People's Republic of Bangladesh
Ministry of Power, Energy and Mineral Resources (MPEMR)

People's Republic of Bangladesh

Data Collection Survey on Development of Infrastructure in Power and Energy

Final Report

November 2018

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Holdings, Inc.
Mitsubishi Research Institute, Inc.

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Abbreviation

Abbreviation	Full Title
ADB	Asian Development Bank
AF	Additional Financing
AIIB	Asian Infrastructure Investment Bank
APSCL	Ashuganj Power Station Company Limited
BAPEX	Bangladesh Petroleum Exploration & Production Company Limited
BDT	Bangladesh Taka
BEST	Brihanmumbai Electric Supply and Transport
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BREB	Bangladesh Rural Electrification Board
CB	Circuit Breaker
CCPP	Combined Cycle Power Plant
CIRR	Commercial Interest Reference Rate
CNG	Compressed Natural Gas
CPGCBL	Coal Power Generation Company of Bangladesh Limited
DER	Distributed Energy Resources
DESCO	Dhaka Electricity Supply Company Limited
DMC	Developing Member Country
EBF	Equity Back Finance
ECA	Export Credit Agencies
ECG	Export Credit Group
EECMP	National Energy Efficiency and Conservation Master Plan
EGCB	Electricity Generation Company of Bangladesh
EIBC	Export-Import Bank of China
EMS	Enegry Management System
EPA	Environmental Protection Agency
EU	European Union
EV	Electric Vehicles
FOHS	Furnace Oil
FSRU	Floating Storage Regasification Unit
FY	Fiscal Year
GDP	Gross Domestic Product
GMS	Greater Mekong Sub region
GNI	Gross National Income
GOB	Government of Bangladesh
GSMP	Gas Sector Master Plan
GTCL	Gas Transmission Company Limited
HOBC	High Octane Blending Componen
HSD	High Speed Diesel
HVDC	High Voltage Direct Current transmission line
IGCC	Coal Gasification Combined Cycle
IOC	International Oil Company

Abbreviation	Full Title
JBIC	Japan Bank for International Cooperation
JBO	Jute Batching Oil
JICA	Japan International Cooperation Agency
KEXIM	Export-Import Bank of Korea
KSURE	Korea Trade Insurance Corporation
KV	Kilo Volt
LDO	Light Diesel Oil
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LUBE	Lubricant
MECE	Mutually Exclusive and Collectively Exhaustive
MoPEMR	Ministry of Power, Energy and Mineral Resources
MS	Motor Spirit
MTT	Mineral Turpentine
MW	Mega Watt
NEXI	Nippon Export and Investment Insurance
NLDC	National Load Dispatching Center
NWPGCL	North West Power Generation Company
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
PBS	Palli Bidyuit Samity
PD	Power Division
PGCB	Power Grid Company of Bangladesh Limited
PPP	Public Private Partnership
PSMP	Power System Master Plan
PSTP	Power Sector Training Policy
RCI	Regional Cooperation and Integration
RE	Renewable Energy
RERED	Rural Electrification and Renewable Energy Development
RLNG	Re-gasified LNG
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SASEC	South Asia Sub-regional Economic Cooperation
SBPL	Summit Barisal Power Plant
SBPS	Special Boiling Point Solvent
SCADA	Supervisory Control And Data Acquisition
SHS	Solar Home System
SKO	Superior Kerosene Oil
SPC	Special Purpose Company
SREDA	Sustainable and Renewable Energy Development Authority
STEP	Special Terms for Economic Partnership
TA	Technical Assistance
TOR	Terms of Reference

Abbreviation	Full Title
TRTA	Technical Assistance
USC	Ultra-Super Critical
USD	United States Dollar
V2G	Vehicle To the Grid
VGF	Viability Gap Funding
WZPDCL	West Zone Power Distribution Company Limited

Chapter 1 Introduction

1.1 Background

The energy supply of the People's Republic of Bangladesh has been greatly dependent on domestically produced natural gas. Considering the foreseeable decrease in the production of natural gas, the Power System Master Plan 2010 (PSMP2010), which was formulated by the Government of Bangladesh with technical assistance from Japan, focused especially on the long-term energy diversification of primary energy sources.

However, energy infrastructure development was not necessarily in line with what was expected in the PSMP2010 because of conditional changes in the availability of energy sources that PSMP2010 assumed would be added as a substantial part of the energy supply. Above all, the restriction on domestic energy production, especially coal (mainly due to socially-sensitive resettlement issues and technical challenges), and the exponential increase of small-scale rental power plants using petroleum products to make up for the delay in developing large-scale power generation that was behind the rapidly growing energy demand were the notable factors that were not sufficiently foreseen in PSMP2010.

Another factor that urged the revision of PSMP2010 was the high growth rate of the national economy, which has seen a growth rate constantly higher than 6% p.a. since 2011. Driven by this economic boom, the Government of Bangladesh (GoB), in its new policy "Vision 2041", set the ambitious target that the country would become a developed country by 2041. Consequently, the power and energy sector, which requires a huge amount of financial resources for infrastructure development, was requested to review its infrastructure development to meet the government policy and strongly support the accelerated growth of the national economy.

It has to be considered that the growth rate of energy demand is not always linear with the growth rate of gross domestic product (GDP) because the energy intensity of GDP varies depending on the stage of economic development, especially in emerging countries like Bangladesh where the industrial structure is expected to shift from light industries to energy-consuming heavy industries, and then to high-tech industries. Therefore, the long-term projection of national energy demand also needs to address studies on the expected path of economic development and its structural changes, not simply forecast the GDP growth rates.

The accelerated, growing demand for energy may be partially softened by another ambitious target of the government, which is to "improve primary energy consumption per GDP by 20% by 2030 compared to 2013 levels". This was formulated in the National Energy Efficiency and Conservation Master Plan (EECMP). Achieving this energy efficiency target is another big challenge, considering that energy prices in the domestic market are not high enough to recover the cost of production. To ensure the sustainable development of the sector, an analysis of energy prices and their reforms also needs to be taken into account.

The expected structural changes in the national economy, i.e. the shift to advanced industries that are more dependent on the energy supply in the production process, also require consideration for improving the quality of the electricity supply while constantly increasing the quantity to meet the demand.

To address the aforementioned various issues, PSMP2016 was developed as a literally comprehensive master plan to cover the following analyses.

- Economic development strategy
- Primary energy demand projection and supply plan
- Power generation and network planning
- Improvement of power supply quality

- Institutional reforms for improving O&M of thermal power generation
- Region-wide development of hydropower
- Power and energy analysis and the impact of tariff reforms on national economy

An important thing to be noted is that PSMP2016 is not only the master plan for power supply but also for other modes of energy supply, covering comprehensively the country's energy supply and demand, and provided a thorough view combining these two parts. In Bangladesh, these areas are administrated by the Power Division and the Energy and Mineral Resources Division respectively within the Ministry of Power, Energy and Mineral Resources (MPEMR). The master plan was therefore presented as a joint outcome for these two Divisions.

1.2 Objectives

Since PSMP2016 was established, there have been new developments related to power and energy infrastructure in Bangladesh. Many of these developments are related to projects based on frameworks for cooperation between the governments of Japan and Bangladesh or efforts by Japanese companies to participate in such projects in some manner, and they can also be viewed as proof of the close public-private relationship that is beginning to be established between Japan and Bangladesh in the energy field.

- Completion of the construction of the country's first floating storage and regasification unit (FSRU) and the commencement of LNG imports
- Bidding for the country's first land-based LNG terminal, for which five companies/consortiums were shortlisted (including three from Japan)
- Opening of official channels between the governments of India and Bangladesh related to the cross border transmission grid system
- Dhaka - Chittagong transmission line project (yen-loan project)
- Dhaka underground substation construction project (yen-loan project)
- Power supply reliability improvement support project (funded by the World Bank)
- SCADA/EMS feasibility study (funded by METI of Japan)

Taking into consideration these recent developments, this study aims to identify projects that serve to provide long-term and sound infrastructure development in Bangladesh's power and energy sector and propose foundations for achieving them.

1.3 Methodologies for this Study

There are four key perspectives in carrying out this study, as per the below. Of these, A. and B. provide aspects in identifying what fields to focus on in order to develop Bangladesh's power and energy infrastructure. C. serves for defining the prioritization in carrying out the infrastructure development, and D. provides support for enhancing the effectiveness of these projects from the institutional aspect.

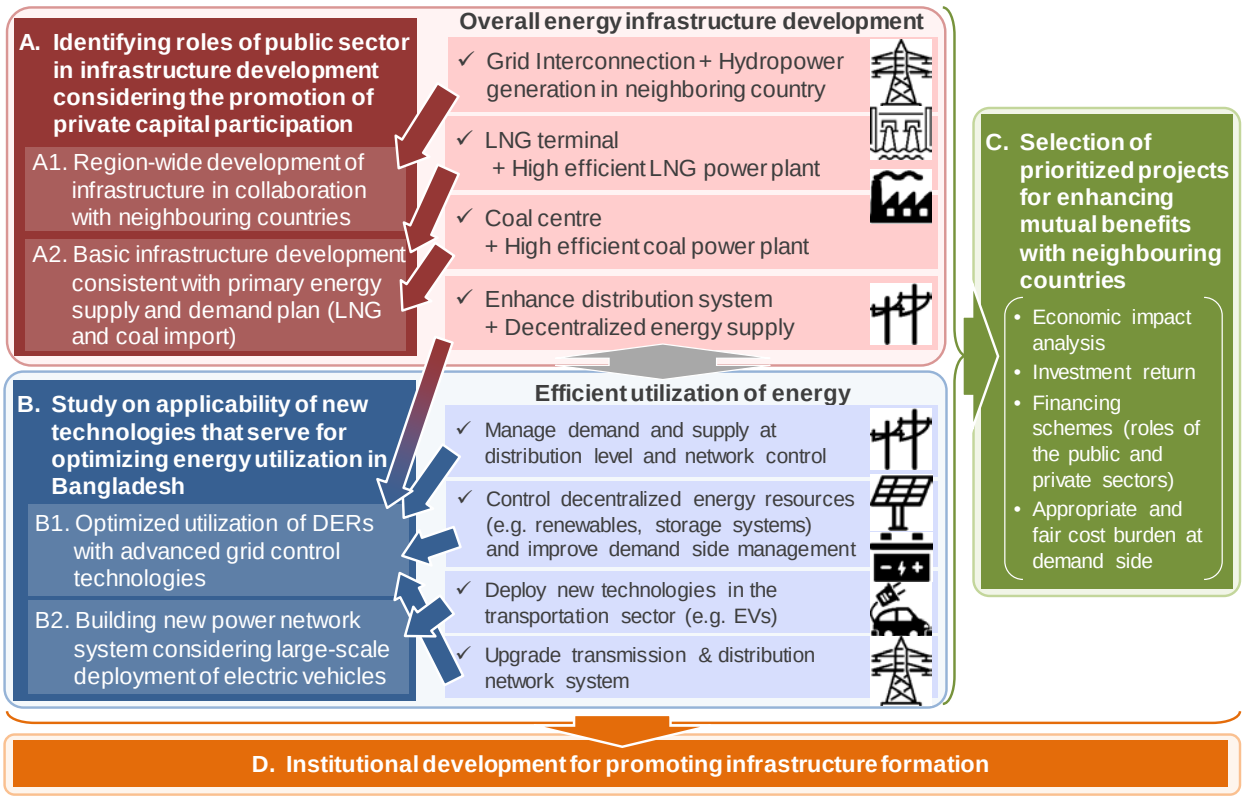
A. Identifying roles of public sector for overall infrastructure development considering the promotion of private capital participation

B. Study on applicability of new technologies that serve for optimized utilization of energy in Bangladesh

C. Selection of prioritized projects that serve for maximizing cost benefits and enhancing mutual benefits with neighboring countries

D. Institutional development for promoting infrastructure formation

The figure below indicates the relationship between these four points and projects where cooperation and assistance from Japan can be expected to be highly effective based on the assumptions as mentioned above.



Source: JICA Survey Team

Figure 1-1 Four main perspectives of this study

1.4 JICA Survey Outline

The JICA Survey Team is composed of the following members.

■ Team Formations

Assignment	Name
Team Leader/ Power Sector	Toshiyuki KOBAYASHI
Sub-Team Leader/ Primary Energy	Mari IWATA
LNG & Coal , Import Strategy	Yasushi IIDA
Financing Structure	Kunio HATANAKA
Legal Structure	Tosh YOSHIDA
Transmission/ Distribution	Noboru SEKI

■ Project Duration

From 20th August 2018 to 30th November 2018

■ Activities with counterparts.

Activities on JICA survey with counterparts of Bangladesh is as follows.

