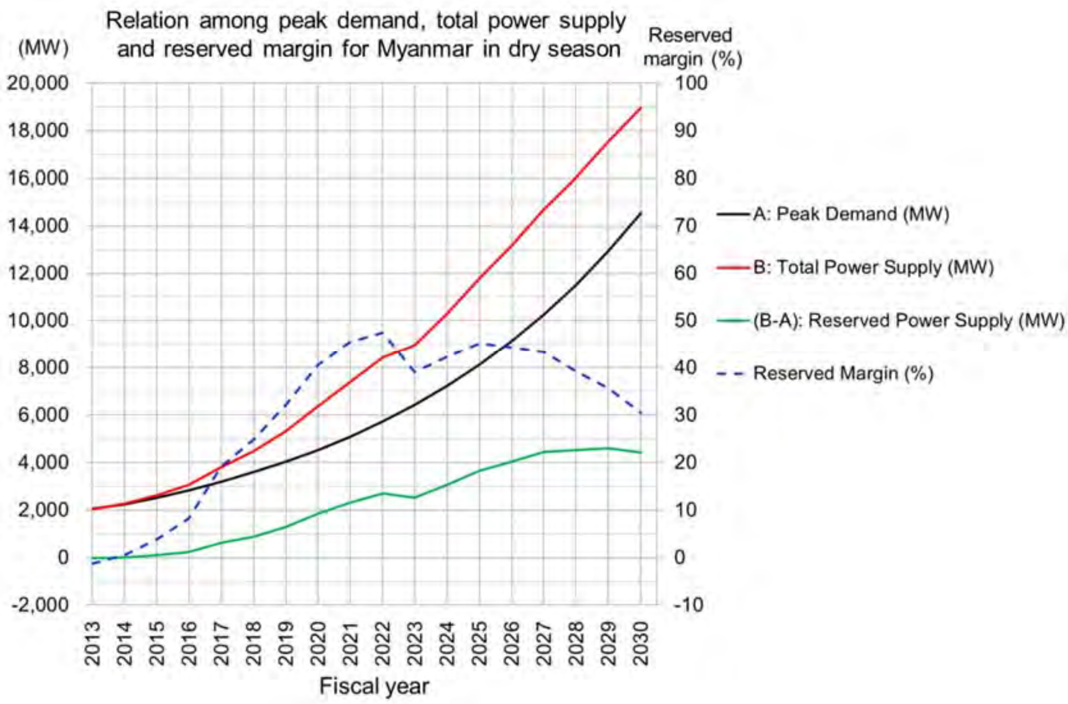
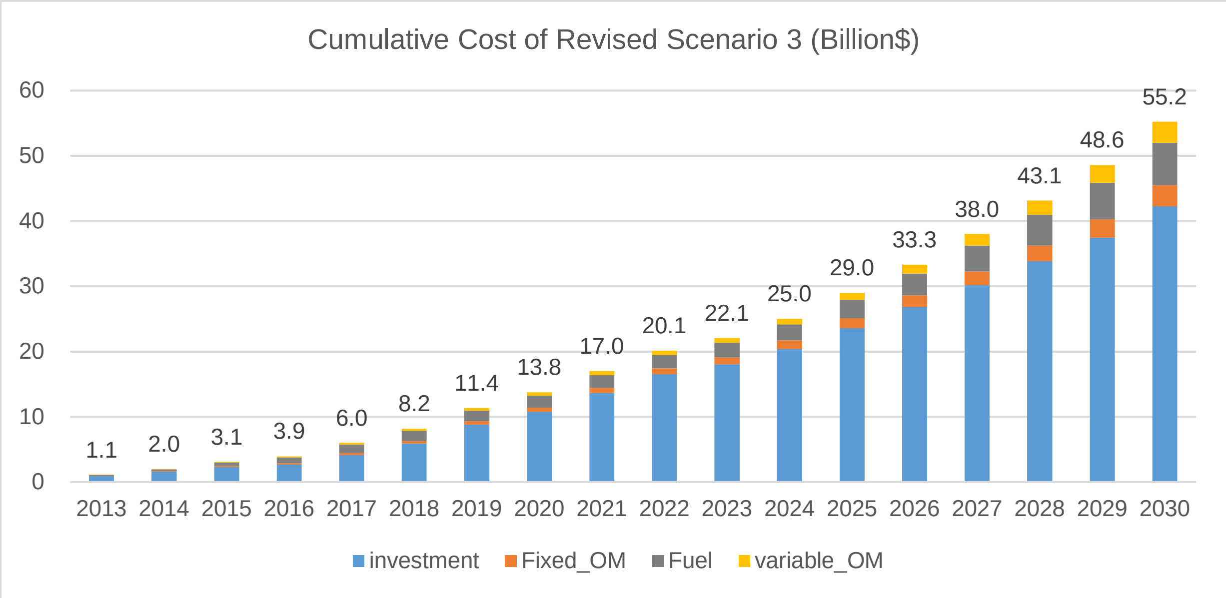


Fig. 5-9 Demand and Supply Balance during the Dry Season

(3) Revised Total Cost and LRMC for Scenario 3

Regarding the cost of revised Scenario 3 through 2030, the capital cost is approximately USD 42 billion, with O&M (including fuel) costing approximately USD 13 billion. The Total Cost is approximately USD 55 billion, which is shown in Fig. 5-10. Moreover, calculation of the LRMC has also been reviewed: the LRMC of revised Scenario 3 is 7.18 US cents/kWh (as opposed to the original 7.99 US cents/kWh). As the operational year of the new coal-fired TPP is shifted outward, the value of LRMC is decreased.



Cost is not calculated from present value. O&M cost and Fuel cost include the existing facilities.

Fig. 5-10 Cumulative Cost of Power Development

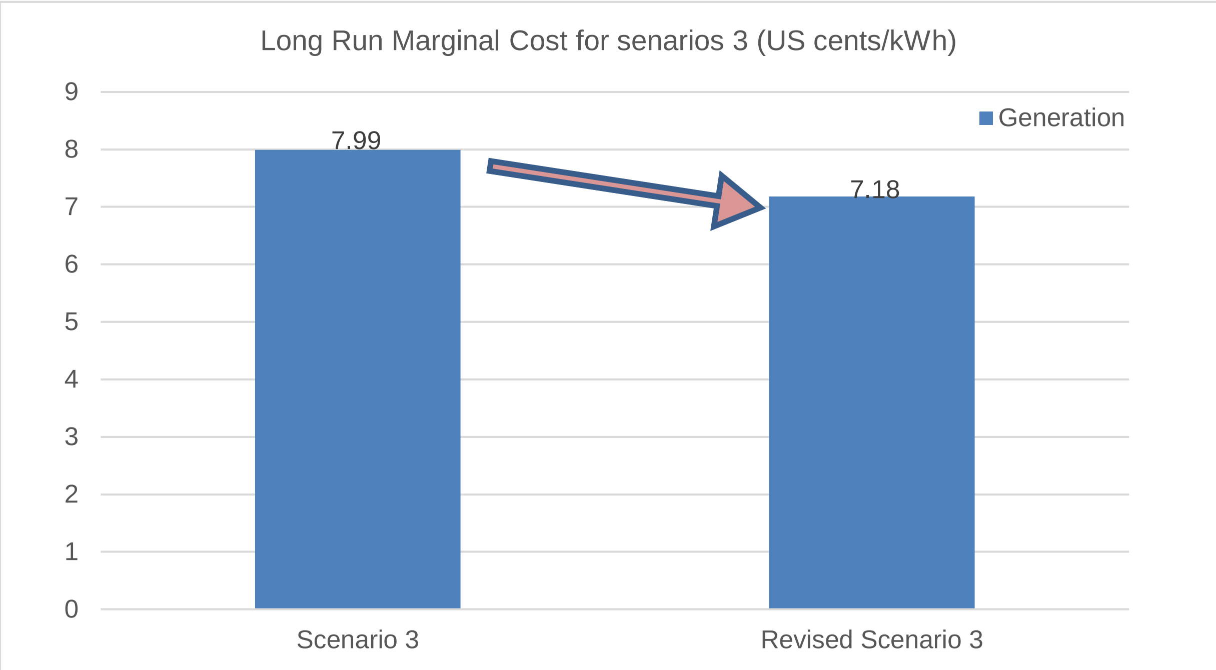


Fig. 5-11 Comparison of LRMC in Scenario 3 and that in Revised Scenario 3

CHAPTER 6 POWER SYSTEM DEVELOPMENT PLAN

6.1 OUTLINE OF POWER SYSTEM IN MYANMAR

6.1.1 Characteristics and Problems of Power System

In Myanmar, power demand areas and major power plants (primarily HPPs) are far away from one another; transmission lines connecting these areas thus are very long in length. Due to limited government budgets, construction and maintenance of the power system has not been carried out properly. From the limitation of government economical aspect, the construction of power system has not been carried out properly. As a result, lack of power supply and power transmission capacity has been occurred, and faced to the frequent blackout because of transmission line faults.

It is crucial to install and reinforce the bulk power system connection from the northern to the southern areas of the country with the bulk power system in Yangon Area in order to achieve continuous economic growth and enable hydropower supply generation utilizing abundant available water resources.

6.1.2 Main Projects under Construction

The following high voltage transmission line projects are on-going:

- ♦ Development of 230kV transmission lines connecting the northern and southern areas of the country (running through the middle of Myanmar).
- ♦ Expansion of 230kV power transmission system to transmit electric power to the western, southwestern, and southern areas of the country.
- ♦ Installation of new transmission lines for connecting new power stations to the grid.

The development of transmission lines for connecting the northern to the southern area of the country is critical because these lines have low transmission capacities in their current state and are the weak links in the power system. In consideration of the increase in power demand in the south, some transmission lines requiring immediate measures have already been improved. Fig. 6-1 shows the outline of the current power system in Myanmar (including projects already under construction).