1st Survey

Date	Time	Place to visit	Agenda
Monday, 3rd Sep. 2018	14:30 ~15:15	Planning Commission - Chief (Industry& Energy Division)	Planning Commission's views on the current status of power and energy industry in Bangladesh and areas to be strengthened;
	16:00 ~17:30	Rupantarita Prakritik Gas Company Limited (RPGCL) - Managing Director, General Manager (LNG Division)	Current status of LNG import plans (FSRU and on-shore terminal); Necessity to strengthen the institutional capacity related to LNG import;
Tuesday, 4th Sep. 2018	10:00 ~11:00	Power Division, Ministry of Power, Energy and Mineral Resources (MPEMR) - Additional Secretary	Bangladesh government's works on updating PSMP2016 (PSMP revisited); Overall status of the power sector Power division's roles in LNG import;
	11:30 ~12:30	Power Grid Company of Bangladesh (PGCB) - Managing Director, Chief Engineer (P&D)	PGCB's plan of expanding power transmission network and expectation of assistance from Japan;
	14:00 ~15:00	Bangladesh Energy Regulatory Commission (BERC) - Chairman, Member	BERD's view on the current status of power and energy sector and the necessity of strengthening infrastructure; Tariff regulation;
	15:30 ~16:30	Dhaka Power Distribution Company Limited (DPDC) - Managing Director, Executive Director (Engineering)	DPDC's plan of upgrading power distribution network and expectation of assistance from Japan;
Wednesday, 5th Sep. 2018	10:30 ~11:30	Gas Transmission Company Limited (GTCL) - Managing Director, General Manager (Planning)	Ongoing projects to expand GTCL's gas pipeline network;
	13:00 ~14:00	Dhaka Electric Supply Company Limited (DESCO) - Chief Engineer (P&D), Sub-division Engineer (System planning)	DESCO's plan of upgrading power distribution network and expectation of assistance from Japan;
	13:30 ~15:00	Bangladesh Minerals, Oil and Gas Corporation (Petrobangla) - Director (Operation & Mines), Deputy General Manager, LNG Cell, Senior GM, LNG Cell	Petrobangla's prospects of LNG import plans and expectation of assistance from Japan;
	16:00 ~16:40	Bangladesh Power Development Board (BPDB) - Member (P&D)	BPDB's view on the optimized energy mix to be considered in power development planning;

2nd Survey

Date	Time	Place to visit	Agenda
Sunday, 30th Sep. 2018	14:00 ~15:30	Asian Development Bank – Bangladesh Resident Mission	ADB's policy on assistance in Bangladesh energy and power sector;
Monday, 1st Oct. 2018	10:00 ~11:00	Bangladesh Economic Zone Authority (BEZA)	Current status of energy supply to SEZ in Bangladesh and prospects;
	15:00 ~16:00	Sustainable And Renewable Energy Development Authority (SREDA)	Promotion of renewables, energy storage, and EV in Bangladesh;
	17:30	Yachiyo Engineering	Feasibility of waste-to-power in Bangladesh;

Date	Time	Place to visit	Agenda
	~18:00		
Tuesday, 2nd Oct. 2018	10:00 ~12:00	Bangladesh Minerals, Oil and Gas Corporation (Petrobangla)	Petrobangla's prospects on gas supply and demand based on the Gas Sector Masterplan 2017;
	14:30 ~16:00	Titas Gas Transmission and Distribution Company Limited (TGTDCL)	Energy demand projection and sector-wise policy of gas supply, infrastructure development plan;
Wednesday, 3rd Oct. 2018	13:00 ~14:00	Bangladesh Power Development Board (BPDB) – System Planning	Current status of update works of PSMP by GoB;
	14:30 ~15:00	BPDB - Commercial Operation	Statistics of distribution system, infrastructure development plan;
	15:00 ~15:30	Power Cell	Power Cell's role in the Gas Sector Masterplan 2017;
	16:00 ~17:30	Coal Power Generation Company Bangladesh Limited (CPGCBL)	Current status of Matabari area development and CPGCBL's expectation of Japan's assistance in future;
Thursday, 4th Oct. 2018	10:00 ~11:00	Dhaka Electric Supply Company Limited (DESCO)	Feasibility of distribution undergrounding in Dhaka area Discussion on system reliability statistic data;
	14:00 ~15:00	Dhaka Power Distribution Company Limited (DPDC)	Feasibility of distribution undergrounding in Dhaka area Discussion on system reliability statistic data;

3rd Survey

Date	Time	Place to visit	Agenda
Wednesday. 17th Oct. 2018	10:30 ~11:30	Rupantarita Prakritik Gas Company Limited (RPGCL) - Managing Director	Workshop planned on 30th October; LPG supply and the role of RPGCL;
	12:30 ~13:30	Bangladesh Minerals, Oil and Gas Corporation (Petrobangla) - GM (Production and Marketing)	GSMP2017; Gas distribution, gas tariff; Areas for the further collaboration; Smart meter/pre-paid meter; Gas price elasticity study, gas distribution priority policy development;
	14:30 ~15:30	Bangladesh Energy Regulatory Committee (BERC) - Member	Gas tariff structure and gas market reform; (Lack of) safety standard, operation and maintenance regulations of imported LPG;
Thursday, 18th Oct. 2018	12:00 ~13:00	Bangladesh Power Development Board (BPDB), - Chairman, Director- System Planning	Revisiting PSMP2016 / coal as essential fuel source; BPDB Power Hub development in Moheshkali area; Areas for the further collaboration; Replacing Haripur power plants; Matabari #3 and #4;
Wednesday, 24th Oct. 2018	11:00 ~12:00	EMRD - Additional Secretary	Problems identified in the gas sector; Possible collaboration in the future;
	14:00 ~16:00	BPDB - System Planning	Revisiting PSMP2016; Power sector planning;

4th Survey

Date	Time	Place to visit	Person to meet
Monday. 29th Oct. 2018	15:00 ~16:30	Workshop at Bangladesh Energy Regulatory Commission (BERC) - Chairman, etc.	Presentation on legal framework of gas supply business in Japan and US; (Participants: about 15 people);
Tuesday, 30th Oct. 2018	10:00 ~11:00	Asian Development Bank (ADB), - Country Director	Exchanged views on international financing in power and energy sector in Bangladesh;
	10:30 ～12:30	Workshop at Rupantarita Prakritik Gas Company Limited (RPGCL) - Managing Director, etc.	Presentation on the necessity of contractual arrangement for LNG import (Participants: about 20 people);
	14:00 ～14:45	Power Division, Ministry of Power, Energy and Mineral Resources (MPEMR) - Additional Secretary	Discussion on topics related to the JICA study, especially on the necessity of strengthening human capacity for power engineering and costing (Bangladesh Power Management Institute: BPMI;
	15:00 ～16:00	Energy and Mineral Resources Division, MPEMR - Secretary	Presentation on the outcome of the JICA study and discussion, legal framework to address LNG import, financing scheme etc.;

Workshops on LNG Import

Workshop at Bangladesh Energy Regulatory Commission (BERC)

Workshop at Rupantarita Prakritik Gas Company Limited (RPGCL)

High level discussion with Energy Division

High level discussion with Power Division, MPEMR

Power Division, MPEMR:
Meeting with Additional Secretary (Planning & RE)

Power Division, MPEMR:
Meeting with Additional Secretary (Development)

International development agencies

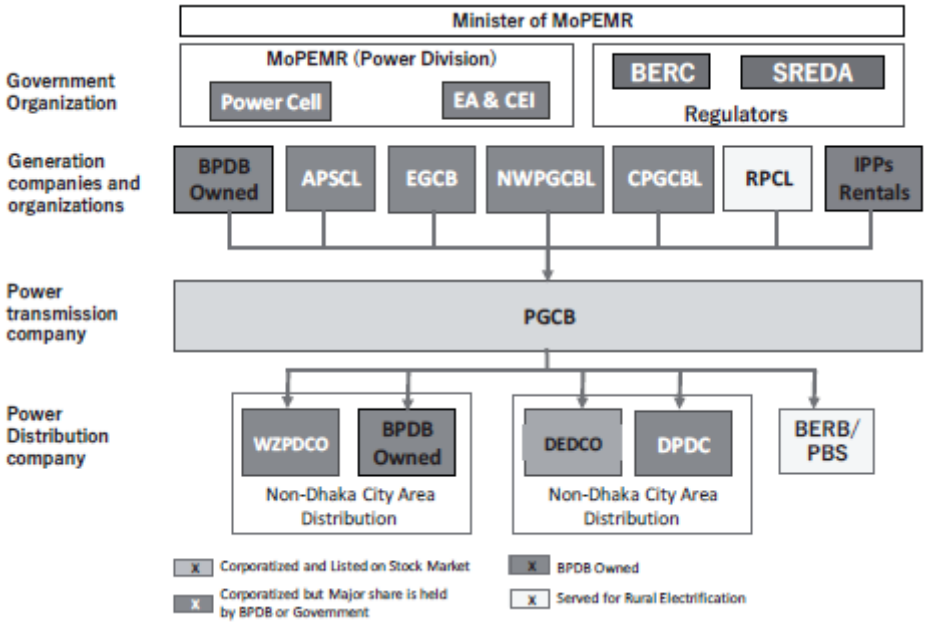
Asian Development Bank (ADB):
Meeting with Country Director

Chapter 2 Review of Power and Energy Sector in Bangladesh

2.1 Power Sector Structure

For government agencies, the Power Division, under the Ministry of Power, Energy and Mineral Resources (MPEMR), is responsible for overall policy formulation for the power sector in Bangladesh. The Bangladesh Energy Regulatory Commission serves as a regulatory body, responsible for setting rules and regulations to ensure transparency of transactions among utility companies and end-consumers.

The power supply business can be roughly divided into power generation, power transmission and power distribution/retail, and different businesses exist in each of them. In power generation, public sector utilities such as Bangladesh Power Development Board (BPDB) and its affiliates conduct the majority of generation, but there are also privately-funded power generators such as IPPs. In power transmission, Power Grid Company of Bangladesh (PGCB) is a monopoly that owns and operates the power transmission network for the whole country. In power distribution/retail, there are five utility companies and each of them is a regional monopoly with service areas. DESCO and DPDC are the suppliers in the Dhaka area, and BPDB and WZPDCL supply electricity to other urban/suburban areas. REB is responsible for rural electrification in remote rural areas.



Source: PSMP2016

Figure 2-1 Overview of Bangladesh Power Sector

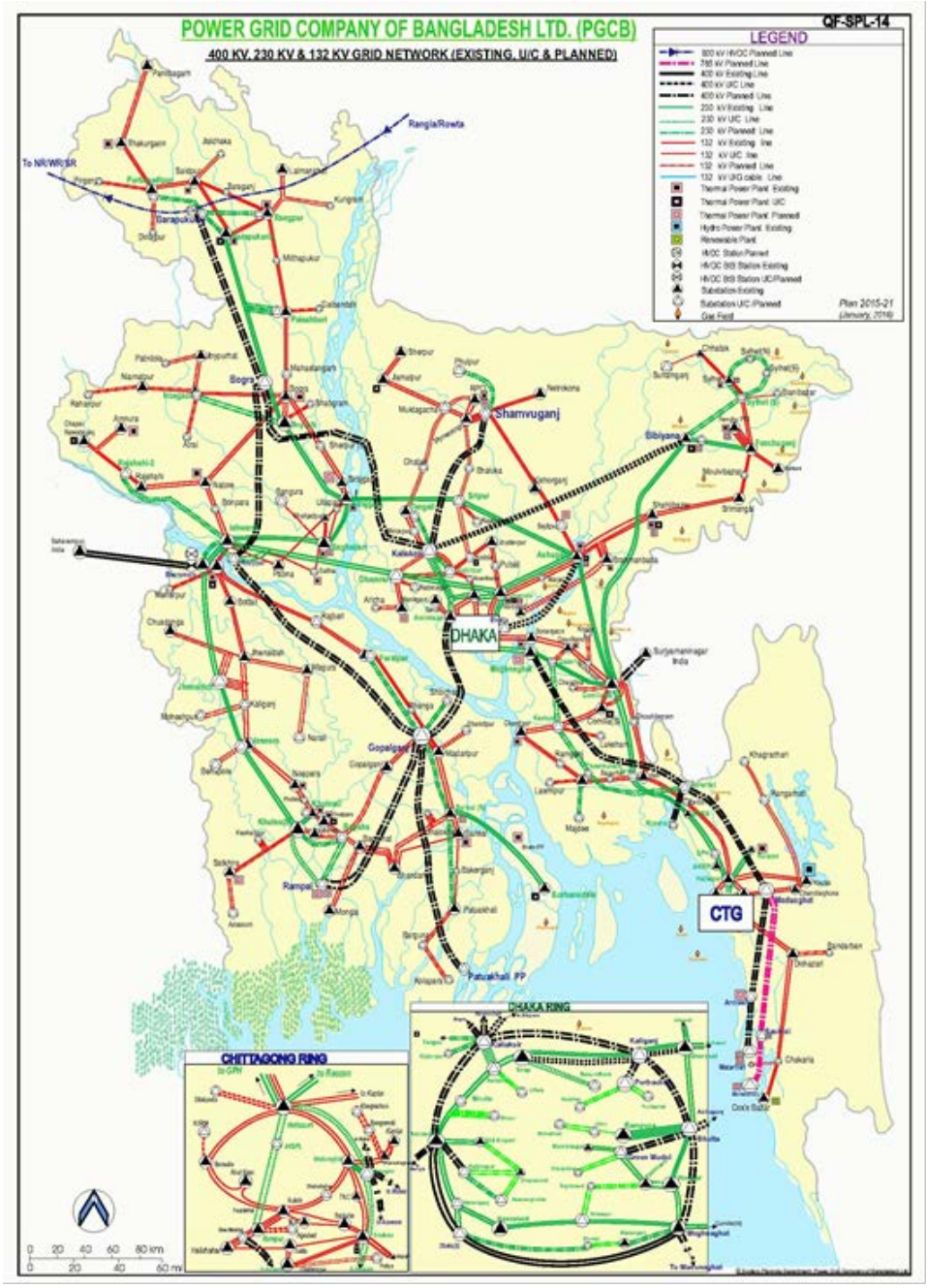
2.1.1 Generation

BPBD was initially established as the Water and Power Development Board under the East Pakistan administration. After independence, it became the Power Development Board in 1972, with an installed capacity of just 200MW. Until the 1990s, when power sector reforms made substantial progress, BPDB was a vertically integrated power entity. Even now, BPDB owns 30 to 40% of installed capacity and distribution lines.
Besides BPDB, the following Power Generation Entities exist.