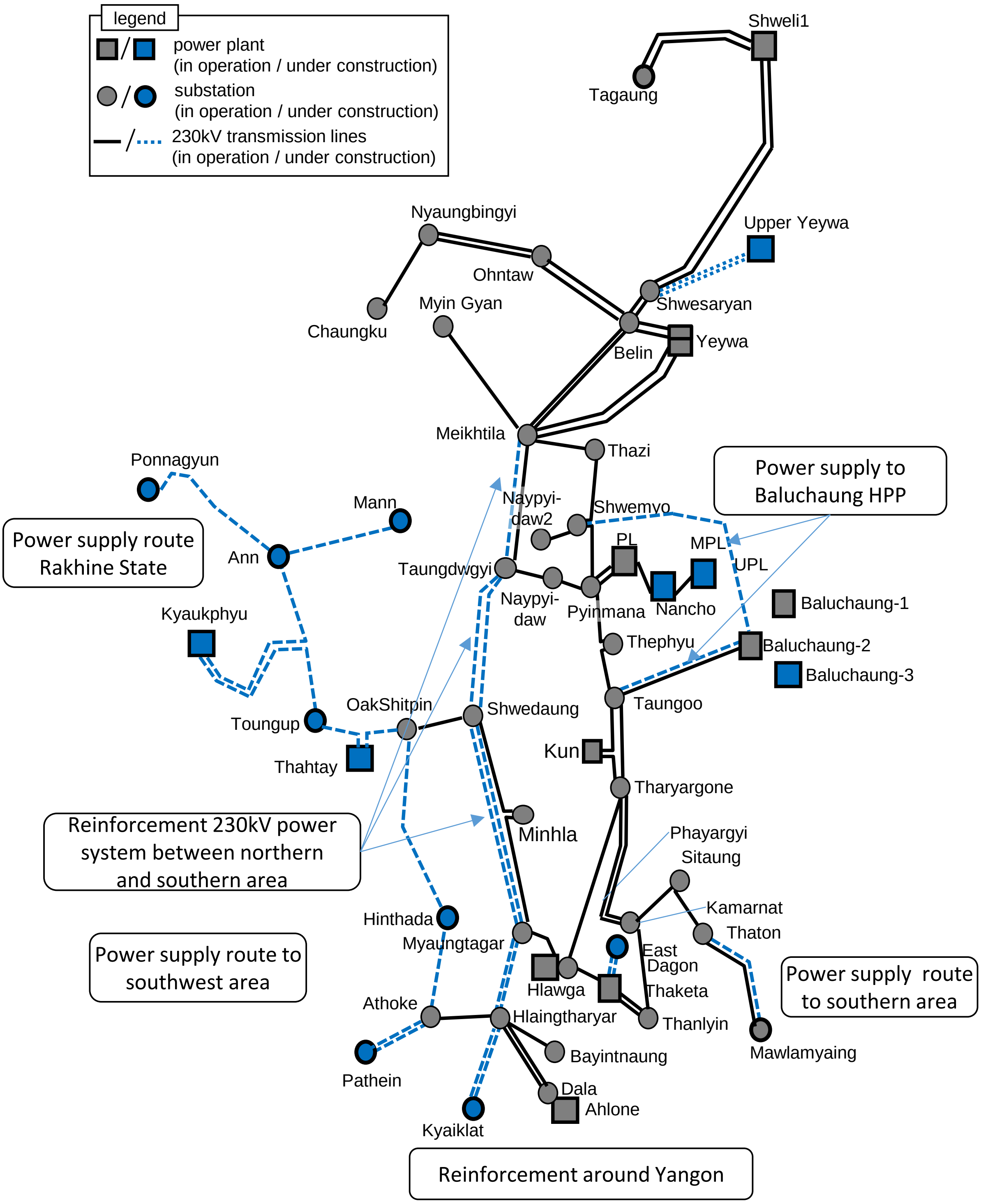


Fig. 6-1 Outline of the Current Power System in Myanmar (including projects under construction)

6.2 MIDDLE TERM POWER SYSTEM DEVELOPMENT PLAN BASED ON THE PGDP

By 2020, as the target year of middle term, hydropower developed in the north and middle areas and gas and coal thermal power around Yangon will be transmitted to the major demand areas. Main construction projects are the 500kV transmission line project as a backbone, with new transmission line construction from plants to the grid and reinforcement of the power system grid around Yangon. Fig. 6-2 shows the block balance diagram in 2020 which was used for the system development plan. Fig. 6-4 shows the bulk power system development plan in 2020.

Main features of the development plan include:

- *Installation of a 500kV transmission line (Meikhtila - Hlaingtharyar).*
  Expansion of transmission capacity between the northern area and high demand center around Yangon will be achieved in order to solve bottlenecks in this transmission route. The supply capacity will be significantly increased to meet power demand.

- *Installation of a 500kV transmission line (Meikhtila - Shweli-3).*
  A new transmission line to connect the existing grid and Shweli-3 Hydropower station is required by 2020. As there is a large potential for hydropower around this area, 500kV for this new line is recommended.

- *Expansion of a 230kV transmission line.*
  As for the 230kV system, expansion of the existing grid is planned, mainly for the purpose of connecting new thermal plants and transmitting power to northern and southern areas.

6.3 LONG TERM POWER SYSTEM DEVELOPMENT PLAN BASED ON THE PGDP

By 2030, power demand is expected to triple from 2020. As such, proper power system development corresponding to power demand will be necessary. As for the 500kV transmission line, the second route which runs through the eastern side of the country will be installed. The increase of transmission capacity from the western and southern areas of the country to Yangon will be required because of the planned construction of large scale thermal plants in Ayeyarwady and Tanintharyi.

Further to the system in high demand areas, it will be necessary to expand the local transmission lines around the bulk power system with double circuits. It will also be necessary to reinforce the power system in Yangon to harmonize the distribution system with urban planning.

Fig. 6-3 shows the block balance diagram in 2030 which is used for the system development plan. Fig. 6-5 shows the bulk power system development plan in 2030.

The main features of this development plan include:

- Installation of a 500kV transmission line (Shweli-3 - Mansan - Namsan - Baluchaung-Thaketa):

  An expansion of transmission capacity from various areas to Yangon is a high priority project in order to increase power supply capacity.

- Installation of a 500kV transmission line (Hlaingtharyar - Kunchangon):

  There are construction plans for TPPs until 2030. Kunchangon TPP, at 3,270 MW, has the largest generation capacity. Therefore, installation of a 500kV transmission line from the power plant to Hlaingtharyar is a high priority in order to deal with the power demand in the Yangon area.

- Expansion of a 230kV transmission line:

  As for 230kV system, expansion of transmission capacity from western and southern areas to Yangon is considered. New 230kV transmission lines from planned HPPs to existing substations are also considered.

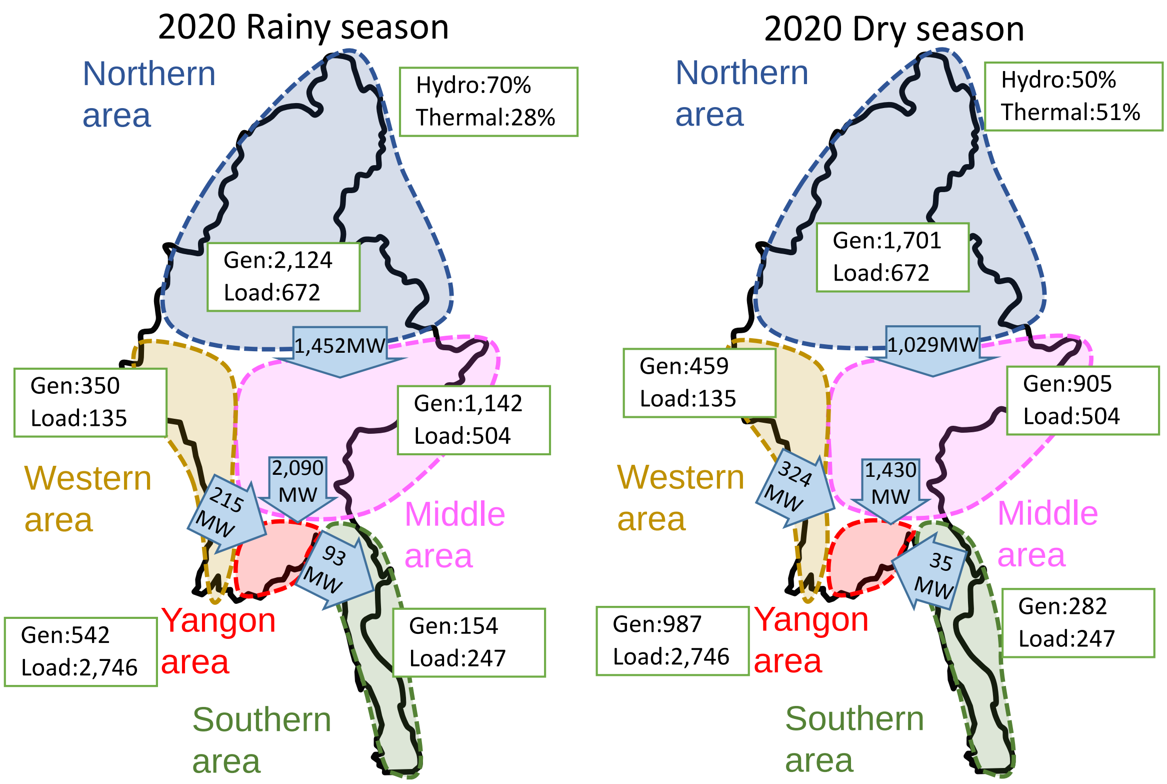


Fig. 6-2 Block Balance Diagram with the High Case Demand in 2020 (Common in Scenarios, Rainy and Dry Seasons)

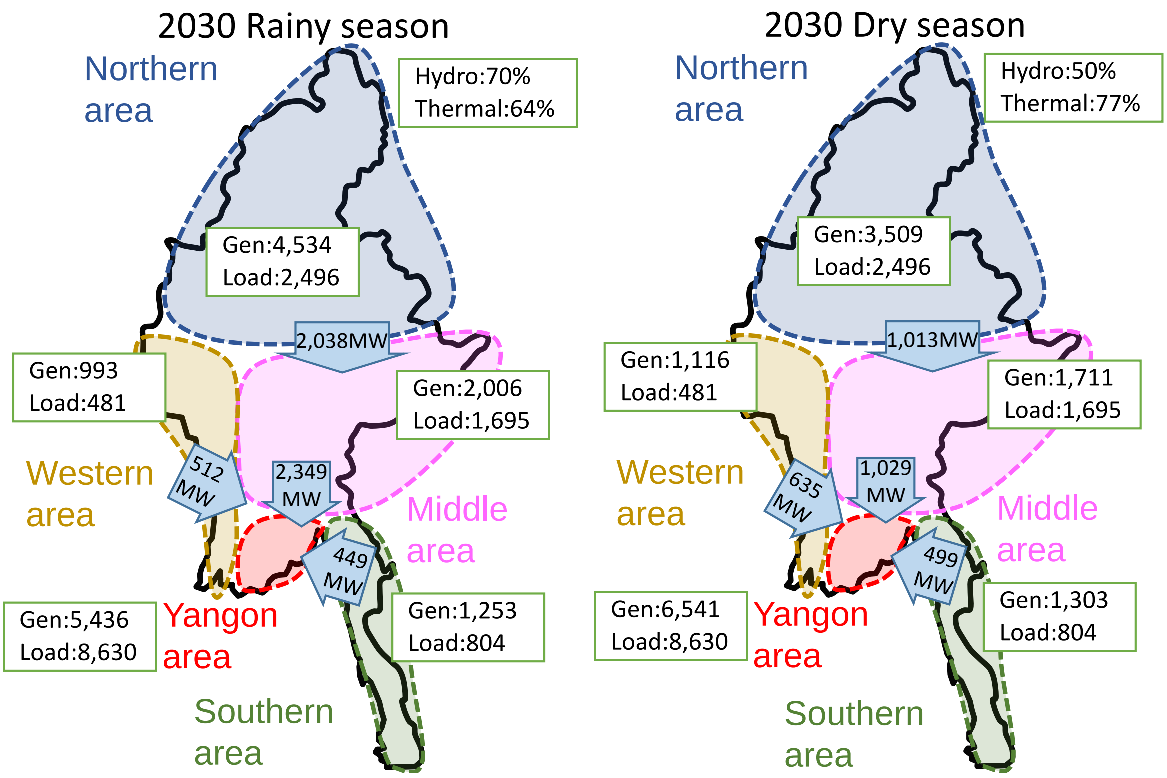


Fig. 6-3 Block Balance Diagram with the High Case Demand in 2030 (Scenario 3, Rainy and Dry Seasons)

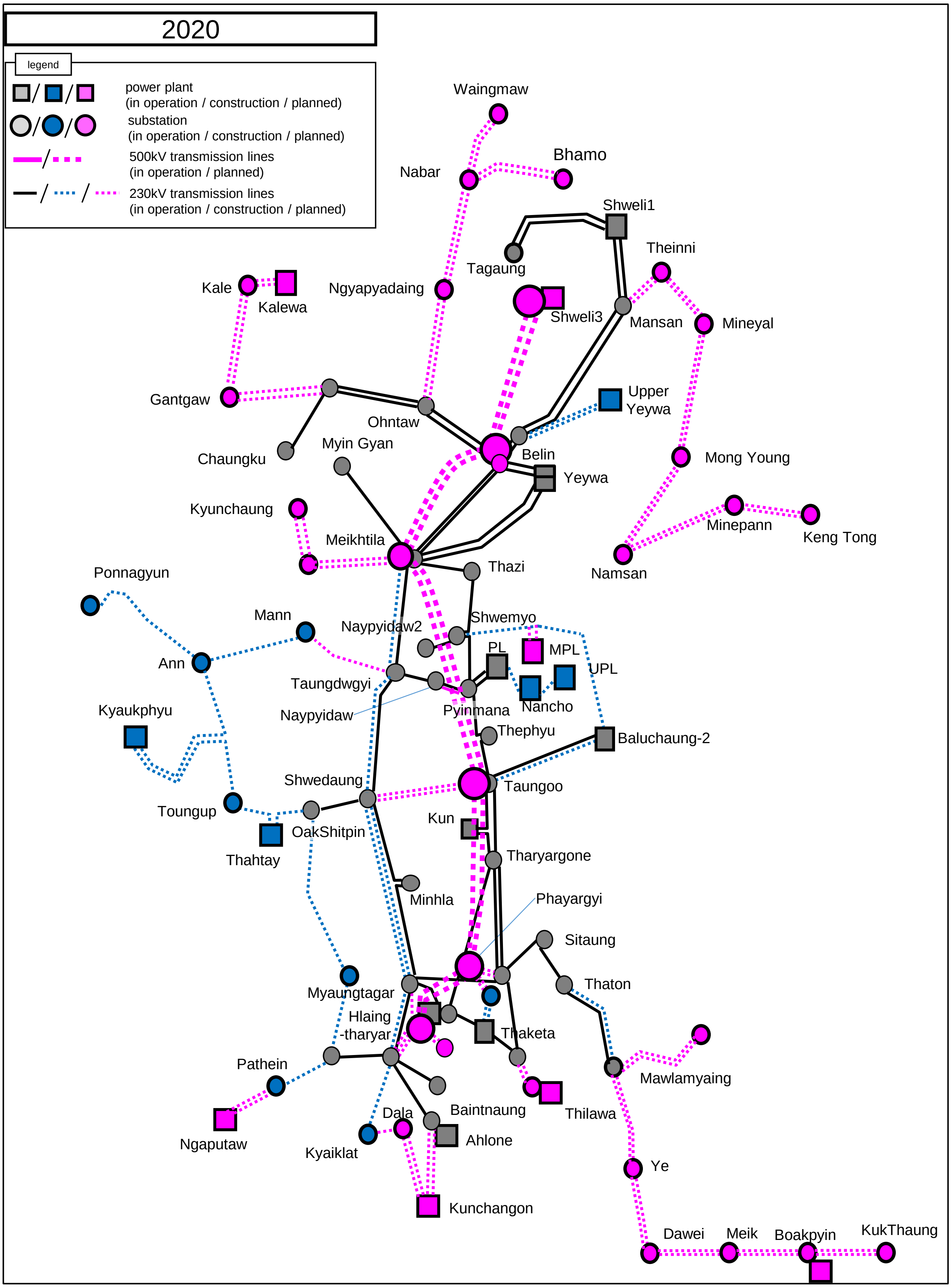


Fig. 6-4 Bulk Power System Development Plan (in 2020, Common Scenario)

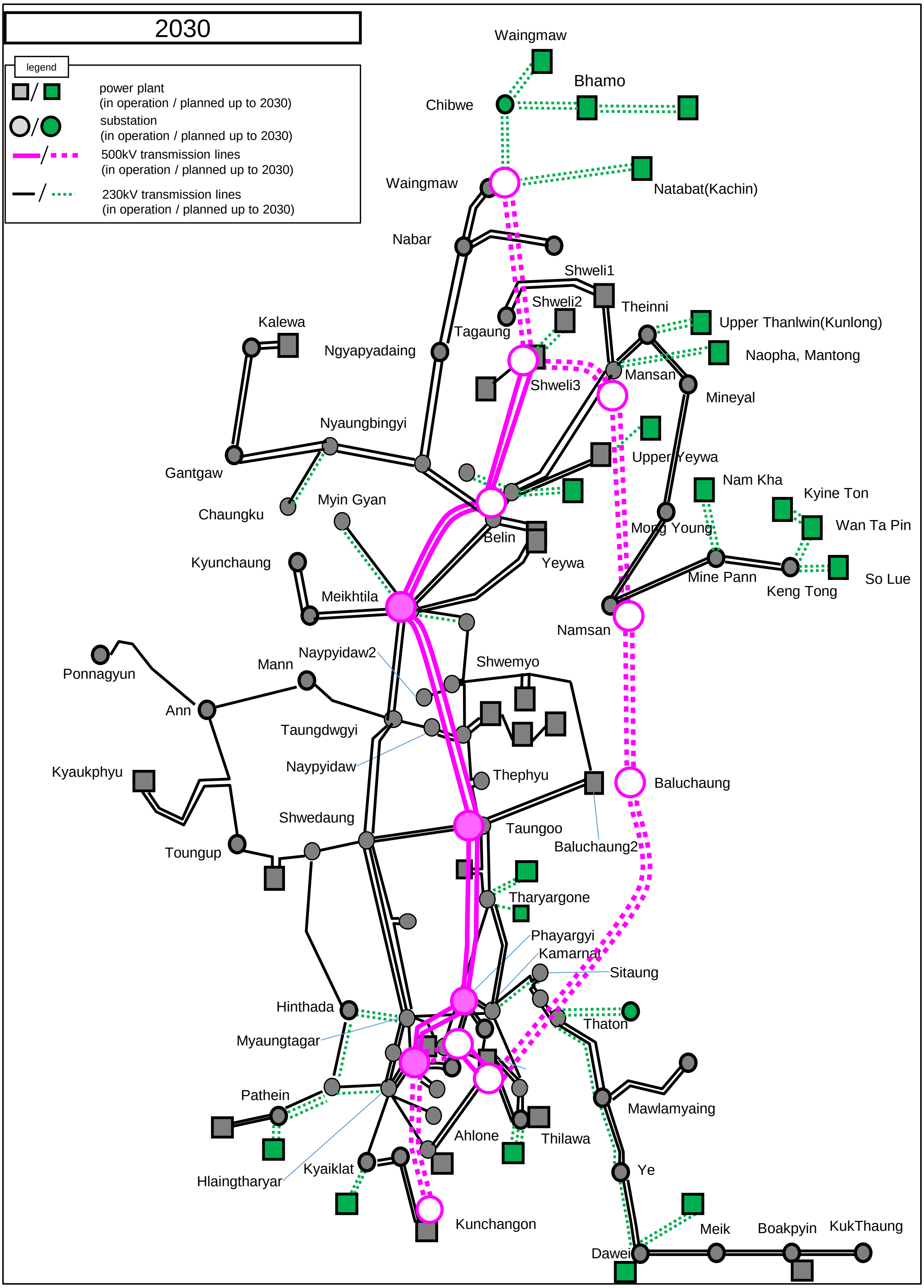


Fig. 6-5 Bulk Power System Development Plan (in 2030, Scenario 3)

CHAPTER 7 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

7.1 SERIOUS ADVERSE IMPACTS OF EACH POWER SOURCE

Predicted serious adverse environmental and social impacts within the broad range of mainstream power plant types include resettlement/indigenous peoples, ecosystem/rare species, water pollution/water usage, air pollution and greenhouse gas emissions.

Large scale hydropower projects could impose serious adverse impacts including resettlement/ indigenous people, ecosystem/rare species, and water pollution/water usage. Thermal power, especially coal-fired thermal power, could impose impacts including air pollution and greenhouse gas emissions. Mainstream serious adverse impacts by power project types are shown in Table 7-21.

Table 7-1 Predicted Serious Adverse Impacts by Power Source

Potential Serious Adverse Impact	Large Scale Hydropower	Medium/ Small Scale Hydropower	Gas Thermal Power	Coal-Fired Thermal Power
Resettlement/ Indigenous People	Likely <u>large scale</u>	Possible	Possible	Possible
Ecosystem / Rare Species	Likely <u>large scale</u>	Possible	Possible	Possible
Water Pollution/ Water Usage	Likely water quality degradation by reservoir	Reduction of run-off in the river section	Rare	Likely From coal storage and ash disposal
Air Pollution	none	none	NOx	<u>SOx*1, NOx*2, SPM*3</u>
Greenhouse Gas Emission	None, if timber remain in reservoir, CH_4 likely	none	CO_2	<u>Lots of CO_2 relatively</u>
{Re}: Suitable Load for supply	Peak Load Middle Load	Middle Load Base Load	Peak Load Middle Load	Mainly Base Load

(Note) Classification of Hydropower Project in the Study.
Hydropower projects are classified to be large scale hydropower and medium/small hydropower based on the maximum power of 1,000 MW along main rivers.