- Ashganji Power Station Company Limited (APSCL)
- Electricity Generation Company of Bangladesh (EGCB)
- North West Power Generation Company Limited (NWPGCL)
- Coal Power Generation Company of Bangladesh Limited (CPGCBL)

2.1.2 Power Transmission

Power Grid Company of Bangladesh (PGCB) was established in 1995, as a result of the unbundling of the power sector, and is the sole transmission company in Bangladesh. It has a National Load Dispatch Center (NLDC) as one of its sub-divisions. As discussed in the later Chapter, the independence of NLDC from PGCB will be an important institutional issue for network operations in Bangladesh. PGCB is also a semi-private company, whereby 25% of its issued shares are listed on the stock market (the remaining 75% are owned by the Government). PGCB's main assets are 400kV, 230kV and 132kV transmission lines, and wheeling charges are the only revenue source. PGCB also has a long list of development partner-funded projects, including with JICA, World Bank and ADB.



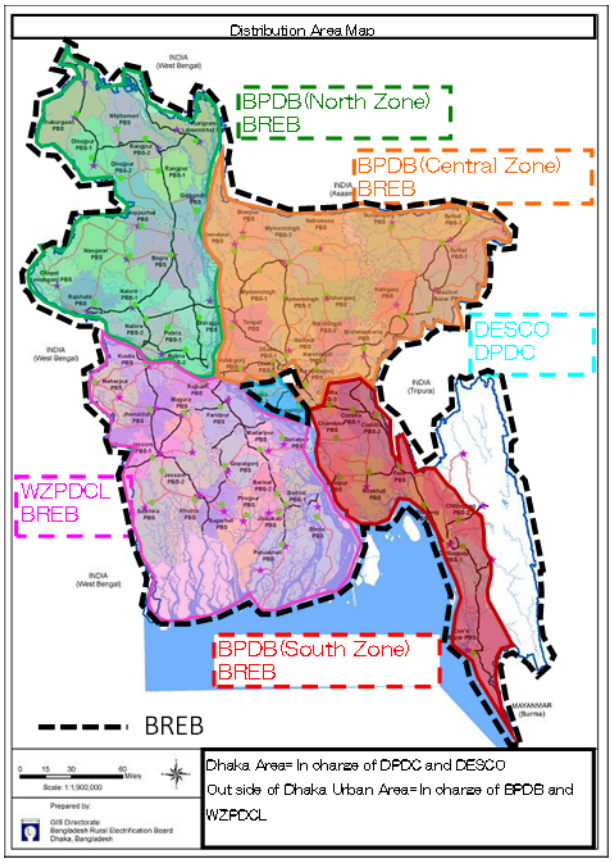
Source: PGCB Annual Report

Figure 2-2 Diagram of power transmission network in Bangladesh

2.1.3 Power Distribution

There are five urban area distribution companies in Bangladesh. DESCO and DPDC are in charge of the Dhaka area, and WZPDCL is in charge of the western municipalities, including the Khulna and Barisal areas. The remainder of municipal power distribution operations are still under BPDB (see the below figure).

DESCO and DPDC have made significant operational improvements since their corporatization. DESCO outsourced its meter-readers and introduced performance-based compensation, reducing meter-reader fraud. DESCO and DPDC introduced a prepayment billing system and improved the billing collection rate. With these operational efforts, both companies achieved system losses of less than 9%, and billing collection ratios of more than 98% at DESCO and 90% at DPDC, which are higher than those of other distribution entities.



Source: PSMP2016

Figure 2-3 Distribution Companies and Areas

2.2 Vision 2021 and Vision 2041

Bangladesh has reached developing country status, rising from the least developed country level. The government is working to make Bangladesh a middle income country by 2021 and to reach developed country status by 2041. A quality and uninterrupted power supply is essential for Bangladesh to become an industrial country. When the present government came to power in 2009, electricity generation was 4,942 MW; this has increased to 20,000 MW (including 2,800MW of captive power). The government is determined to supply electricity to every consumer by 2021. According to the government targets, 24,000 MW shall be generated by 2021, 40,000MW by 2030 and 60,000 MW by 2041, based on the PSMP2016 high demand case.

In 2009, the length of transmission lines was 8,000 circuit km. This has now increased to 11,112 circuit km and it will be further increased to 36,870 circuit km by 2041. Similarly in 2009, the length of

distribution lines was 260,000 km. This has now increased to 455,000 km and, as per the plans, will be further increased to 500,030 km by 2041.

2.3 Generation Planning

2.3.1 Power Sector statistics over ten years

90.5% of the total population currently receives electricity. 100% of people will receive electricity by 2021. The amount of power generation per person per year is 464 kWh (captive power). However, this amount is lower than in other countries. As per the targets, electricity consumption will be 600 kWh per person per year by 2021.

Table 2-1 Statistics from 2009 to 2018 (August) at a glance

Sl. No.	Description	2009	2018	Progress (Increase/ Decrease)
1	Power Generation (MW)	4,942	20,000*	(+) 15,058
2	Maximum Power Generation (MW)	3,268 (Jan. 2009)	11,387 (18 July 2018)	(+) 8,119
3	Total Length of Transmission Line (CKT Km)	8,000	11,122	(+) 3,122
4	Capacity of Grid Sub-stations (MVA)	15,870	36,045	(+) 20,175
5	Total Distribution Lines (Km)	260,000	455,000	(+) 195,000
6	Number of Consumers	1 Crore 8 Lac	2 Crore 99 Lac	(+) 1 Crore 91 Lac
7	Irrigation Connection	234,000	361,000	(+) 127,000
8	System Loss (Transmission and Distribution)	18.45%	11.40%	(-) 7.05%
9	Percentage of Population with electricity connection (with renewable energy)	47%	90.50%	(+) 43.50%
10	Per-capita power generation: kWh (with captive power)	220	464	(+) 224

*Including 2,800MW of captive power

Source: Power Division

2.3.2 Expected Addition of Power Generation Capacity Up to 2021

According to the Power Division, about 16 GW of generation capacity is expected to be added to the power supply. Both the public sector and the private sector (e.g. IPP) account for a little less than half of the total addition of generation capacity, and power imports from India take up the remainder.

Table 2-2 Expected Addition of Power Generation Capacity Up to 2021

Year	2018 (MW)	2019 (MW)	2020 (MW)	2021 (MW)	Total (MW)
Public Sector	1,814	2,451	1,044	2,165	7,474
Private Sector	2,171	2,759	163	1,901	6,994
Import	1,160	-	340	-	1,500
Total	5,145	5,210	1,547	4,066	15,968

Source: Power Division

2.3.3 Initiative for Implementation of Plan

From 2009 to June 2018, 134 contracts had been signed for installation of new power plants, with a capacity of 24,346 MW. 78 power plants, with a capacity of 10,116 MW, are in operation among the power plants under contract.

Table 2-3 Contracts for Installation of New Power Plants from 2009 to 2018

Type of Power Plant	No. of Power Plants	Installed Capacity (MW)
Government	48	12,061
Rental	20	1,653
IPP	66	10,632
Total	134	24,346

Source: Power Division

2.3.4 Power Generation and Diversification of Energy

Capacity of power generation was 4,942 MW in 2009, which was not enough to meet the demand. Construction of power plants based on imported Coal, Atomic Energy and LNG have been considered. Power generation planning has been undertaken based on Gas/LNG and Coal by 2041, and this will be 35% of total generation according to PSMP2016.

2.3.5 Construction of LNG Terminals

A contract was signed for the installation of an LNG terminal (FSRU) at Moheshkhali, in the Cox's Bazar district. Under this project, 500 mmcfd of gas is to be supplied to the National Grid. Another contract was signed with Summit Group on April 20, 2017. Under this contract, 500 mmcfd of gas will be added to the National Grid. In addition to this, discussions are being held to sign a contract with Reliance Power Ltd. of India for installation of an FSRU with a capacity of 500 mmcfd. Another contract was signed on 08/04/2017 with Petronet LNG Ltd. of India for the installation of a land-based LNG terminal with a capacity of 1000 mmcfd daily at Kutubdia, Cox's Bazar.

2.3.6 Imports of Power from India

In October 2013, 500 MW of power imports from India started through a 400 kV Transmission Line and HVDC B2B sub-station. Another 500 MW will be imported through the Baharampur-Bheramara link as soon as the BD-India program is finalized. 160 MW is currently imported from the Palatana power plant in Tripura, India. A 500 MW HVDC B2B is under construction and, by relocating an existing 132 kV transmission line, an additional 340 MW will be imported through HVDC.

2.3.7 Coal based mega projects

(1) Rampal 1320 MW Coal Based Power Plant
2x 660MW under the Bangladesh India Friendship Power Co. Ltd, at a cost of 1.68 billion USD. Out of this, 1.2 billion USD will be under ECA. Commercial operations are expected to begin from September 2021. Super Thermal technology.

(2) Matarbari 1200 MW Coal Based Power Plant
2x 600MW under CPGCL, with cooperation from JICA and GOB. 1st unit to start operation by January 2024; 2nd unit by June 2024. USC technology.

(3) Payra 1320 MW Coal Based Thermal Power Plant
2x 660MW NWPGCL + CMC 50:50 partnership. USCT.
Project cost = 19,828 crore BDT
1st unit: April 2019; 2nd unit: October 2019
2nd phase: 2x 660 1320 MW
3rd unit: December 2021; 4th unit: December 2022

(4) Patuakhali 1320 MW Coal Based Thermal Power Plant by RPCL
RPCL + NICL, Chinese joint venture

915.74 acres of land acquired. EPC tender has been floated.
Planned for operation from 2022 with USC technology.

(5) Maheshkhali 1320 MW Coal Based Thermal Power Plant via joint venture between Bangladesh and Chinese government.
BPDB + CHDHK, China: 50:50
Operations expected to start from 2023-24
EPC contractor selection is in progress.

2.3.8 Nuclear Power Plants

A contract has been signed between Bangladesh and Russia for construction of a Nuclear Power Plant. Generation of 1200 MW will start by 2023, with another 1200 MW by 2024. Construction work for this power plant is in progress.

2.4 Power Transmission and Distribution Planning

2.4.1 Power Transmission

(1) Current status

PGCB (Power Grid Company of Bangladesh) is a monopoly that owns and operates the entire transmission network system in Bangladesh.

In accordance with the government's initiative to expand the country's power supply system so that it will be able to provide electricity to every consumer by 2021, PGCB has been expanding and strengthening its power transmission network. Considering that new power generation using imported LNG and coal will be developed mainly in the southern regions, a 765kV double-circuit line will be installed that connects south and north - from Moheshkhali to Dhaka and from Payra to Dhaka - according to PGCB's 2041 transmission plan.

Besides extending the grid within the country, PGCB has also set out on a project to install a 500 MW HVDC back-to-back substation in Comilla for international grid connection with Tripura in India.

PGCB's ongoing and planned projects are shown in the following table.

Table 2-4 List of PGCB's ongoing and planned projects

	Projects Name	Major scope of works	Main objectives of the Project	Project Cost(M US$)			Financing Status	Project Completion Year	Status	Tenure
				Local	Foreign (PA/ FE)	Total				
1	Renovation and Capacity Enhancement of Existing Grid Substations and Transmission Lines	i) Transformer Upgradation: -400/132kV: 01 no's (650 MVA) -230/132kV: 07 no's (3000 MVA) -230/33kV: 01 no's (140 MVA) -132/33kV: 20 no's (2400 MVA) ii) Reconductoring: 14 no's (483.4 Ckt. Km) iii) Stringing: 02 no's (86 Ckt. Km) iv) New Line: 02 no's (12 Ckt. Km)	i) To meet the growing demand	47.3	88.3	136	Expected from GoB	December, 2022	DPP Preperationin Progress	
2	*Southwest Grid Network Expansion Project (Phase-2)*	i) 230/132/33 KV SS: Rupsha GIS (3x350/450, 3x80/120 MVA), ii) 230/132KV SS: Bhola GIS (230/33kV, 2x120/140 MVA) ii) 132/33 kV SS: 10 no's [Shibchar GIS ,Bangha GIS, Jhalokhati GIS, Phultola GIS(3x80/120 MVA Each), Meherpur GIS, Monirampur GIS, Pirojpur GIS, Maheshpur GIS ,Domar GIS, Hatibandha GIS (2x80/120MVA each)] v) 230 kV Line: 338 Ckt. km. vi) 132 kV Line: 106 Ckt. Km. vii) 132kV line Strining:50 Ckt. Km iii) 230 kV Line: 212 Ckt. km. iv) 132 kV Line: 298 Ckt. Km. v) 132 kV Line Stringing: 82 Ckt. km. vi) 230 kV bay extension: 4 no's vii) 132 kV Bay extension : 8 No's	i)To meet the growing demand of Khulna & Barisal area. ii) To enhance the power supply capacity & reliability of Khulna & Barisal Region.	80	175	255	*Expected from ADB*	June, 2023	a) Feasibility consultant Study in progress	July,2019-June, 2023
3	*Expansion and Strengthening of Power System Network Under DPDC Area*	i.400/230kV New Indoor GIS Substation :2 nos. , 3000 MVA ii.230/132kV New Indoor GIS Substation :7 nos. ,7650 MVA iii.New Transmission Line: - 400kV Line:370 Ckt. km - 230kV Line:111 Ckt. km - 230kV Cable:96 Ckt. km -132kV Line: 8.8 Ckt. km iv.Bay Extension work at other Substations : 8 no's	To meet the growing power demand & quality improvement of- -Dhaka City & Adjacent	98	850	948	*Expected from EXIM Bank, China (G-G)*	June, 2022	a) Financial Negotiation in progress. b) Feasibility study in progress	June,2018-June, 2022