*1 SOx : Sulfur Oxide
*2 NOx : Nitrogen Oxide
*3 SPM : Suspended Particle Matters

Table 7-2 Installed Capacity and Power Source Composition

Scenarios	Scenario 1		Scenario 2		Scenario 3		Environmental and Social Consideration	
	MW	%	MW	%	MW	%	MW	%
Large Scale HPP	24,295	**55.8**	24,295	**56.1**	2,825	**10.4**	0	**0**
Small/medium Scale HPP	9,471	**21.8**	9,471	**21.9**	9,525	**35.2**	15,000	**51.7**
Gas TPP	4,986	**11.5**	2,484	**5.7**	4,758	**17.6**	7,000	**24.1**
Coal-fired TPP	2,760	**6.3**	5,030	**11.6**	7,940	**29.4**	4,000	**13.8**
Renewable Energy	2,000	**4.6**	2,000	**4.6**	2,000	**7.4**	3,000	**10.4**
Total in the Scenarios	43,512	**100**	43,280	**100**	27,047	**100**	29,000	**100**
Concept of Development	Projects, which have usage of domestic energy, have priority		Projects, which total cost in 2014-2030 is least, should be developed		Ratio of power sources such as hydro, gas TPP and coal-fired TPP should be balanced		Power sources, which have less environmental impacts, are promote for development	
Power Sources Composition	All hydropower in the MOEP list are nominated. Gas TPP using domestic natural gas are nominated at a maximum without considering constrained product situation		Coal-fired TPP are increased due to low generation cost instead of low sharing domestic gas-fired TPP considering constrained product situation. The others are nominated based on the MOEP list.		Gas TPP using domestic natural gas are nominated as same as domestic energy consumption scenario. Large scale HPP is deselected except two HPP of Upper Thanliwn (Kunlong) Naopha Mantong in Joint Venture Agreement stage. Coal-fired TPP are took the place of Large scale HPP.		The large scale HPP is not nominated. The ratio of small/ medium scale HPP and gas TPP are nominated more than that in other scenarios to reduce the development of the coal-fired TPP This option is developed as a basis of evaluation on environmental and social aspect in scenarios.	

(Note 1) HPP stands for HPP and TPP stands for TPP.
(Note 2) The demand forecast in the year 2030 is 14,542MW, with which total dependable power should meet. The total installed capacity differs according to scenario alternatives, which have different power source compositions, because the dependable power differs among the power source compositions.

7.2 ENVIRONMENTAL AND SOCIAL CONSIDERATION ALTERNATIVE OPTION

The most effective way to evaluate a scenario is to compare alternative ones. One of the purposes of comparing alternative scenarios is to show the wide range of options for decision-makers and to be able to more easily evaluate the best option among them. Alternative scenarios can vary considerably.

Chapter 5 highlights the three scenarios. In addition to that, environmental and social consideration options, as well as a no-action alternative (also known as a zero option), was introduced.

Environmental and social consideration options were developed to have the least environmental and social impact as a basis of evaluation on the three scenarios (in terms of environmental and social aspects). This option includes new development schemes, which have yet to be included in the MOEP. The installed capacities of power plants are applied in this Study instead of the average actual capacities in Chapter 5.

The installed capacities of the small/medium scale HPPs, gas TPPs and renewable energy plants are set to be approximately 1.5 times more than these in Scenario 3 as possibly achievable by

2030. Specifically:

(a) Projects which are located in Protected Areas should not be included.

(b) Large scale hydropower which would cause possible serious impacts such as involuntary resettlement, indigenous people and ecosystem, should not be included.

(c) The installed capacity of small/medium scale hydropower is set to be 15,000 kW. The power source composition ratio is about 52%.

(d) Gas thermal power is set to be 7,000 kW. The power source composition ratio is about 24%.

(e) Renewable energy plants is set to be 3,000MW. The power source composition ratio is about 10%.

(f) Coal-fired thermal power fill the supply and demand gap with total installed capacity of 4,000MW. The power source composition ratio is about 14%.

7.3 POWER SOURCES COMPOSITION

Total installed capacity, ratio of power sources, and characteristics of four scenarios are shown in Table 7-3.

Table 7-3 Weighting for Environmental Items and Power Project Types

Category	Environmental Items	Weighting for Environmental Items *1	Level of Environmental Impact in each Environmental Item *2				
			Large Scale Hydropower	Medium/ Small Scale Hydropower	Gas Thermal Power	Coal-fired Thermal Power	Transmission Line
1 Social Environment	(1) Resettlement	AA	a	B	c	b	c
	(2) Living and Livelihood	A	a	B	c	b	c
	(3) Heritage	AA	–	–	–	–	–
	(4) Landscape	C	c	C	a	b	a
	(5) Indigenous Peoples	A	a	B	c	b	c
2 Natural Environment	(6) Protected Areas	AA	–	–	–	–	–
	(7) Ecosystem	AA	a	B	c	b	c
	(8) Topography and Geology	B	a	C	c	c	c
3 Pollution Control	(9) Air Quality	A	–	–	c	a	–
	(10) Water Quality	A	a	C	c	b	–
	(11) Wastes	B	c	C	b	a	–
	(12) Noise, Vibration, Odor	C	c	–	a	b	–
	(13) Global Warming	B	c	C	b	a	c

Note 1) "Weighting for Environmental Items" is defined to be four ranks by the Study Team
AA = Extremely large impacts and difficult mitigation possibility
A = Large impacts and tough mitigation possibility
B = Medium impacts and relatively easy mitigation possibility
C = Small impact and easy mitigation possibility

Note 2) "Level of environmental Impact in each Environmental Item" is defined to be three ranks by the Study Team as shown below
a = Large; B = Medium; C = Small; — = none or cannot generalized due to specific items

7.4 STUDY BY MULTI-CRITERIA ANALYSIS

Multi-criteria analysis is a technique to assess alternative scenarios according to a variety of criteria that have different values. This Study for the National Electricity Master Plan covers many prospective plans for various types of power projects. Each project in the National Electricity Master Plan has different environmental impact characteristic as well based upon their different planning.

Multi-criteria analysis is introduced to evaluate alternative scenarios for decision-making in terms of environmental and social consideration. This study is carried out based on the quantitative analysis through weighting and scoring of a wide range of various and qualitative impacts.

Firstly, the importance of the environmental items is weighted. Secondly, the environmental degrees of the main power source types in each environmental item are weighted. After weighting, environmental impact degrees of scenario alternatives are assigned by scoring in numerical terms.

It is one of the questions of multi-criteria analysis that arbitrariness in weighting and scoring could occur depending on the analyst. The Study Team tried to minimize the arbitrariness by means of consultations with the DEP of the MOEP and the ECD (Environmental Conservation Department) of the MOECAF (Ministry of Environmental Conservation and Forestry) throughout the drafting of this report as well as collecting a wide variety of opinions in three workshops which included additional institutions such as NPED (Ministry of National Planning and Economic Development) and MOE.

(1) Weighting for Environmental Items

The degrees of importance for environmental items were weighted when standard power projects were developed by JICA Study Team based on the Checklist for Environmental Items and reflected acceptability by society, past protest movements by residents or NGO (Non-Governmental Organization), suspensions of power projects in Myanmar, the difficulty of mitigations, previous studies, and so forth.

Resettlement, heritage, protected areas, ecosystems, air quality and global warming are ranked AA due to serious and irreversible impacts and the difficulty of mitigations. Living and livelihood, indigenous peoples and water quality are ranked A due to high impact and difficult mitigations. Topography/geology and waste are ranked B due to medium impacts and relatively easy mitigations. Landscape and noise/vibration are ranked C due to small impact and easy mitigations.

(2) Weighting for Power Project Types

The level of environmental impacts for power project types were classified and weighted as a, b and c by JICA Study Team. These were weighted relatively in each environmental item between a. and c. The weighting also reflected acceptability of society, past protest movements by residents or NGOs, suspension of power projects in Myanmar, the difficulty of mitigations, previous studies, and so forth. Within environmental items, heritage and protected areas were excluded from weighting because these are specific local conditions (rather than generalized). Weighting results are shown in Table 7-4.

Table 7-4 Scoring for Environmental Impacts and Power Types

Categories	Environmental Items	Weighted Score for Environmental Items (1)	Large Scale Hydropower		Medium/Small Scale Hydropower		Gas Thermal Power		Coal-fired Thermal Power	
			Score of Environmental Impact (2)	Score of Environmental Impact with Weighting (3)	Score of Environmental Impact (2)	Score of Environmental Impact with Weighting (3)	Score of Environmental Impact (2)	Score of Environmental Impact with Weighting (3)	Score of Environmental Impact (2)	Score of Environmental Impact with Weighting (3)
1. Social Environment	1) Resettlement	10	10	10	5	5	2	2	5	5
	2) Living and Livelihood	8	10	8	5	4	2	1.6	5	4
	3) Heritage	10	0	0	0	0	0	0	0	0
	4) Landscape	2	2	0.4	2	0.4	10	2	5	1
	5) Indigenous Peoples	10	10	10	5	5	2	2	5	5
2. Natural Environment	6) Protected Areas	10	0	0	0	0	0	0	0	0
	7) Ecosystem Rare Species	10	10	10	5	5	2	2	5	5
	8) Topography and Geology	5	10	5	2	1	2	1	2	1
3. Pollution Control	9) Air Quality	10	0	0	0	0	2	2	10	10
	10) Water Quality	8	10	8	2	1.6	2	1.6	5	4
	11) Wastes	5	2	1	2	1	5	2.5	10	5
	12) Noise, Vibration,	2	2	0.4	0	0	10	2	5	1
13) Global Warming		10	2	2	2	2	5	5	10	10
Total Scores (4)			54.8		25		23.7		51	
Environmental Impacts Degrees (5)			**4.2**		**1.9**		**1.8**		**3.9**	

Note 1: Weights from 0 to 10 is set up to "Environmental Items" and "Power Project Types" shown in the table 7.5-6 by JICA Study Team considering past objective lesson
Environmental Items: AA=10, A=8, B=5, C=2 Power Project Types in an Environmental Item: a=10, b=5, c=2, -=0

Note 2: (3) is calculated by multiplied (1) and (2) and divided 10; (3) = (1) x (2) / 10

Note 3: (4) is calculated by adding all of (3)

Note 4: (5) is calculated by divided 13 of total number of items and 10. Maximum impact for every items will be 10 score.

(3) Scoring of Environmental Impacts Degrees

Environmental items are scored as AA=10, A=8, B=5 and C=2. The level of environmental impacts degrees for power source types are scored as a=10, b=5 and c=2. Scores of all environmental impacts degrees for each power source type are added to designate the environmental impacts degrees for each power source type.

The environmental impacts degrees are regarded as indicators for evaluation of power source types. A high mark means a large environmental impact. The result of the scoring is shown in Table 7-5.

(4) Evaluation of Scenarios

The scenario alternatives are evaluated by focusing on the total installed capacities of each power source type in 2030. The environmental impact degrees of the alternative scenarios are calculated by multiplying the amount of installed capacities with the impact degrees of the power sources.

The environmental impact degrees are regarded as indicators for evaluation of the alternative scenarios. The results are shown in Fig. 7-1.

The power source composition, which differs from the vision and target of each alternative scenario, influences the environmental impact degrees. The results are shown below.

1) Scenario 1: Domestic Energy Consumption (Large Scale Hydro Oriented)
   The ratio of large scale hydropower is dominant with a high environmental impact degree.
2) Scenario 2: Least Cost
   The ratio of large scale hydropower is dominant with a high environmental impact degree.
3) Scenario 3: Power Resources Balance
   The ratio of some large scale hydropower and a lot of coal fired thermal power are dominant with a medium environmental impact degree.
4) Environmental and Social Consideration option
   The ratio of medium/small scale hydropower and gas thermal power is dominant with a low environmental impact degree.

As mentioned above, the future power source composition, which differs from the vision and target of each alternative scenario, influences the environmental impact degrees. Scenario 3 has less environmental impacts besides the environmental consideration option. Scenario 1 and Scenario 2 have more environmental impacts because of the number of large scale hydropower projects.

In order to implement power projects following the National Electricity Master Plan in consideration of environmental and social aspects, new small/medium scale hydropower projects should be formulated and developed, prospective natural gas should be further explored and renewable energy power projects - including solar power - should be promoted through incentives. These are all considered domestic energy resources that have low environmental and social impacts.

Regarding the input of coal-fired thermal power projects to meet base demand, the introduction of CCT is indispensable in order to mitigate environmental impacts. The CCT includes facilities and technologies of environmental mitigation measures to reduce air pollutants including SOx (Sulfur Oxide), NOx (Nitrogen Oxide) and suspended particulate matter as well as USC technology with world class thermal efficiency (about 45%) to mitigate CO_2 emotions.

Table 7-5 Power Source Composition and Environmental Impact Degrees in Scenarios

Power Type		Large Scale Hydropower	Small/medium Scale Hydropower	Gas Thermal Power	Coal-fired Thermal Power	Renewable Energy	Total (5)	Ratio to Environmental Option (6)
Score of Environmental Impacts (1)		4.2	1.9	1.8	3.9	0.0		
Scenario 1	Installed Capacity (MW) (2)	24,295	9,471	4,986	2,760	2,000	43,512	2.4
	Ratio of Power Sources (3)	55.8%	21.8%	11.5%	6.3%	4.6%	100%	
	Environmental Impact Degrees (4)	**1.02**	**0.18**	**0.09**	**0.11**	**0.0**	**1.41**	
Scenario 2	Installed Capacity (MW) (2)	24,295	9,471	2,484	5,030	2,000	43,280	2,5
	Ratio of Power Sources (3)	56.1%	21.9%	5.7%	11.6%	4.6%	100%	
	Environmental Impact Degrees (4)	**1.02**	**0.18**	**0.05**	**0.20**	**0.0**	**1.45**	
Scenario 3	Installed Capacity (MW) (2)	2,825	9,524	4,758	7,940	2,000	27,047	1.2
	Ratio of Power Sources (3)	10.4%	35.2%	17.6%	29.4%	7.4%	100%	
	Environmental Impact Degrees (4)	**0.12**	**0.18**	**0.09**	**0.31**	**0.0**	**0.70**	
Environmental and Social Consideration	Installed Capacity (MW) (2)	0	15,000	7,000	4,000	3,000	29,000	1
	Ratio of Power Sources (3)	0.0%	51.7%	24.1%	13.8%	10.3%	100%	
	Environmental Impact Degrees (4)	**0.0**	**0.29**	**0.13**	**0.16**	**0.0**	**0.57**	

Note 1 Impact degrees of (4) are calculated by (1) multiplying of (2) and divided 100,000 as easy visible indicators: (1) × (2)/100,000

Note 2 Impact degrees of renewable energy (solar) is set up zero, because predicted impacts are quite low compared to the other sources

Table 7-6 Evaluation of Environmental Impact Degrees

Rate of Power Source/ Impact Degrees		Scenario 1	Scenario 2	Scenario 3	Environmental and Social Consideration
Rate of Sources	Large scale hydropower	Large	Large	Small - Medium	None
	Coal-fired thermal power	Small	Small - Medium	Medium-Large	Small - Medium
Impact Degrees	Resettlement/indigenous peoples	Large	Large	Small - Medium	Small
	Ecosystem/rare species	Large	Large	Small - Medium	Small
	Air pollution	Small	Small	Medium-Large	Medium
	Global warming	Small	Small	Medium-Large	Medium
	Total	**Large**	**Large**	**Medium**	**Small**

(Note) The evaluation on impact degrees is relatively compared in scenario alternative by the Study Team

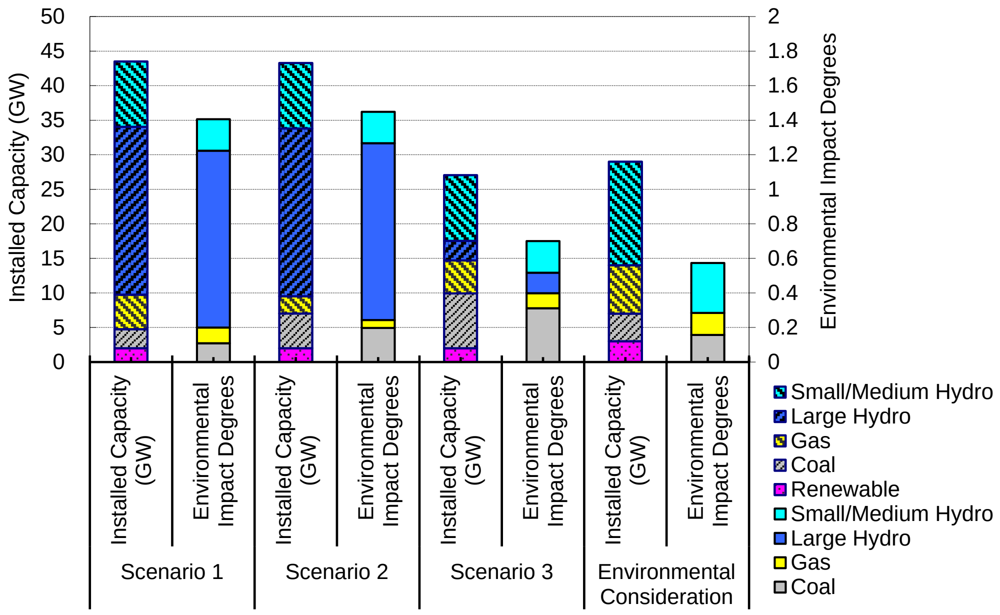


Fig. 7-1 Power Source Composition and Environmental Impact Degrees in Scenarios

7.5 MITIGATION MEASURES

MOEP should apply mitigation measures for power development. Two kinds of mitigation measures, which are for the renewal of the National Electricity Master Plan and the formulation of projects, were analyzed.

i) Mitigation for the National Electricity Master Plan
   (a) Concepts of Mitigation
   (b) Project Sites Selection with Less Environmental Impacts
   (c) Mitigation Costs in Project Costs

ii) Principles of Mitigation for Projects
   (a) Mitigation for Social Impacts
   (b) Mitigation for Ecology and Biodiversity
   (c) Benefit Sharing Mechanism
   (d) Adoption of CCT

CHAPTER 8 ECONOMIC AND FINANCIAL ANALYSIS

8.1 INTERNATIONAL COMPARISON OF ELECTRICITY TARIFFS AND TRANSMISSION AND DISTRIBUTION LOSSES

Compared with the electricity tariffs in other Asian countries, electricity prices in Myanmar are characterized as follows:

- The overall level is lower than in neighboring countries.
- Tariffs between industry and residents are heavily cross-subsidized.

From the perspective of international competition, electricity tariffs will be convergent into one price, and it will be difficult to continue the current subsidization and cross-subsidization system in the near future.

Judging from the country's financial status, grant contributions from the GoM will become more difficult to come by. Likewise, when taking international competition into consideration, it will be impossible to increase electricity tariffs for industrial usage as industrial power prices converge. This will lead to difficulties even in continuing the system of cross-subsidies. If both subsidies become difficult in practice, the Power Sector will have difficulty maintaining sustainability other than by raising household electricity tariff rates.

Transmission and distribution loss also causes serious financial problems for the Power Sector. Trends show transmission and distribution losses have decreased; however, the level of loss, about 25 %, is still high.

8.2 STRUCTURAL PROBLEMS

Salient structural problems in the Power Sector include:

- Power tariffs are not determined by the cost of generation.
- Electricity tariffs are controlled so as to primarily cover fuel and electricity purchase costs.
- GoM support (via subsidies) discourages organizations to improve management efficiency.
- With the increase of IPPs, the current structure of the Power Sector by means of GoM support (subsidies) will not be sustainable

8.3 FINANCIAL ANALYSIS OF THE POWER SECTOR

(1) Financial Characteristics of the Power Sector

Financial characteristics of electric sector organizations in Myanmar are as follows:

1) Contribution from the GoM (state contributions in case of MEPEs) is large.
2) In principle, income after tax goes to the GoM as a state contribution.

These factors indicate that decisions about investment cannot be made by the electric companies alone.

All State Enterprises include the SEE (State Economic Enterprise) account and other accounts. When creating a budget, a fare receipt is not considered. When there is a surplus, it is refunded back to the GoM as the state contribution. However, the ratio of cash refunds is decreasing from past ratios.

The electricity tariffs until now were set so as to cover only material purchase costs (including consecutive power purchase amounts). However, the problem is that current electricity tariffs are not enough to cover the costs due to the sudden increase in fuel prices, including devaluation of the exchange rate. The increase in electricity tariffs in April 2014 is not considered to be aiming at covering all capital expenditures through tariffs, but rather at absorbing increasing fuel costs.

(1) HPGE

HPGE shows exceptionally high profits formally, and after paying taxes, it has been returned funds to the GoM as the state contribution. However, from 2012-2013, the percentage of state contributions has decreased.

(2) MEPE

Due to the increase of import cost in dollars for fuel by devaluation of the exchange rate from 1USD = 5 Kyats to 1USD = 800-900 Kyats in 2012-2013, revenue for 2012-2013 has increased significantly. As a result, the wholesale prices from MEPE to distribution companies increased from 35 Kyats/kWh against ESE and MEPE (2012 April - 2012 July) to 37 Kyats/kWh against ESE (since 2012 August) and 40 Kyats/kWh against YESB (since 2012 August).

(3) YESB

Due to the power purchase price increase from 20 Kyats/kWh to 40 Kyats/kWh by MEPE, the profit of YESB dropped in 2012-2013.
Regarding its Balance Sheet (BS), the reason for cost increases in its bank balance in 2012-2013 was due to the finance provided by Myanmar Development Bank, which is under the Myanmar Central Bank (recently renamed Myanmar Economic Bank #3). Although the bank balance is the cash, YESB cannot use it freely for capital expenditures without approval by the MOEP.