	Projects Name	Major scope of works	Main objectives of the Project	Project Cost(M US$)			Financing Status	Project Completion Year	Status	Tenure
				Local	Foreign (PA/ FE)	Total				
4	*Madunaghat - Moheskhali 765kV Transmission line*	i) 765 kV Line: 200 Ckt. km ii) Two 400 kV bay at Madunaghat	* To establish transmission infrastructure for evacuation of power to be generated from proposed power plants at Maheshkhali. * To provide reliable power to all over the country.	149	194	343	*Proposed for EDCF, Korea*	June, 2023	a) PDPP sent to Power Division on 30-08-2015 b) PDPP approved by Planning Commission in principle on 01.11.2015 b) Feasibility consultant appointment in progress	June,2019-June, 2023
5	*Banshkhali-Madunaghat 400kV Transmission Line Project*	i) 400 kV line: 130 Ckt. km. ii) 400 kV GIS Bay Extension: 2 no's	(i) To ensure reliable transmission facilities to evacuate power from proposed coal based thermal PP project at Banshkhali (1320 MW) (ii) To meet the growing demand of the Chattogram zone in more reliable way.	29	69	99	*Proposed for AIIB/GoB*	June, 2021	a) PDPP sent to Power Division on 27.04.16 b)PDPP approved by Planning Commission in principle on 12.06.2016 c) Feasibility consultant appointment in progress d) Shandong Taikai shown interest for EPC-F format financing.	June,2018-June, 2021
6	*Expansion and Strengthening of Power System Network in DESCO & its Adjacent Area (Phase-1)*	i) 400/230 kV GIS SS: Kaliganj, Purbachaliii) 230/132 kV GIS/GIT SS: Gulshan, Uttara, Mirpur, Ashulia, Mohakhali, Purbachal-2iii) 400 kV (O/H+U/G) line: 56 Ckt. kmiv) 230 kV (O/H+U/G) line: 102 Ckt. km	To meet the growing power demand & quality improvement of- -DESCO & Adjacent area	174	356	530	*Proposed for ADB & KfW*	December, 2023	a) PDPP sent to Power Division on 02.11.16b) PDPP approved by Planning Commission in principle on 22.03.2017c) KfW shown interest to	June, 2019-Dec,2023

	Projects Name	Major scope of works	Main objectives of the Project	Project Cost(M US$)			Financing Status	Project Completion Year	Status	Tenure
				Local	Foreign (PA/ FE)	Total				
									perform the feasibility study of the whole project and finance 100m Euro.	
7	*Construction of Payra-Gopalganj-Aminbazar 400kV Transmission System*	i) 400kV double circuit line: 265 km ii) 400/132/33kV AIS SS: Jhalokati (2x325 MVA, 2x80/120 MVA) iii) 400/230kV, 2x1000 MVA Transformer at Aminbazar 400/230kV SS iv) 400kV AIS Bay Extension: 8 no's v) 230kV AIS Bay Extension: 2 no's	To establish additional 400kV transmission infrastructure for evacuation of power from NWPGCL 3600 MW LNG based power station and BCPCL 2nd phase 1320 MW Coal based Power Station from Payra (Patuakhali).	124	378	502	*Proposed for ADB*	December, 2021	a) Revised PDPP sent to Power Division on 10.06.18	
8	*Bornagar-Parbitipur-Katihar 765 kV Bangladesh-India Grid Interconnection Project (Bangladesh Part)*	i.500MW HVDC Station at Barapukuria ii.765kV double circuit transmission Line: 154 Km	* To connect the huge hydroelectric potential of Bhutan and Arunachal Province to India through Bangladesh territory * To draw 500-100MW power at Barapukuria from Cross Border Interconnection	177	413	590	*Proposed for 3rd New Credit Loan (India)*	December, 2025	Decision not finalize in 13th JSC meeting. Decision is expected in the next JSC meeting	June,2020-Dec,2025

	Projects Name	Major scope of works	Main objectives of the Project	Project Cost(M US$)			Financing Status	Project Completion Year	Status	Tenure
				Local	Foreign (PA/ FE)	Total				
9	*Madunaghat-Bhulta 765 kV Transmission Line Project*	i) 765 kV line: 500 ckt. Km (Conductor: Hexa Cardinal) ii) 400kV bay extension: 4 no's (Bhulta & Madunaghat)	i) To establish high capacity transmission infrastructure for evacuation of power from Chattogram to Dhaka ii) To provide reliable power to all over the country	293	412	705	*Proposed for WB*	December, 2024	a) PDPP sent to Power Division on 06.09.16 b) PDPP approved by Planning Commission in principle on 18.10.2016 c) Feasibility consultant appointment in progress	June, 2020-Dec,2024
Total Cost (M US$)				1,045	2,672	3,717				
Total Cost (Crore BDT)				8,154	20,839	28,992				

Source: PGCB

(2) Issues identified

PSMP2016 identified the following issues regarding the development of the power transmission system in Bangladesh.

- Power Supply-Demand Imbalance among the Regions
  The power interconnections to neighboring countries, the seaports for importing fuel and the mining points for domestic coal/gas will be scattered around the country, causing regional energy imbalance and requiring power trades among the regions. These kinds of trends seem to have enhanced and further transmission lines for regional connections will be needed from the mid and long-term points of view.
- Power Imports and Exports via Interconnections
  Power imports from hydropower stations in neighboring countries such as India, Bhutan or Nepal are planned, in consideration of the possibility of obtaining an economical energy supply due to the shortages in the domestic gas supply, and of broadening the energy sources for Bangladesh. Information regarding interconnections will be collected and a related detailed power system analysis will be carried out.
- Transmission Lines Crossing Rivers
  There will be a restriction of power flows between the eastern and western sides of the country because Bangladesh has two large rivers in its center, Jamuna and Padma, with widths of 4.5km to 6km even at their narrowest points. It would entail much cost to construct power transmission lines across these large rivers.
  A bridge across the Padma River was designed in detail in 2010 and the contractors that are currently undergoing selection will also construct the seven bases of towers for the 400kV transmission line connecting Khulna to Dhaka, located at its downstream side. Their construction method may be applied for other river crossing transmission lines in Jamuna and Padma.
- Optimal operation planning for power system
  Improvement of power supply reliability and economic merits are expected to occur through local power systems connecting to each other. However, new issues such as concerns about accident impacts from weak points in the system upon the whole system, and the necessity of different know-how for operating a large, country-wide connection system will be created. Countermeasures for the issues will be discussed and examined with the relevant counterparts.

PGCB has already taken the initiative of strengthening the capacity of the transmission network, and some projects have been supported by international development agencies such as the Dhaka-Chittagong transmission line project, which is financed by an ODA yen-loan.

However, as shown in PGCB's long-term projection, the power demand in the country is expected to grow rapidly and further upgrading and modernizing of its transmission network system will become necessary. To meet this, not only grid expansion within the country but also the development of cross-border interconnections need to be in place within an appropriate timeframe.

Table 2-5 Maximum power demand forecast at PGCB's 132 kV substations

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Comilla	1,170	1,307	1,466	1,642	1,842	2,045	2,283	2,525	2,788	3,033	3,313
Chittagong	1,017	1,134	1,318	1,449	1,591	1,743	1,910	2,071	2,257	2,405	2,618
Khulna	1,341	1,453	1,596	1,747	1,943	2,141	2,354	2,602	2,791	2,988	3,212
Bogra	1,473	1,617	1,783	1,981	2,191	2,398	2,615	2,833	3,055	3,293	3,505
Dhaka	1,869	2,106	2,334	2,589	2,954	3,286	3,629	3,943	4,279	4,589	4,903
DESCO	956	1,058	1,230	1,367	1,483	1,647	1,795	1,958	2,140	2,374	2,578
DPDC	1,510	1,675	1,934	2,101	2,321	2,581	2,868	3,173	3,535	3,880	4,242
Total	9,336	10,350	11,660	12,874	14,325	15,841	17,454	19,106	20,844	22,562	24,370

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Comilla	3,565	3,824	4,053	4,337	4,573	4,746	4,925	5,088	5,258	5,434
Chittagong	2,823	3,009	3,208	3,367	3,534	3,695	3,856	4,024	4,200	4,385
Khulna	3,407	3,595	3,805	4,036	4,262	4,424	4,557	4,712	4,865	5,024
Bogra	3,718	3,936	4,161	4,374	4,588	4,759	4,922	5,087	5,259	5,435
Dhaka	5,200	5,547	5,901	6,247	6,606	7,003	7,336	7,657	7,993	8,346
DESCO	2,807	3,032	3,274	3,580	3,853	4,081	4,326	4,565	4,818	5,089
DPDC	4,723	5,139	5,558	6,003	6,450	6,885	7,274	7,659	8,056	8,490
Total	26,243	28,082	29,960	31,943	33,866	35,593	37,195	38,793	40,449	42,203

Source: PSMP2016 Final Report

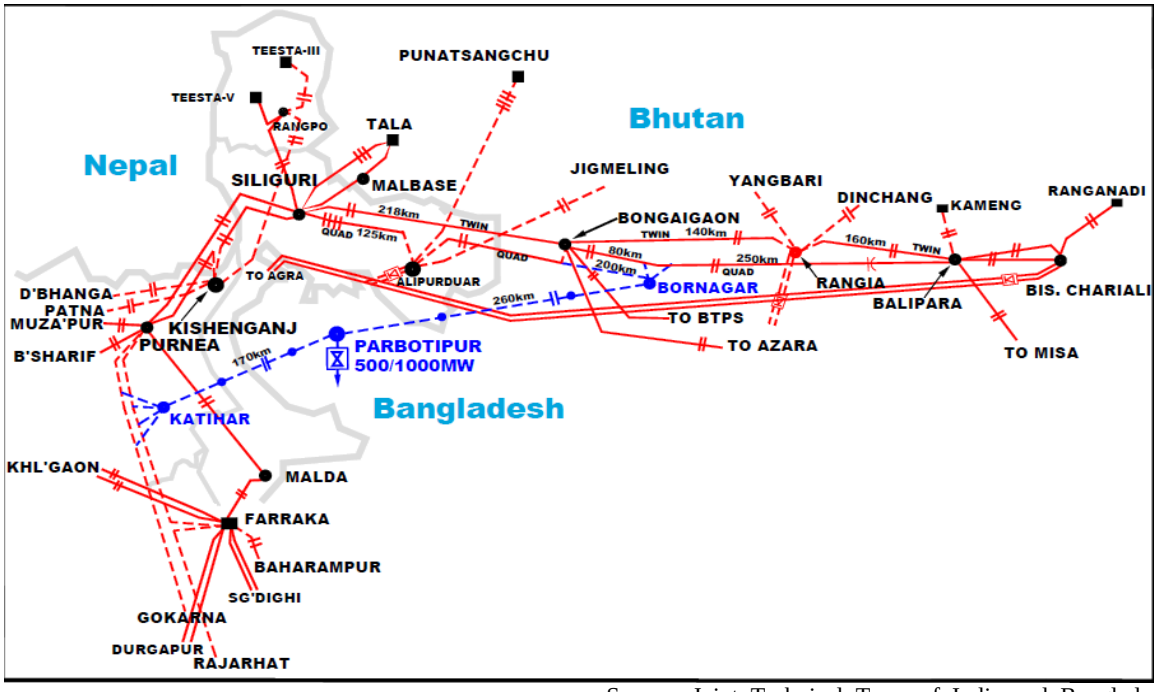
(3) Cross-border Grid Interconnections

In the power demand-supply projection in PSMP2016, Bangladesh is expected to increase its power imports from neighboring countries up to 14,000MW (maximum scenario), or at least to 9,000MW (minimum scenario) by 2041. To meet this, both cross-border grid interconnections and hydropower generation facilities in neighboring countries (India, Nepal, Bhutan) need to be developed to feed the energy demand in Bangladesh.

At present (as of November 2018), Bangladesh's power transmission system has two cross-border interconnections with India. One is an HVDC (high-voltage direct current) double-circuit interconnection from Bheramara in the west to Baharampur in India, which has a capacity of 1,000MW (500MW x 2). The other is the interconnection from Comilla North in the east to Surajmaninagar in India, with a capacity of 100MW, for importing power from India. There are plans to install a back-to-back AC/DC converter in the same place to increase the interconnection capacity to 500MW. This project is supported by the Asian Development Bank (ADB) and the bidding process is underway. This project is expected to be completed within three years.

In addition, PGCB is planning to develop a new grid interconnection in the northern region. The interconnection plan, which would connect with India at both the eastern and western sides of Bangladesh using 765kV lines, has already been discussed with the Indian counterpart.

According to PGCB's Interconnection Plan, if power imports from Bhutan are taken into account it is necessary to install a back-to-back substation at Barapukuria, where a 500MW AC/DC converter system will be installed at the first stage, with every addition of 500MW AC/DC converter unit at each stage of the upgrading.



Source: Joint Technical Team of India and Bangladesh "Report on the Feasibility of Additional Interconnection between India and Bangladesh" (July 2016)

Figure 2-4 Interconnection Plan in Northern Bangladesh

2.4.2 Power Distribution

(1) Power Distribution System Development Plan

By 2041, total distribution line length will reach 530,000 km. By 2021, 100% of the area will be covered by power distribution.