(4) ESE

Due to the power purchase price increase from 20 Kyats/kWh to 40 Kyats/kWh by MEPE since August 2011 (which is same as YESB), ESE profits dropped in 2012-2013. Due to the newly introduced Cash at Bank in 2012-2013, the scale of BS doubled.

8.4 FINANCIAL BENCHMARK COMPARISON

The financial status of the power sector was compared between organizations in Myanmar and similar enterprises in neighboring countries to consider financial benchmarks.

1) Each enterprise's profit level in Myanmar is significantly lower than similar enterprises in neighboring countries.

2) Organizations' sales and profit level per employee in Myanmar are significantly lower than other organizations in neighboring countries.

3) As for sales and profits of respective companies in Myanmar's power sector, it is clear that sales are similar in size. HPGE's profit rate is much higher than other local organizations in Myanmar.

4) When sales and profits per person in four domestic companies are compared, figures of

HPGE are higher than others, and MEPE and YESB are at the same level. ESE is lower than the others.

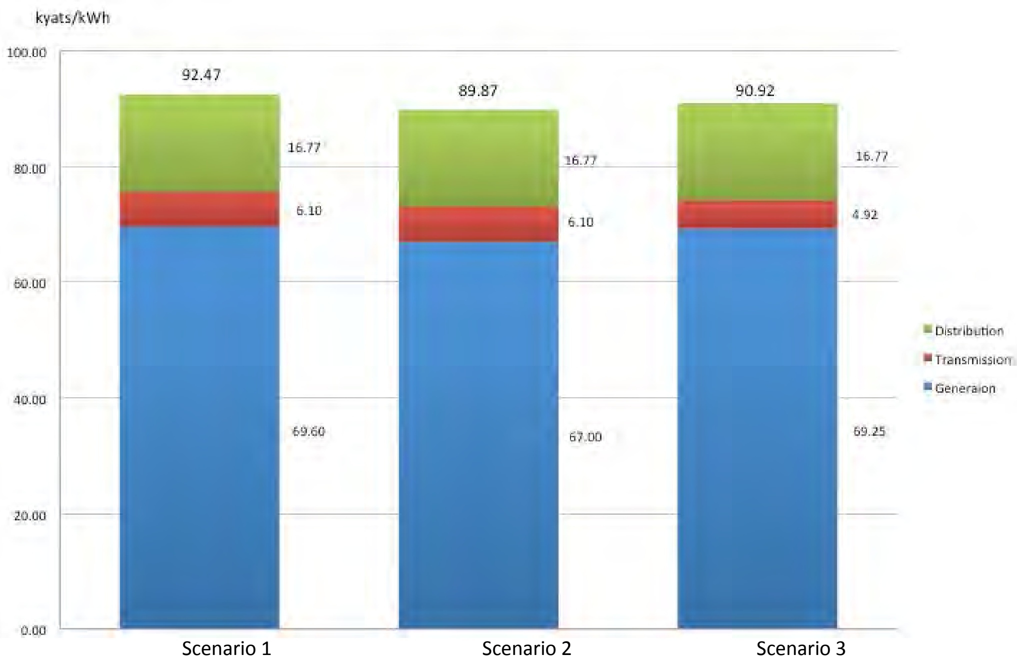
8.5 LRMC

LRMC is a marginal cost (optimal resource distribution for society can be carried out) over a long period of time. It is a resource input distribution, maximizing total amount of economic value at a certain point. Because of this, the current optimal price can be calculated using the concept of present value. The LRMC of each Scenario was computed and results are presented in Table 8-1 and Fig. 8-1.

Table 8-1 Results of Calculation of LRMC

		(A) LRMC (Generation)	(B) LRAIC* (Transmission) Kyats/kWh	(A) + (B) Wholesale Tariff LRMC	(C) LRAIC (Distribution)	(A) + (B) + (C) G + T + D
Scenario 1 Domestic Energy Consumption Scenario (Large Scale Hydro Oriented)	LRMC Kyat/kWh	69.60	6.1	75.70	16.97	92.47
	LRMC cents/kWh	7.22	0.63	7.85	1.74	9.59
Scenario 2 Least Cost Scenario	LRMC Kyat/kWh	67.00	6.1	73.10	16.97	89.87
	LRMC cents/kWh	6.95	0.63	7.58	1.74	9.32
Scenario 3 Power Resources Balance Scenario	LRMC Kyat/kWh	69.25	4.9	74.15	16.77	90.92
	LRMC cents/kWh	7.18	0.51	7.69	1.74	9.43

Note: 1 us cents = 9.64 kyats
* LRAIC : Long Run Average Incremental Cost



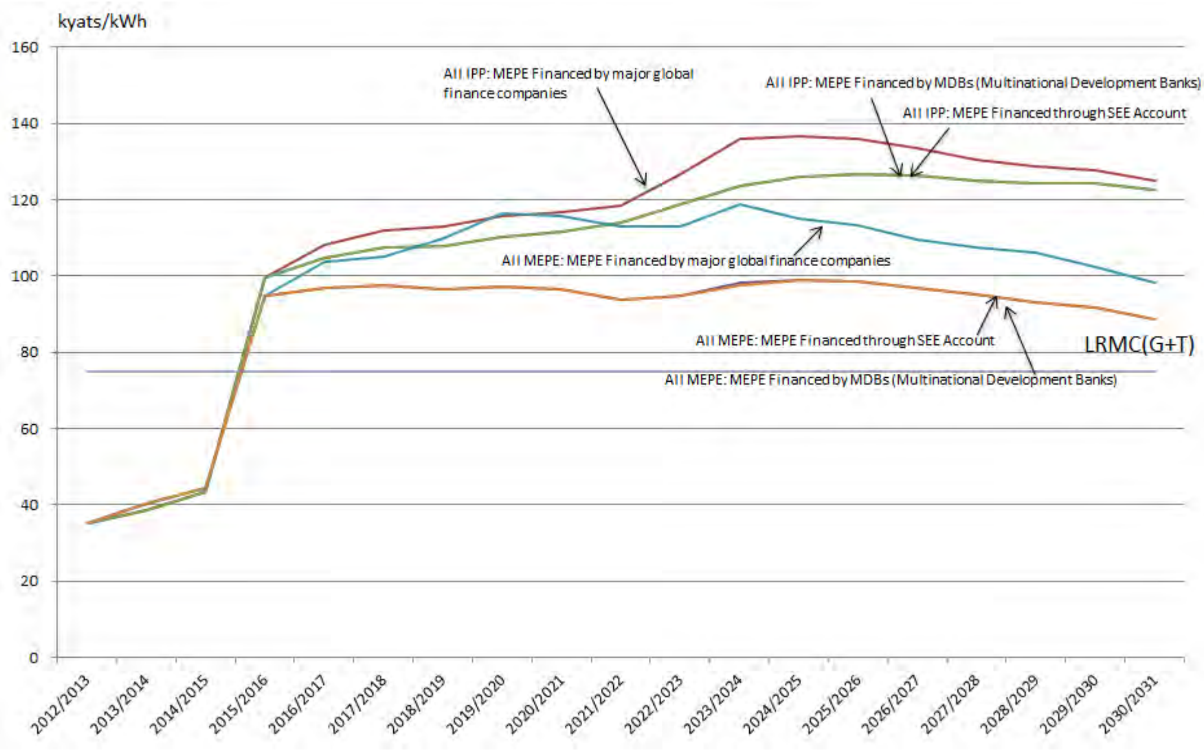
Note 1: 1 US cents = 9.64 kyats
Note 2: Calculation for distribution is based on YESB system

Fig. 8-1 LRMC for Respective Scenarios (Kyats/kWh)

8.6 INTRODUCTION OF APPROPRIATE TARIFF LEVELS

Tariff level satisfying the financial sustainability of the electric company (Financial Tariff) is calculated via simulation of the balance sheet of the company. Thus, JICA Study Team calculates the tariff level of break-even on the basis of financial conditions in the period of analysis (2014 ~ 2030).

As Fig. 8-2 shows, the break-even tariff is higher in the All IPP case than in the All MEPE case. This means that since the purchase price from IPP is high, an even higher wholesale tariff need to be paid.



Note 1: In the graph, IPP SEE account and IPP MDB (Multilateral Development Bank), and MEPE SEE account and MEPE MDB are almost identical

Note 2: SEE Account is calculated as electricity tariff/kWh

Fig. 8-2 Scenario 3 Break-Even Tariff

The table below shows PPA prices computed for Financial Tariffs.

Table 8-2 Optimal PPA to Realize Target IRR (%)

		IRR* (0%)	IRR (10%)	IRR (15%)
Hydro IPP	Kyats/kWh	21.20	64.20	89.21
	UScents/kWh	2.20	6.66	9.25
Gas IPP	Kyats/kWh	18.41	46.18	62.63
	UScents/kWh	19.1	4.79	6.50
Coal IPP	Kyats/kWh	59.22	92.73	112.37
	UScents/kWh	6.14	9.62	11.66
HPGE (Reference)	Kyats/kWh	20.00		
	UScents/kWh	2.07		
Thauk Ye Khat 2	Kyats/kWh	70.00		
	UScents/kWh	7.26		