(2) Construction of underground Substations within Dhaka Metropolitan Area

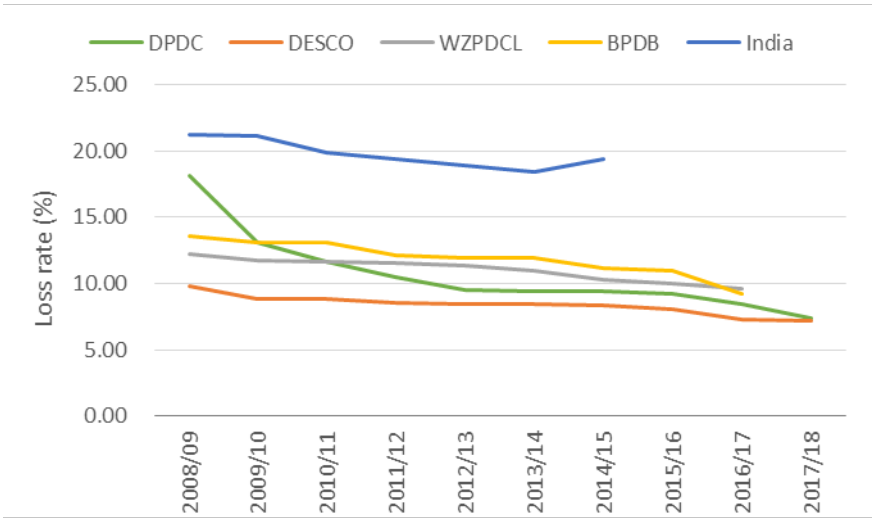
With JICA's cooperation, two UGSS, in Gulshan (DESCO) and Kawranbazar (DPDC area), are being built with a 360 MVA 132/33/11 capacity. PGCB will later construct a 230/132 kV UGSS and a 34-story commercial building will be constructed over the s/s.

(3) Rural Electrification Program

By June 2018, in 460 upazilas 80 PBS, a total of 397,000 km of lines and 837 substations, with a 9,775 MVA capacity, had been constructed, with 75,891 villages electrically connected. 325,000 irrigation pumps and 23,400,000 consumers of varying categories are connected. By August 5, 2018, 79 upazilas were 100% electrically connected. Another 460 upazilas will be 100% connected gradually.

(4) Distribution System Loss Reduction

The historical trends of the distribution system loss rate for each distribution company (discom) are shown in the following figure. In general, a gradually improving trend can be observed for each discom, reaching mostly below 10%. This can be evaluated as rather good performance considering that the distribution system loss rate is still as high as about 18%.



Source: Based on data provided by distribution companies in Bangladesh and World Bank statistics (India)

Figure 2-5 Historical trend of distribution system loss rate for each discom

The distribution system loss rate can be divided into technical loss, which arises from the current flow in the medium and low voltage distribution network, and non-technical loss, which is caused by end-consumer power pilferage, meter defects, and so on. In the service areas of DPDC and DESCO, where the loss rate reached as low as 7%, technical loss is considered to account for the majority of the total loss.

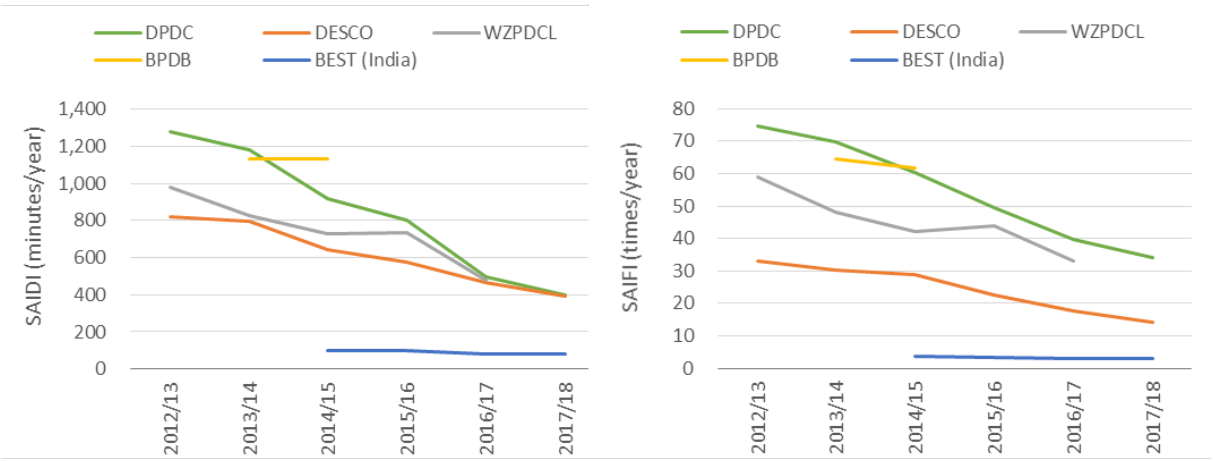
Theoretically, the technical loss increases in proportion to the square of the current, and also in proportion to the length of conductors. Therefore, a higher loss rate can be observed in heavily loaded distribution lines with large currents, and in long-length lines in low-voltage networks. Measures for reducing technical loss include reducing the number of heavily-loaded lines, long-length lines and low-voltage lines. For medium voltage networks, installation of new distribution substations and load reallocation/levelization among the network can be a solution. For low-voltage networks, installation of new transformers and conversion of single-phase lines into three-phase lines are considered effective solutions.

Solutions for reducing the non-technical loss vary depending on the causes, but it must first be identified where the non-technical loss occurs and how much it is. The first step to be taken is to install a metering device at the secondary side of each transformer to measure the gap between the energy sent from the transformer and the sum of the metered energy consumption of consumers connected to that transformer. Then, focusing on the transformers that recorded a high gap, the second step is to identify the reason for this gap and to take appropriate measures.

(5) Improving Power Supply Reliability

In general, the reliability of a power distribution network is measured by the indicators SAIFI (System Average Interruption Frequency Index), which is the average number of blackouts for each consumer, and SAIDI (System Average Interruption Duration Index), which is the average duration of blackouts for each consumer. The historical SAIFI and SAIDI trends for each distribution company (discom) are shown in the following figure.

Like the distribution system loss rate, a declining trend can be observed, which indicates that the system reliability has improved. However, compared with the performance of Brihanmumbai Electric Supply and Transport (BEST) Undertaking, which supplies electricity in India's Mumbai area, both SAIFI and SAIDI still remain at a high level and this indicates that there is still room for further improvement.



Source: Based on data provided by distribution companies in Bangladesh and the website of BESCOM (India)

Figure 2-6 Historical trend of SAIFI (left) and SAIDI (right) for each discom

Taking measures for improving power supply reliability cannot easily be justified in terms of the economic benefit for the discom against the costs, but intangible benefits can be considerable because reliability strongly contributes to customer satisfaction. In the Annual Performance Agreement, the Managing Director of each discom makes a commitment to the Secretary of the Power Division on targets for SAIFI and SAIDI.

Solutions for improving the power supply reliability can be roughly divided into the following types.

(a) Preventing the occurrence of accidents (blackouts)
(b) In the case of an accident, minimizing its effect
(c) Taking measures for immediate restoration from accidents

Examples of solutions for each of these are described below.

- Preventing the occurrence of accidents (blackouts)
  Reducing the exposure of overhead conductors to the causes of damage to the appliance, such as flying objects, tree contact and salt damage, is an effective solution in order to reduce the probability of accidents. Application of insulated conductors and replacement with appliances that have limited conductor exposure can be considered.
  In addition, as a solution for reducing blackouts caused by line work (though not accidents), carrying out uninterrupted line work by installing a temporary bypass line is worth considering.
- In the case of an accident, minimizing its effect
  The typical distribution network configuration in Bangladesh, especially in rural areas, is a radial network where feeder lines are not interconnected with each other. In this network, once an accident occurs on a feeder, power supply to all the consumers downstream from the fault point has to be suspended. If an interconnection among feeders were established, only the fault point on a feeder would be isolated in the case of an accident so the power supply to the other parts on the feeder can be maintained. By doing this, the areas affected by the accident can be minimized.
  In addition, implementation of a distribution automation system that can control the switching automatically can shorten the time for minimizing the affected areas.
- Taking measures for immediate restoration
  Quick detection of the fault point is the most effective solution for reducing the duration of power outages with minimum cost. Introducing a remote-control system and appliances to identify the damaged part of the feeder within as narrow an area as possible help reduce the time needed for line workers to detect fault points in the field.

2.5 Revisiting PSMP2016 (Periodic Update of PSMP based on PSMP2016)

2.5.1 Background

The Government of Bangladesh has fixed a target to become a high-income country by 2041. The development of energy and power infrastructure is therefore very important for the long-term economic development of the country. The draft Power System Master Plan (PSMP) 2016, which is JICA-financed, has been prepared in an attempt at formulating a comprehensive energy and power development plan up to the year 2041, covering energy balance, power balance and tariff strategies. The new PSMP study considers all the challenges and offers feasible and implementable proposals and action plans for Bangladesh. Many of the power plants in Bangladesh cannot achieve commercial operation within the stipulated time due to a variety of reasons. Moreover, some existing power plants cannot generate electricity as specified in terms of power, thermal efficiency etc. for each unit. As a result, the shortage of power means that facilities are not allowed to stop and undertake periodic maintenance in a planned way. In order to secure an uninterruptible electricity supply, it is necessary to find solutions to all of these issues and to establish a comprehensive institutional framework. With this backdrop, the Power Division decided to revisit the targets for generation and transmission depicted in the PSMP2016. Regional balances, fuel diversification, distribution infrastructure, demand side management, investment and generation cost issues will have to be addressed during examination of the PSMP2016.

2.5.2 Implementation framework

The committee has organized a series of formal meetings and discussions with different sector entities and stakeholders to discuss and examine the targets and related data in order to ascertain demand and set a realistic target for power generation capacity. Future demand forecasts and power generation plans from distribution and generation entities are considered. In revisiting PSMP2016 up to 2041, for development of power generation, transmission and distribution an “Integrated Power Development Plan” committee is formed, as follows.

1. Additional Secretary (Planning), Power Division - Convener
2. Member, Renewable Energy, SREDA - Member
3. Joint Secretary (Development), Power Division - Member
4. Joint Chief, Power Division - Member
5. Director General, Power Cell - Member
6. Member (Generation), BPDB - Member
7. Member P&D, BPDB - Member
8. Member P&D, BREB - Member
9. Executive Director, P&D, PGCB - Member
10. Executive Director, Eng., DPDC - Member
11. Executive Director, Eng., DESCO - Member
12. Executive Director, Eng., EGCB - Member
13. Executive Director, Eng., NWPGCL - Member
14. Executive Director, Eng., APSCL - Member
15. Executive Director, P&D, CPGCL - Member
16. Executive Director, Eng., WZPDCL - Member
17. Executive Director, Eng., RPCL - Member
18. Director, P&D, NWZPDC L - Member
19. Chief Engineer, System Operation, PGCB
20. Director, System Planning, BPDB - Member Secretary

2.5.3 Scope of Work for the Committee:

1. Distribution company-wise, area-wise power demand forecast (load demand) up to 2041
2. Prepare an Integrated Power Development Plan keeping in mind energy efficiency and

conservation, demand side management etc. in line with the 2041 projected power capacity, by maintaining required redundancy provisions.
3. Year-wise renewable energy and power import projection preparation
4. Year-wise projection of fuel mix preparation

2.5.4 Revisited Target - 2041

The Revisiting PSMP2016 will soon be approved by the Power Division. Therefore, the JICA survey team would like to obtain such data after official approval of the document.

2.6 Primary Energy Supply & Demand

2.6.1 Updates on LNG Imports in Bangladesh

The Government of Bangladesh has entered into contracts with three different suppliers of LNG.

Table 2-6 LNG import contracts

Qatar	RasLaffan Liquefied Natural Gas Company	2.5 million tons/year
Oman	Oman Trading International	1 million tons/year
Indonesia	Pertamina	17.5 million tons/year (expected)

Source: JICA Survey Team

Other than the above, Astra Transcor Energy (Switzerland) and Gunvor (Singapore) have signed separate MoUs with Petrobangla to provide mid-term contracts. Supply from the LNG Spot Market is also being considered and 29 companies have been enlisted.

For regasification facilities, there are two floating storage and regasification units (FSRUs): one in operation and the other under construction. The first FSRU, operated by Excelerate Energy, completed its test run on August 13, 2018 and the first connection of 100 mmcfd to the national gas grid (Chattogram City Ring Main distribution system) occurred on August 16, 2018. Since September 2018, 300 mmcfd of LNG has been supplied into the Chattogram system. The baseload capacity of the FSRU is 500 mmcfd, but such a large volume cannot be supplied at this moment due to the non-completion of horizontal directional drilling work for a 42-inch diameter gas transmission pipeline from Anwara to Faujdarhat, crossing the Karnaphuli River.

Table 2-7 FSRU projects

Terminal operator	Location	Capacity	Project type	Years	Commissioning schedule
Excelerate Energy	Moheshikali	500 mmcfd (3.5 million ton/year)	BOOT (build, own, operate, transfer)	15 years	Aug/2018
Chuna	Moheshikali	500 mmcfd (3.5 million ton/year)	BOOT (build, own, operate, transfer)	15 years	1st quarter/2019 (expected)

Source: JICA Survey Team

According to Petrobangla, there will be no more permissions for FSRUs. With the first case of FSRU, LNG was not supplied in a timely manner due to unexpected sea turbulence during the monsoon season and subsea pipeline leakage problems. Lack of human capacity at relevant organizations such as Petrobangla, RPGCL and GTCL was also pointed out. All the FSRU projects in the pipeline are likely to be dissolved. If no more FSRUs are constructed, land-based terminals will be the only solution. Upcoming land-based terminals are summarized in the table below.