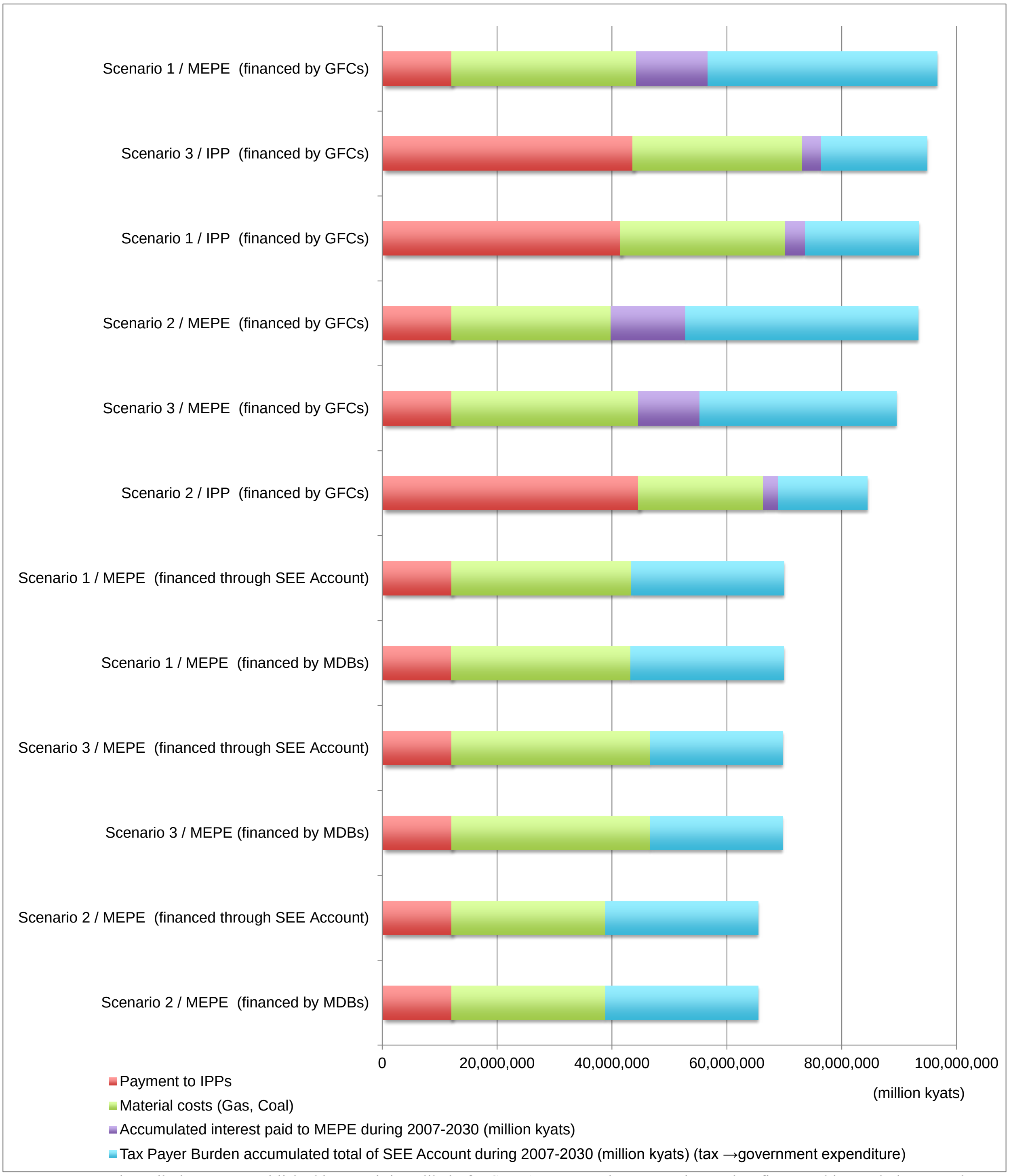
Note 1: It has been assumed that it is only paid for kWh under PPA
Note 2: On our simulation, HPGE is set as 60 kyats/kWh (6.21 cents/kWh)
Note 3:100 cents = 964 Kyats

* IRR : Internal Rate of Return

8.7 FINANCIAL IMPACT ON MYANMAR

As shown in Fig. 8-3, JICA Study Team, considering power balance, electric procurement and finance for MEPE, calculated the financial burden on Myanmar and its people. The burden should be taken as an electricity tariff or the GoM subsidy, and in reality they are combined.

As a current assumption, the burden on Myanmar is established by MEPE. The burden is heaviest in the case where finance is procured from the Global Financial Companies such as private banks. In other cases, procurement from IPPs is estimated to be a higher burden on Myanmar as a whole. The lowest-burden case is where in all electricity scenario plants are established and finance is procured from the GoM finance or from MDBs (Multilateral Development Bank(s)).



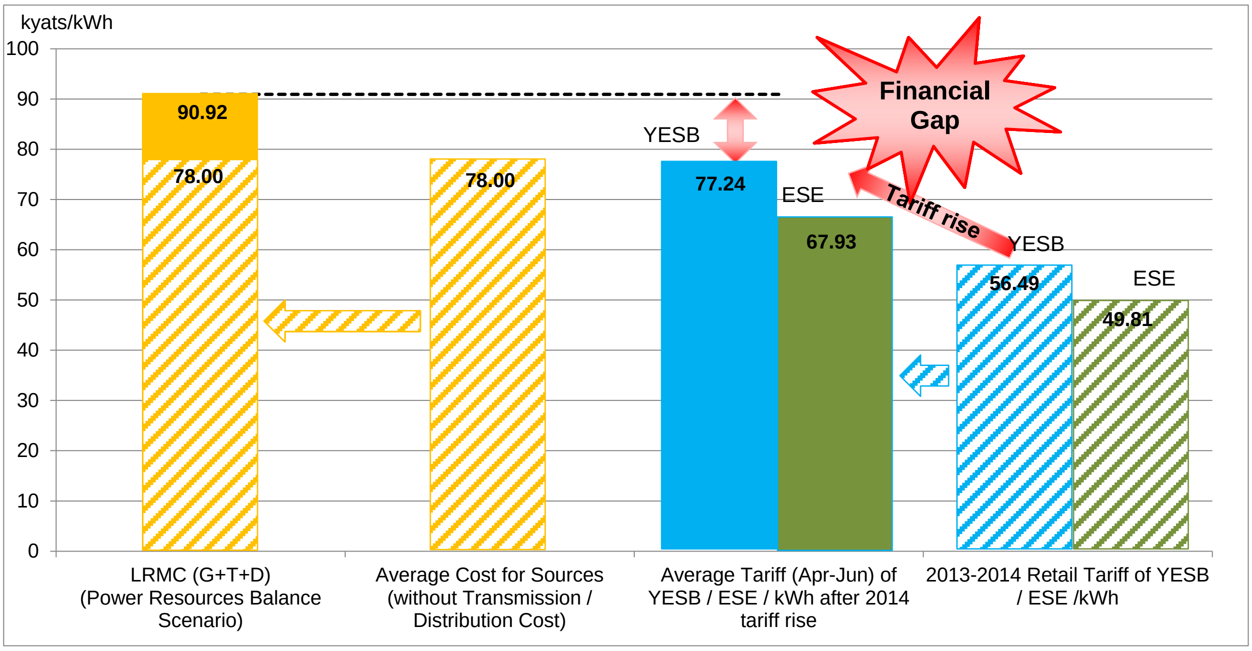
Note: Because when all plants are established by IPP, it is unlikely for SEE Account and MDBs to be used as finance, this graph does not show these cases.

Fig. 8-3 Breakdown of Burden on Myanmar 2007 ~ 2030 (Million Kyat)

8.8 MAIN STRUCTURAL ISSUES OF MYANMAR'S POWER TARIFF

Main issues concerning the power tariff system are as follows:

1) The current tariff level is significantly lower than LRMC. There exists a considerable financial gap. As previously described, subsidies for both household and industry usages become difficult in practice. The power sector will have difficulty maintaining sustainability other than by raising electricity tariffs.



Note 1 : YESB : Units consumed (2013-2014), 4,246.53 Million kWh
Income from Sales of Electricity (2013-2014) 240,815.428 kyats in Million

Note 2 : YESB: Unit consumed (2014, April-June) : 1,233.586 Million kWh
Income from electricity sales (2014, April-June): 95,277.846 kyats in Million

Note 3 : ESE : Units consumed (2013～2014), 5,366.11 Million kWh
Income from sale of electricity(2013～2014), 267,314.66 kyats in Million

Note 4 : ESE : Units consumed (Apr-Jun 2014), 1,580.19 Million kWh
Income (Apr-Jun 2014), 107,338.34 kyats in Million

Note 5 : Income = Unit sold annually + Maintenance + House Power Fee

Note 6 : For Average Cost for Sources (without Transmission/Distribution Cost), sourced from Myanmar Ahlim Newspaper 10th November 2013

Source: YESB Statistics, ESE Statistics 2012-2013, 2013-2014; Myanmar Ahlim Newspaper 10th November 2013

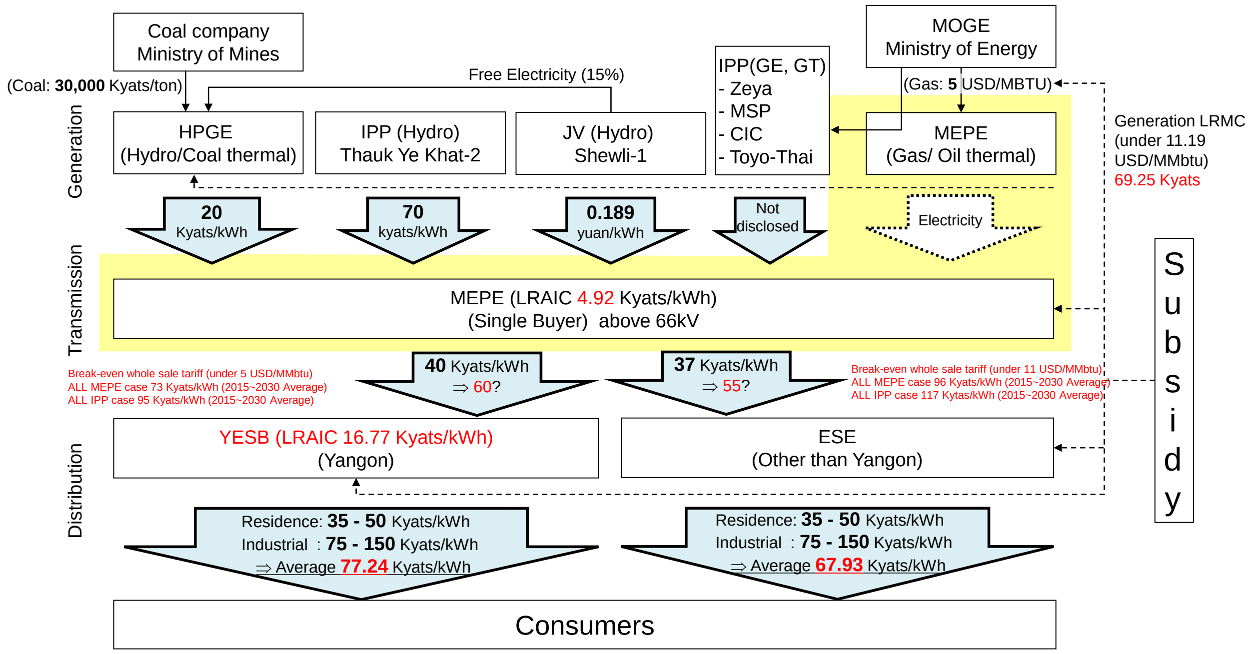
Fig. 8-4 Financial Gap

2) A comprehensive framework including a power development system and SEE account will be considered.

In April 2014 the electricity tariff was revised. Given this revision, the wholesale tariff from MEPE to YESB and ESE needs to be at a level that includes long term investment, financial costs and profits for both distribution companies.

On the other hand, break-even wholesale tariffs calculated by financial modeling (Scenario 3; 2014 ~ 2030 average) are as follows: if the gas tariff is 5 USD/MMBtu, then All MEPE Case is 73 kyats/kWh and All IPP Case is 95 kyats/kWh; if the gas tariff is 11.19

USD/MMBtu, then the former is 96 Kyats/kWh and the latter is 117 Kyats/kWh. Under the current wholesale tariff, to financially maintain the electricity sector, subsidization needs to continue.