Table 2-8 Land-based LNG terminal projects

Terminal operator		Location	Capacity
Petronet	India	Kutubdia	1,000 mmcfd (7.0 million tons/year)
China Huan Qiu Contracting & Engineering Corporation (HQC)	China	Maheshkhali	1,000 mmcfd (7.0 million tons/year)
SembCorp	Singapore	Maheshkhali	1,000 mmcfd (7.0 million tons/year)

Source: JICA Survey Team

2.6.2 Gas Sector Master Plan 2017

(1) Overview and Current Status

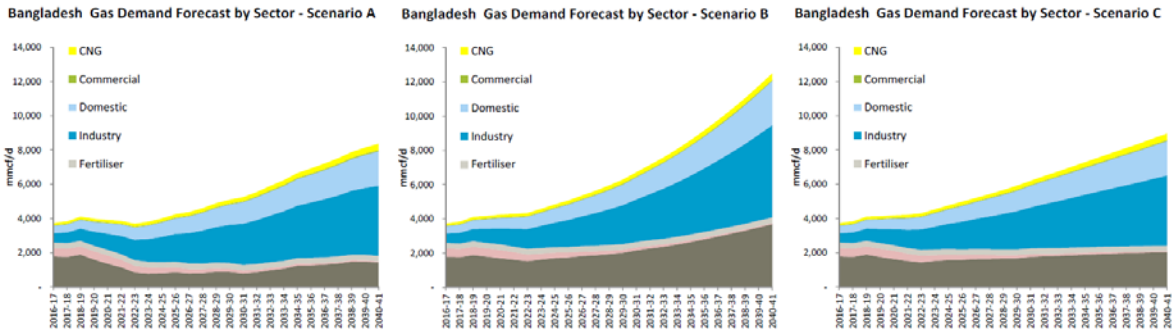
The Bangladesh Oil, Gas and Mineral Corporation (Petrobangla) and the Power Cell under the Power Division of MPEMR jointly entrusted the Denmark-based consulting group Ramboll to prepare a new masterplan for the gas sector called "Gas Sector Master Plan (GSMP) Bangladesh 2017". This masterplan is to revise the existing Gas Sector Master Plan Bangladesh 2006" and provides the long-term projection of gas supply and demand up to 2041 in the place of existing masterplan that was targeting 2025.

This masterplan study was financed by the World Bank as a part of Rural Electrification and Renewable Energy Development II (RERED II) project. The World Bank provided the find to the Power Cell and the Power Cell selected the consultant to undertake the study. This study credits Petrobangla as the co-owner of this study, but according to Petrobangla, its role was to provide data for analysis and comments on the output upon request. The Petrobangla officer who met the JICA study team explained that Petrobangla reviewed the supply and demand projection of natural gas up to 2041 upon receiving the draft study report, but that this does not necessarily mean that this projection conforms to Petrobangla's business plan.

(2) Demand Projection

The draft final report of GSMP2017 was prepared in July 2017 and, after about half a year of revision, the final report that was completed in February 2018. A significant change from the draft final report to the final report is the downward revision of gas demand projection. As a result, the future gas demand projected in GSMP2017 has neared that of PSMP2016.

The draft final report of GSMP2017 provided three scenarios of demand projection; A: base scenario (similar to PSMP2016), B: high growth scenario, and C: climate scenario, as seen in the following figure. This draft final report recommends using Scenario B, where the gas demand in 2041 reaches about 12,000 mmcfd,



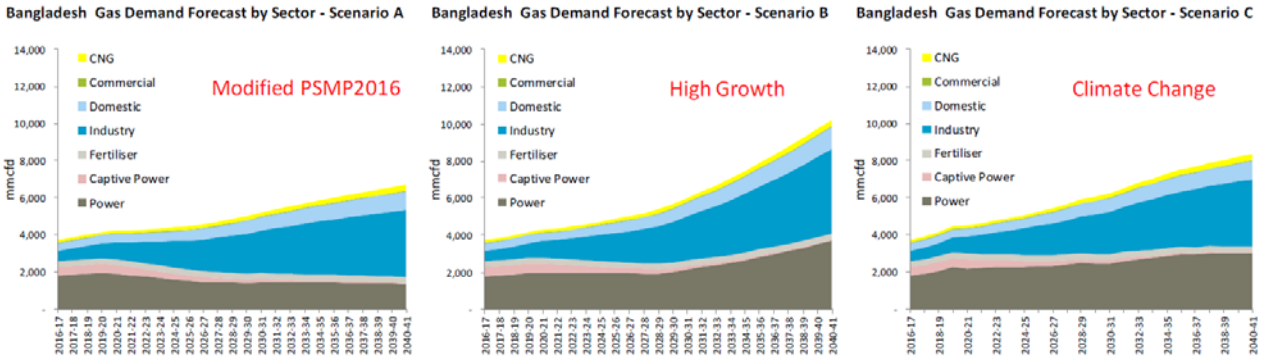
Source: GSMP2017 Draft Final Report

Figure 2-7 Three scenarios of gas demand projection in GSMP2017 Draft Final Report

There are two reasons why this scenario's gas demand projection in 2041 is doubled from that of PSMP2016. One reason is that this scenario assumes that the GDP will grow constantly at 7% p.a. until 2041, whereas PSMP2016 sees the growth rate getting moderate from mid-2020s (average of the entire period: 6.1% p.a.). Another reason is that this scenario takes into account that "no firm policy has been implemented with respect to other fuels, coal, nuclear and renewable (solar, wind, bio)" and assumes that the country's energy supply will continue to be highly dependent on natural gas.

The final report of GSMP2017, which was revised following the consultation with local stakeholders, also provided three scenarios of demand projection with the same name; A: base scenario (similar to PSMP2016), B: high growth scenario, and C: climate scenario. However, the gas demand projection of each scenario was revised downwards and the gas demand in 2041 is about 6,000 mmcfd in Scenario A, about 10,000mmcfd in scenario B, and about 8,000 mmcfd in Scenario C.

The total demand in Scenario A is almost as high as that in PSMP2016, though its sector-wise breakdown is slightly different. This final report refers to Scenario C "as our basis", where gas demand projection is higher than that in Scenario A (and PSMP2016). The main reason is that this scenario assumes that share of coal for power generation will be more restricted and natural gas will be more utilized than Scenario A (and PSMP2016). Other than that, there is no critical difference in the assumptions of demand projection.

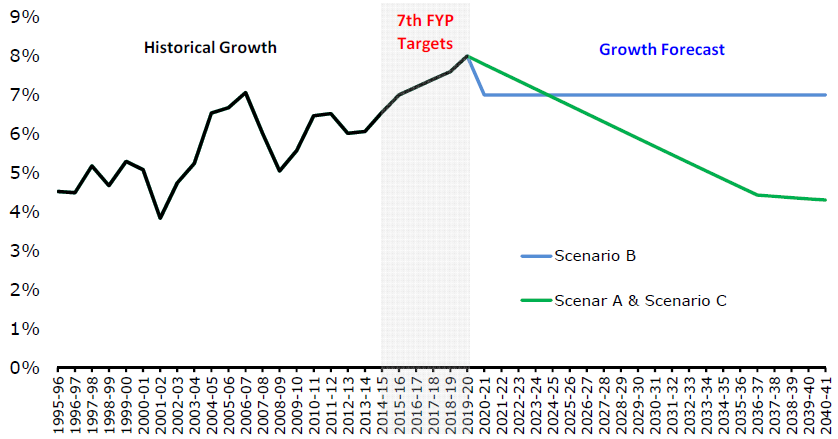


Source: GSMP2017 Final Report

Figure 2-8 Three scenarios of gas demand projection in GSMP2017 Final Report

Macroeconomic projection

Like PSMP2016, GSMP2017 also adopted to make a demand projection as the sum of sector-wise projection (power generation, industry, domestic, commercial, transport etc.) based on the GDP growth. Scenarios A and C assumes the GDP growth getting moderate, down from 8% p.a. in 2020 to 4.3% p.a. in 2041. This is a similar assumption to that of PSMP2016, which considers the growth rate getting moderate with the economy reaching certain level of maturity. Scenario B, in the meanwhile, assumes that Bangladesh economy continues growing constantly at 7% p.a., which means that the target growth rate of the Government's 7th Five-Year Plan will be maintained.

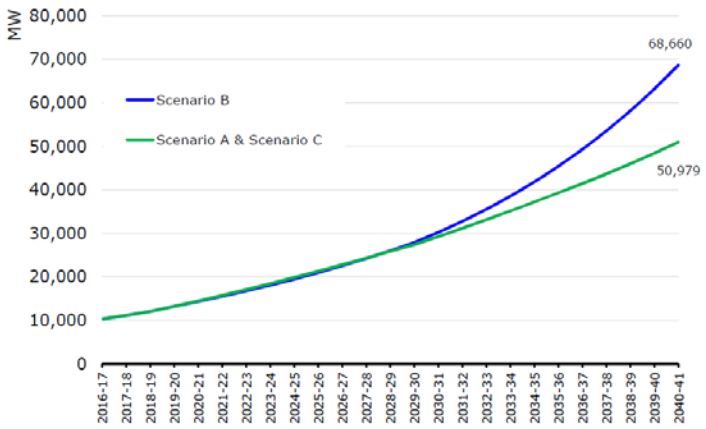


Source: GSMP2017 Final Report

Figure 2-9 Projection of GDP growth rate (real-base) in GSMP2017 Final Report

Projection of gas demand for power generation (power supply from the grid)

GSMP 2017 also adopts a similar methodology in projecting gas demand for power generation, that is, estimating the peak demand considering its elasticity against the GDP growth rate. In PSMP2016, the peak demand (total demand on the national grid) in 2041 is projected as 48,000 MW (low case) / 51,000 MW (base case) / 55,900 MW (high case). GSMP2017 sees the peak demand in 2041 to be 50,979 MW in Scenarios A and C, which is almost as high as PSMP's base case. The peak demand in Scenario B is 68,660MW, which is still more than 20% higher than that of PSMP's high case.



Source: GSMP2017 Final Report

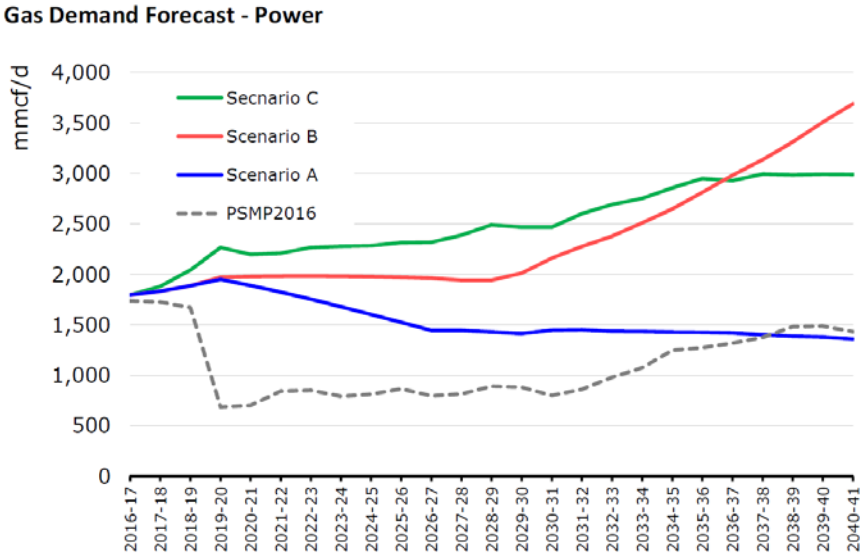
Figure 2-10 Power peak demand projection in GSMP2017 Final Report

A significant difference to be noted between GSMP2017 and PSMP2016 is the assumption of energy mix, i.e. share of natural gas in total power generation.

In Scenario A (base scenario), the total power demand is similar to that of PSMP, but the development of new coal-fired power plants will be delayed and existing low-efficiency gas-fired power generation will remain instead at least on a short- and mid-term basis. Therefore, gas demand for power generation will not decrease as drastically as expected in PSMP2016.

In Scenario B (high growth scenario), the total power demand will grow higher than that in Scenario A, but it will trigger earlier replacement of exiting gas-fired power generation with new high-efficiency power plants and hence the gas demand for power generation will remain almost constant until 2030.

In Scenario C (climate scenario), where the development of coal-fired power plants will be strictly controlled and substituted by gas-fired power plants gas demand for power generation will become the highest among three scenarios until mid-2030s.



Source: GSMP2017 Final Report

Figure 2-11 Projection of gas demand for power generation in GSMP2017 Final Report

Projection of gas demand for captive power generation

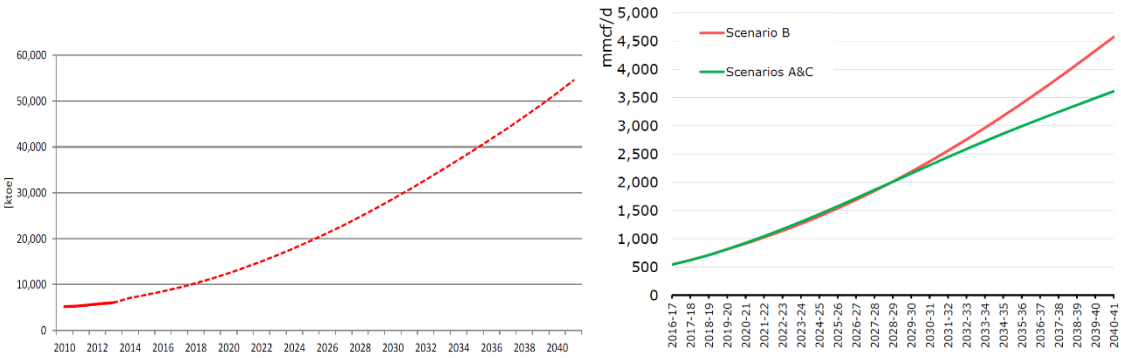
Gas demand projection for captive power generation that is mainly used by the industrial sector has no significant difference from that of PSMP2016.

Projection of gas demand for non-energy use

Gas demand for non-energy use, which is mainly the raw material for producing fertilizer, is supposed to be determined by the capacity of production plants, and GSMP2017 expects that the current level of gas demand, i.e. 316 mmcfd, will continue until 2041. PSMP2016 also assumes that the gas demand for fertilizer will remain constant.

Projection of gas demand for industrial sector

In GSMP2017, projection of the gas demand for industrial sector refers to “elasticity 2.05” against GDP growth rate, which was the average of actual performance from 2004 to 2014. According to the GSMP report, this elasticity is expected to decline gradually by 60% by 2041, considering the gas price hike and the advancement of energy efficiency. The gas demand in 2041 is 3,600 mmcfd in Scenarios A and C, whereas Scenario B sees 4,600 mmcfd reflecting the higher growth of GDP. PSMP projects a more moderate growth rate, about 2,300 mmcfd, assuming that the energy intensity of GDP, which has been increasing gradually in Bangladesh, will reach the maturity around 400 toe/million USD, referring to the historical trend in Southeast Asian countries.

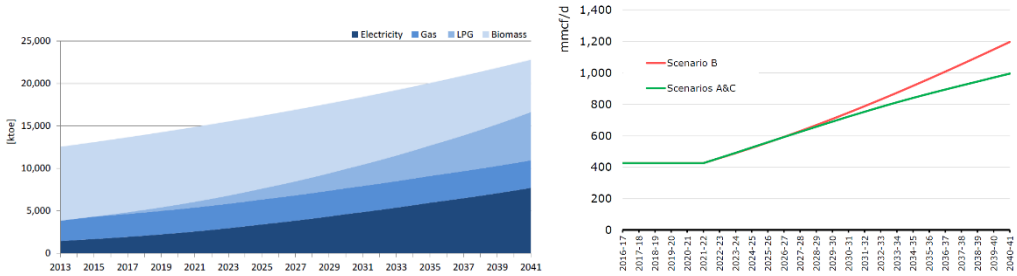


Source: PSMP2016 Final Report (left) and GSMP2017 Final Report (right)

Figure 2-12 Industrial sector demand: projection of total energy demand

Projection of gas demand for domestic sector

In GSMP2017, gas demand for domestic sector is expected to be constant until 2022, considering the government's decision to stop new connection of gas supply. The increased demand will be substituted by LPG. However, GSMP2017 assumes that new gas supply will resume afterwards, i.e. switching back from LPG, taking also into account the limited supply capacity of LPG, though the elasticity of gas demand against GDP will decline gradually towards 2041 reflecting the aging population and energy efficiency. PSMP2016, in the meanwhile, expects that gas demand for residential sector will grow only slightly, i.e. lower than GSMP2017, and that the increased demand will be mainly covered by LPG supply.

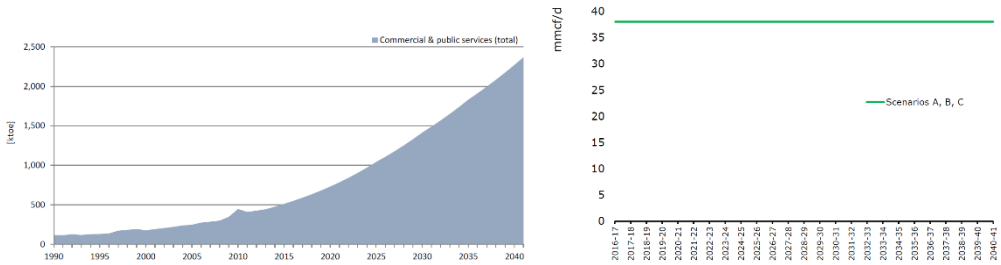


Source: PSMP2016 Final Report (left) and GSMP2017 Final Report (right)

Figure 2-13 Residential sector demand: projection of total energy demand

Projection of gas demand for commercial sector

GSMP2017 assumes that the gas supply for commercial sector will be constant towards 2041, considering that new connection for gas supply will be stopped and that increased gas demand will be covered by LPG. PSMP2016 sees that the gas demand will increase to follow the GDP growth and its demand projection is higher than that of GSMP. However, because the share of commercial sector in total gas demand is small, this difference does not affect the total gas demand significantly.

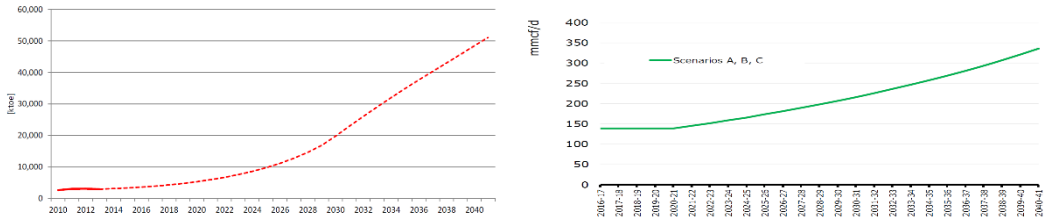


Source: PSMP2016 Final Report (left) and GSMP2017 Final Report (right)

Figure 2-14 Commercial sector demand: projection of total energy demand

Projection of gas demand for transport sector

GSMP2017 expects that the gas demand for transport sector will increase 2.4 times from 139 mmcfd to 335 mmcfd. Though the government currently suspends the conversion to CNG and recommends LPG instead, GSMP's projection assumes that CNG will need to increase because of the limited supply capacity of LPG and refers to the worldwide gas demand projection conducted by Exxon Mobile. PSMP2016 also assumes that CNG will also continue increasing and the expected growth rate is higher than that of GSMP. PSMP2016 considers that the motorization (car ownership) will grow rapidly from mid-2020s when the country's GDP per capita reaches 5,000 USD, referring to the past experience of emerging countries in south eastern Asia. This will exponentially accelerate the gas consumption for transport sector, which is expected to reach about 1,180 mmcfd in 2041.



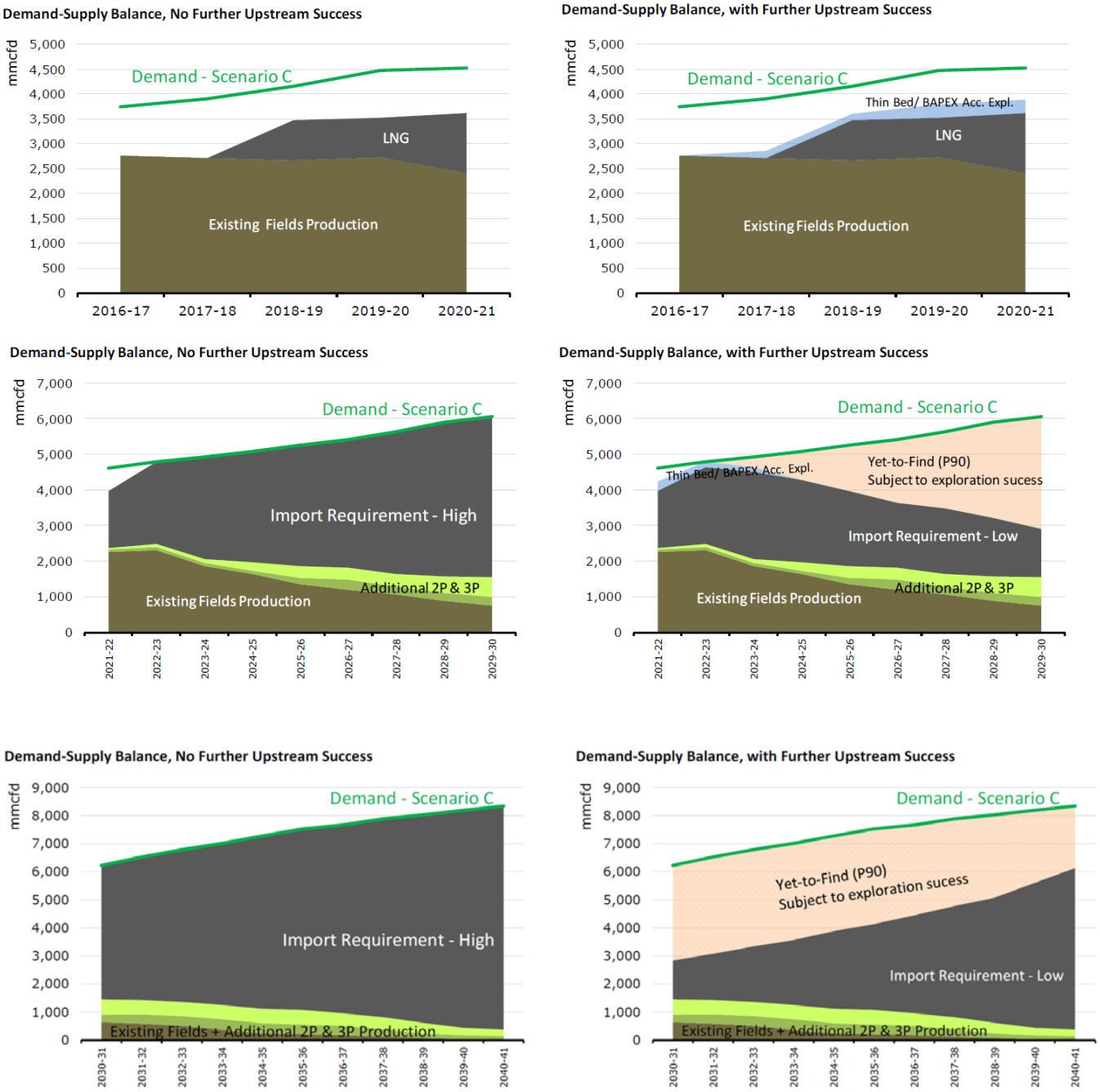
Source: PSMP2016 Final Report (left) and GSMP2017 Final Report (right)

Figure 2-15 Transport sector demand: projection of total energy demand

(3) Planned Gas Supply Projects

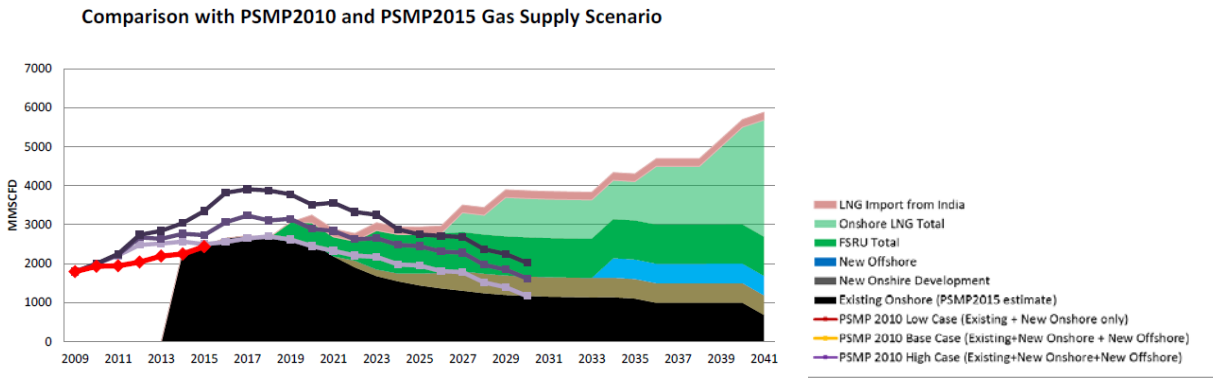
Gas supply scenario

In the GSMP2017, there are two scenarios for gas supply. The total supply in FY 2041 is around 8,000 mmcfd in the both scenarios. One scenario is "no further upstream success scenario" of which domestic gas production assumption is more or less similar to that of PSMP2016. On the other hand, the "with further upstream success" scenario assumes successful development of yet to find resources. Even in that scenario, the volume of imported LNG in FY2041 arises to 5,755 mmcfd.



Source: GSMP2017 Final Report

Figure 2-16 Gas supply scenario in GSMP2017

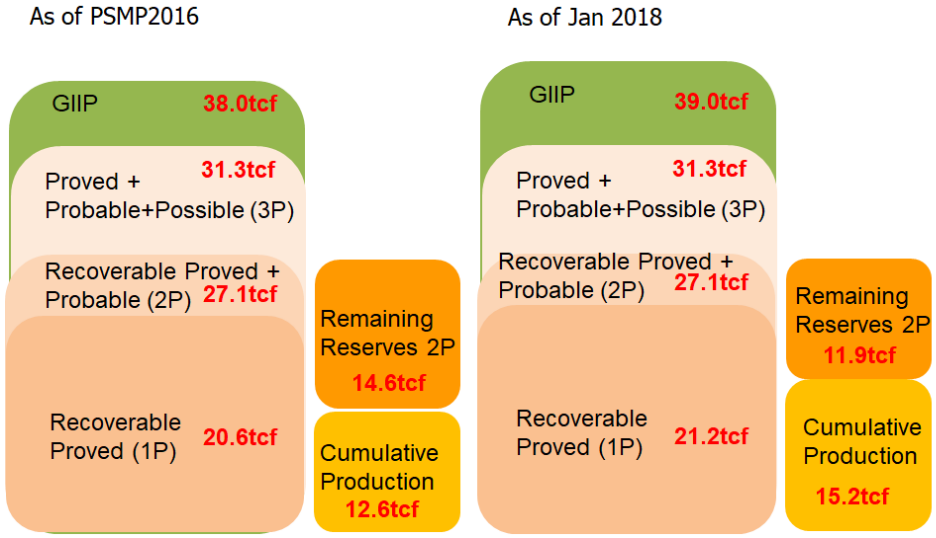


Source: PSMP2016 Final Report

Figure 2-17 Gas supply scenario in PSMP2016

Gas field development

According the latest news source[1], the GIIP estimate is slightly revised upward compared to that of PSMP2016.



Source: JICA Survey Team

Figure 2-18 GIIP estimates

The recent attempt to develop gas fields has been slowed down especially after 2000. Historically the International Oil Companies (IOCs) discovered more than 90% of the gas in Bangladesh, while the local ones still lack technological and financial capabilities. Today the government is not allowing IOCs in onshore areas and looks for joint venture partners with BAPEX. BAPEX, however, lacks managerial and technical capabilities and is likely to fail to meet the target to drill 108 wells (including 53 exploration wells) by 2021. As of now only three IOCs (ONGC, Santos-Kris and Posco-Daewoo) are working in 4 offshore blocks out of 48 blocks (26 onshore, 22 offshore). The capabilities of skilful IOCs need to be utilized in exploring further gas reserves.