Note 1 : Figures for LRMC(G), LRAIC (T+D) are based on Resources Balance Scenario

Note 2 : Average retail figure of YESB, ESE are computed based on revenue and units between April-June, 2014

*18 Kyats/kWh as of August 2014

3) Others

Rules concerning subsidy provision, tariff setting steps and procedures (councils, public hearings, etc.) have yet to be clarified. This structure seems inadequate to reflect administrative efforts such as reduction of transmission and distribution losses and increases of tariff return into corporate performance. Insufficient institutional arrangements for passing on costs such as fuel and currency exchange fluctuations through to end users will become obvious as imports of raw materials (gas, coal) increase.

CHAPTER 9 CONCLUSION AND RECOMMENDATIONS

9.1 CONCLUSION

9.1.1 Power Policy

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

- ♦ The power sector structure has not been restructured after establishment of the MOEP in September 2012. Therefore, the GoM needs to clarify the duties and functions of the concerned governmental departments (DEP, DHPP, and DHPI: Department of Hydropower Implementation) and SOEs (MEPE, HPGE, ESE, YESB) and take strides to make each one function more effectively based on its role and activities. 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 power policies based on the Energy Policy by effective procedures of decision-making regarding such policies, proper compliance with the new Environmental and Foreign Investment Laws and Regulations, etc.

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

- ♦ The GoM should implement investment to power projects for generation, transmission and distribution according to rational, effective and comprehensive plans of private investment and the Government budget. GoM should implement a transparent pricing policy based on appropriate subsidies and power generation costs to secure financial soundness and proper investment conditions.

- ♦ Under the rapidly changing circumstances of the Myanmar power sector, it is urgently required to strength human resource development and capacity building of GoM (MOEP and other relevant authorities) staff so as to better implement restructuring of the power sector, newly related laws and regulations, IPP introduction with international bidding and PPA negotiations, accountability of social and environmental considerations of power projects, the Electricity Tariff Policy by electricity regulatory authorities, etc. Improvement of the planning ability of the power sector as a whole, with appropriate redistribution of authority, will be necessary.

9.1.2 Formulation of the National Electricity Master Plan

(1) Concept of Three Scenarios

JICA Study Team studied the National Electricity Master Plan 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

Table 9-1 Concept of Each Scenario

Item	Description
Period	2013 - 2030
Demand	High Case (4,531MW in 2020 and 14,542MW in 2030)
Tool	Wien Automatic System Planning Package IV (WASP IV) to find optimal expansion plan

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

(2) Comparison of 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 (refer Fig. 5-2).

Table 9-2 Summary of Comparison of Scenarios

Scenario	1	2	**3**
Priority	Domestic Energy Consumption (Large Scale Hydro Oriented)	Least Cost	**Power Resources Balance**
Max. power demand & Power Supply, 2030	MPD: 14.5 GW PS: 18.9 GW		
Installed (Max) Capacity for Myanmar, 2030	28.8 GW	28.6 GW	**23.6 GW (due to less large hydro)**
Energy (Power) Resources	All possible hydro potential 45.5GW. All gas supply to Power Sector, 200 ~ 300 bbtud. Rest with coal and renewables.	All possible hydro potential. Some domestic supplied gas is replaced by imported coal. Rest with coal and renewables.	**Feasible/primary hydro potential, 9.4GW, is selected.** **All gas supply to Power Sector is used.** **Rest with coal and renewables.** **<u>Energy resources are well balanced to improve energy security.</u>**
Power Sources for Myanmar, 2030 (Unit GW)	Large Hydro: 12.1 (42%) Small & Medium Hydro: 6.9 (24%) Gas: 5.0 (17%) Coal: 2.8 (10%) Renewable: 2.0 (7%)	Large Hydro: 12.1 (42%) Small & Medium Hydro: 6.9 (24%) Gas: 2.5 (9%) Coal: 5.0 (18%) Renewable: 2.0 (7%)	**Large Hydro: 1.4 (6%)** **Small & Medium Hydro: 7.5 (32%)** **Gas: 4.8 (20%)** **Coal: 7.9 (33%)** **Renewable: 2.0 (9%)**
LRMC for Generation	7.2 cents/kWh	7.0 cents/kWh	**8.0 cents/kWh**
Long Run Average Incremental Cost for High Voltage Transmission Line	0.6 cents/kWh (500 kV direct current links added)	0.6 cents/kWh (500 kV direct current links added)	**0.5 cents/kWh**
Environment impact	Larger impact by large hydro p/s	Larger impact by large hydro p/s	**More greenhouse gas emission and air pollution by coal p/s**
Feasibility of target	Difficulty of large hydro p/s in terms of environmental impact, long lead time and long high voltage direct current transmission line. Fuel for gas p/s to be imported.	Difficulty of large hydro p/s in terms of environmental impact, long lead time and long high voltage direct current transmission line. On-going gas plants are suspended.	**Large hydro p/s is excluded to avoid risks.** **Fuel for gas p/s to be imported.** **Environment impact by coal p/s should be mitigated.**
Overall Review Result	Less feasible due to more large hydro development.	Less feasible due to more large hydro development.	**More feasible because environmental effect of coal p/s can be mitigated.** **More reliable because energy security becomes higher due to balanced power resources.**

(3) Power Resources Balance Scenario (Scenario 3)

The quantity of power supply and the operational year of power plants in Scenario 3 have been reviewed by recent interviews and discussions with MOEP.

The result of arrangement with MOEP is shown in Table 5-4 (supply planning) and Fig. 5-5 (annual transition of power supply). Based on this Scenario, sensitivity analysis should be studied in the future considering the feasible change of basic conditions.

In 2030, total installed capacity will be 27.0GW, with the installed capacity for Myanmar at

23.6GW and the actual capacity during the dry season 18.9GW (which includes the reserve margin (kW) of approximately 30% of the demand).

The cumulative cost of power generation and system development of revised Scenario 3 from fiscal year 2013 to 2030 is shown in Table 9-3. Calculation of the LRMC has been reviewed; the LRMC from the final (revised) Scenario 3 is 7.69 US cents/kWh (compared with the original Scenario 3 figure of 8.50 US cents/kWh). As the operational year of the new coal-fired TPPs is shifted later, the value of the LRMC (power generation) is decreased.

Table 9-3 Development Cost of Final (Revised) Scenario 3

Billion $

Item	2013 ~ 2020	2013 ~ 2030
Power Generation	13.8	55.2
Power System	2.7	5.6
Total	**16.5**	**60.8**

Note 1 : Cost is not calculated from present value.
Note 2 : O&M cost and Fuel cost is included.
Note 3 : Transmission and Substation is included.

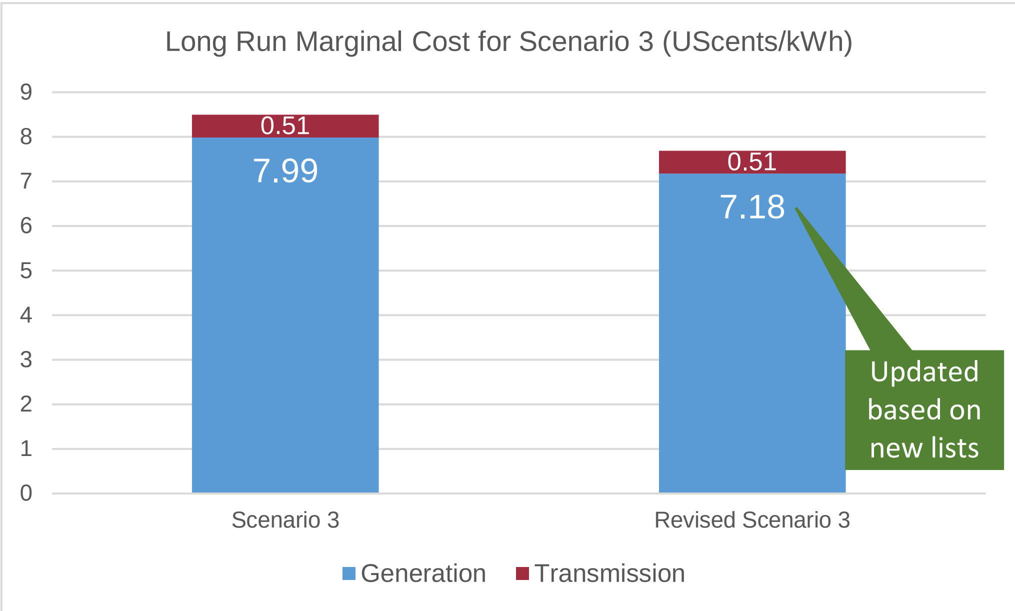


Fig. 9-1 Revision of LRMC

9.1.3 Power Tariff System

In this study, following issues in the electric power sector are clarified by the economic and financial analysis.

(i) Difference of the financial burden by the developer and capital procurement (Fig. 8-3)
(ii) Financial gap of power tariff between the current system and LRMC (Fig. 8-4)

The GoM should focus on the following points regarding structural reform of the power tariff:

(1) Difference of financial burden on people according to the development scheme

Procurement of electricity from IPPs is assumed to be bigger burden for Myanmar than the self-construction by MEPE or HPGE. An optimal IPP ratio should be decided based upon management efficiency.

(2) Procurement of Power Tariff System

Critical points on reforming the power tariff system regarding procurement are as follows:

1) The current uniform tariff at the national level should be reconsidered. Also, supply cost per region with relevant tariffs should be introduced.

2) For a safe and stable electricity supply based on the National Electricity Master Plan, it is necessary for a gradual reduction of subsidization and the introduction of cost-covering tariffs.

9.2 RECOMMENDATIONS

The National Electricity Master Plan was formulated in this study. Comprehensive conclusions are explained in previous sections. As for formulation of the National Electricity Master Plan, focal points in this study are mainly concentrated on the planning of long term power generation development and power system development. However, revisions of the National Electricity Master Plan in accordance with situation changes and development of a road map based on detailed information for each project are required for the next step. From this viewpoint, recommendations for issues to be undertaken by GoM in the future are summarized as shown below.

(1) Structural Reform and Human Resource Development in the Electric Power Sector

(2) Establishment of Development Scheme for the Power Generation

(3) Capacity Building for the Sustainable Formulation of National Electricity Master Plan for MOEP

(4) Formulation of Hydropower Master Plan (Road Map)

(5) Implementation of Rehabilitation Projects for Existing HPPs

(6) Implementation of Feasibility Study for Coal Thermal Power Development

(7) Implementation of Bulk Power System Project around Yangon

(8) Implementation of Improving the Distribution Power System in Major Cities in Local Areas in Myanmar

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