Gas transmission pipeline

In anticipating more regasified LNG to be connected to the national gas grid, the enhancement of gas transmission pipeline is a prioritized issue. The ongoing projects of transmission pipeline is summarized in the table below.

[1] Energy and Power, Vol16, Isssu9, 16/Oct/2018

Table 2-9 Gas transmission pipeline development projects

Name of the project	Project period	Executing agency	Estimated cost (million BDT)	Fund source
Hatikumrul-Bheramara Gas Transmission Pipeline Project (30" x 98.10 km)	Jan/2006 to Jun/2018	GTCL	1,494.133	ADB
Bakhrabad-Siddhirganj Gas Transmission Pipeline Project (30" x 60 km)	Jul/2007 to Dec/2018	GTCL	8,497.00	WB
South-West Region Gas Distribution Network Project	Jan/2010 to Sep/2015	SGCL	6,000.00	ADB
Rehabilitation and Expansion of Existing Supervisory Control and Data Acquisition (SCADA) System of National Gas Grid under GTCL (Component-B of Bharamara Combined Cycle Power Plant Development Project)	Jan/2013 to Dec/2018	GTCL	2,940.04	JICA
Natural Gas Efficiency Project (Dhanua- Elenga and West Bank of Bangabandhu Bridge - Nalka Gas Transmission Pipeline) (30" x 52 km and 24" x 14 km)	Jul/2014 to Jun/2019	GTCL	9,791.80	JICA
Construction of Chattogram-Feni-Bakhrabad Gas Transmission Parallel Pipeline Project	Jul/2016 to Jun/2019	GTCL	19,623.80	ADB
Gas Transmission Capacity Expansion Project (Ashuganj-Bakhrabad) (30" x 61 km)	Jan/2010 to Dec/2017	GTCL	5,134.60	GoB
Construction of Moheshkhali-Anowara Gas Transmission Pipeline Project (30" x 91 km)	Jul/2014 to Jun/2018	GTCL	10,396.70	GoB
Construction of 20" x 1000 psig x 30 km Gas Transmission Pipeline from Sreepur to Joydevpur CGS	Jul/2013 to Jun/2018	TGTDCL	2,355.30	TGTDCL
Construction of Anowara-Fouzderhat Gas Transmission Pipeline Project	Apr/2016 to Jun/2018	GTCL	7,761.10	GTCL

Source: Petrobangla Annual Report 2017

The recent study conducted by JICA[2] reveals the following challenges facing the gas transmission.

- Drawings and documents are often missing.
- There is no universal design standard.
- To supply regasified LNG after blended with domestic natural gas, system integration/advanced control is required.
- To meet demand from gas fired power plants, gas demand profile by power plant and gas supply profile need to be phased in.

2.6.3 Sector-wise Policy of Gas Supply

Petrobangla developed Five Year Gas Supply Strategy (Year 2015- 2019). More recently in the annual report 2017, Petrobangla showed the sector wise gas demand forecast up to 2022. According to Petrobangla, mid- and long-term gas demand forecast should be in line with GSMP2017. For the short-term forecast, the demand in the fertilizer, commercial, domestic, tea-estate and CNG sectors remain the same. Especially for the commercial, domestic and CNG sectors, it is the government policy no to supply natural gas any longer. LPS is an alternative source of fuel.

[2] Nippon Koei and Chiyoda U-Tech (2018) “Data Collection Survey on Computerization of Gas and Power Network Infrastructure”

Table 2-10 Sector wise gas demand forecast (2017 to 2022)

Figures are in BCF

Sector	2017-18	2018-19	2019-20	2020-21	2021-22
Power	607	657	728	705	709
Captive	152	152	152	152	140
Fertilizer	98	98	98	98	98
Industry	191	253	321	366	390
Commercial	9	9	9	9	9
Domestic	133	133	134	133	133
Tea-Estate	2	2	2	2	2
CNG	41	41	41	39	34
Total	**1235**	**1346**	**1487**	**1505**	**1516**

Source : Production & Marketing Division, Petrobangla.

Source: Petrobangla Annual Report 2017

Through the discussion with Petrobangla, the survey team understood that there is no distribution priority policy in Petrobangla. In supplying the limited amount of natural gas, there might be useful to conduct a study on price elasticity/willingness to pay among different sectors.

2.6.4 Oil & LPG Supply

The demand for petroleum products has been rapidly increasing. Sales of the petroleum products by Bangladesh Petroleum Corporation (BPC), the national oil products marketing company, is shown in the table below. The dominant product is diesel, in addition to sales from BPC, the private sector directly imports petroleum products for their own use. LPG is also imported and distributed by the licensed private companies. It is reported that 2.0 million ton of petroleum products is imported annually through the private channel[3].

Table 2-11 Sales of Petroleum Products in the last 5 years

(Unit: ton)

Product	2013-14	2014-15	2015-16	2016-17	2017-18
JetA-1	323,327	338,829	347,323	376,700	408,272
HOBC (High Octane Blending Component)	117,452	126,114	147,557	186,911	230,280
MS (Motor Spirit, Petrol)	178,674	166,823	137,360	232,359	284,668
SKO (Superior Kerosene Oil)	289,871	263,029	213,685	170,993	138,403
HSD (High speed Diesel)	3,242,554	3,396,061	3,606,404	4,000,044	4,835,712
LDO (Light diesel)	1,064	2,666	2,758	660	96
JBO (Jute Batching Oil)	23,538	18,729	16,859	17,133	17,910
FOHS (Furnace Oil)	1,202,505	906,771	711,889	806,440	925,150

[3] Energy and Power, Vol16, Isssu8, 1/Oct/2018

Product	2013-14	2014-15	2015-16	2016-17	2017-18
LUBE (Lubricant)	17,823	17,869	17,445	18,752	19,812
SBPS (Special Boiling Point Solvent)	368	234	207	865	1,993
MTT (Mineral Turpentine)	7,821	7,038	2,037	6,475	10,338
LPG	17,529	17,424	16,050	16,370	16,303
BITUMEN	62,440	59,836	36,446	55,028	59,399
Total	5,484,966	5,321,423	5,256,020	5,888,730	6,948,336

Source: JICA Survey Team

BPC has been working on some projects to reduce costs of and secure the increasing flow of imported petroleum products. One is a single mooring project at Kutubdia to reduce transshipping costs in sea ports. Another is the construction of liquid fuel pipeline. So far, a feasibility was conducted for pipeline between Chottorgram and Dhaka. Another project to construct 130 km pipeline from Numaligarth (India) to Parbatripur has been initiated mainly to meet demand in agricultural sector during irrigation season in the northern region.

Chapter 3 Financial Assistance from International Development Agencies

3.1 Variations of Financial Schemes

3.1.1 Outline of Financial Instruments for Infrastructure Development

Financial resources from Japan to secure necessary funds for implementing infrastructure development projects in developing countries can be roughly classified into the following three schemes.

- ODA (Official Development Assistance) funds, to be provided as ODA loan or grant aid;
- Export credit by JBIC, co-financed with Japanese commercial banks; and
- Corporate finance by Japanese commercial banks.

The brief outline of these finance schemes is shown below. In the following diagrams, “Petrobangla” is used as an example of “Borrower” or “Implementing Agency”.

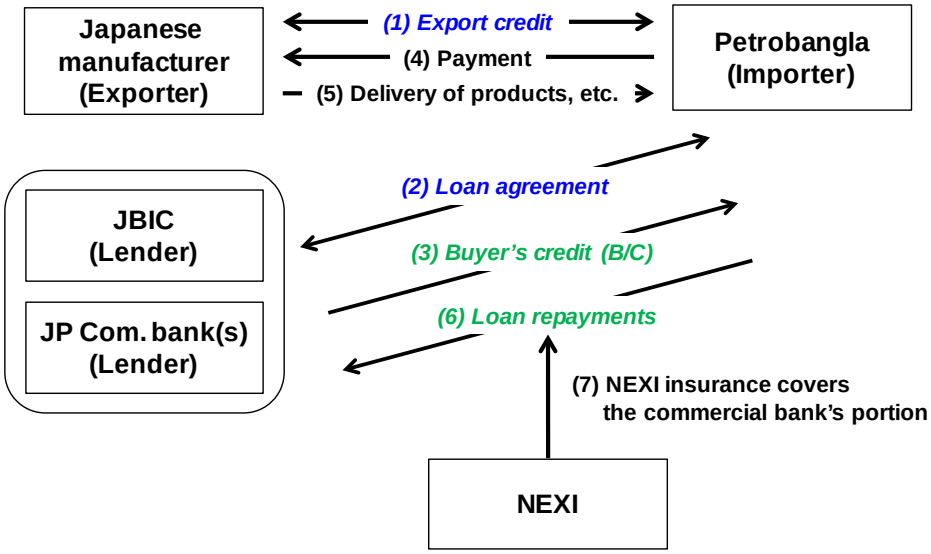
Table 3-1 Finance schemes provided from Japan

scheme		Japanese agency etc.	Description
ODA assistance	ODA loan	JICA	Concessional loan
	Grant aid	JICA	No repayment obligation
Export credit (Buyer’s credit, Commercial bank loans)		JBIC / NEXI, Japanese commercial bank(s)	Co-finance by JBIC and commercial banks. Commercial banks’ tranche will be enhanced by NEXI’s export credit insurance.
Corporate finance		Japanese commercial bank(s)	Ordinary corporate finance for high feasibility projects.

Source: JICA Survey Team

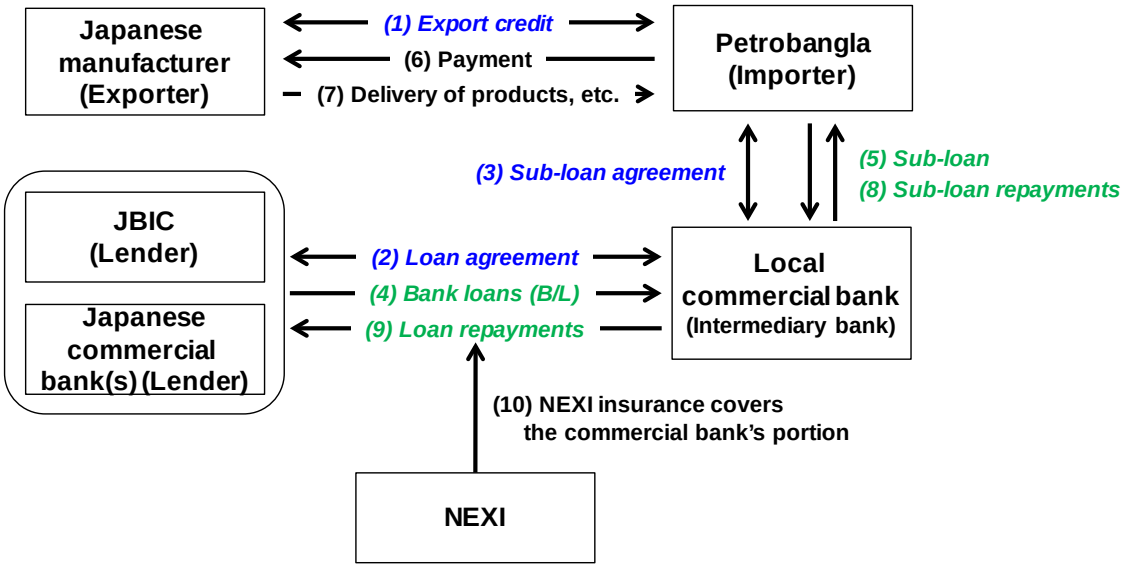
Source: JICA Survey Team

Figure 3-1 Finance scheme of ODA loan



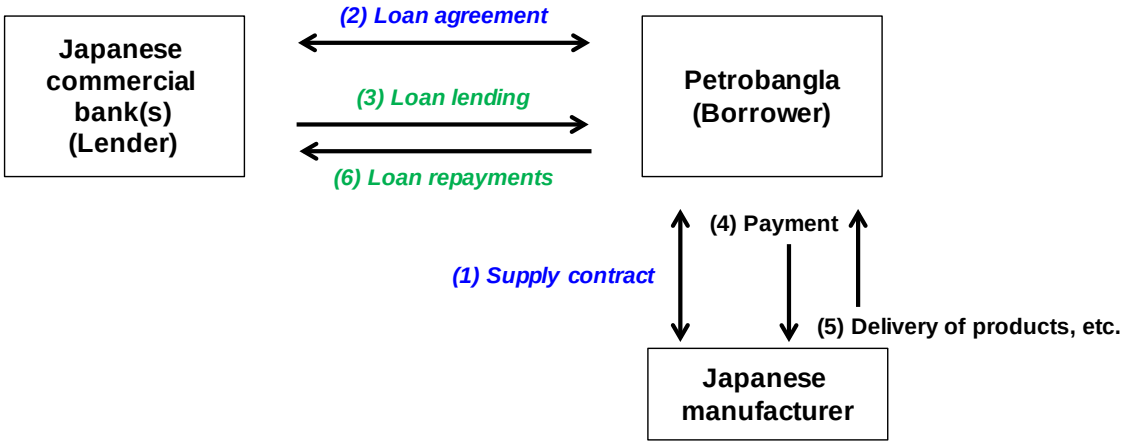
Source: JICA Survey Team

Figure 3-2 Finance scheme of export credit (buyer’s credit)



Source: JICA Survey Team

Figure 3-3 Finance scheme of export credit (bank Loan)



Source: JICA Survey Team

Figure 3-4 Finance Scheme of Corporate Finance

3.1.2 OECD Guidelines

OECD (Organization for Economic Co-operation and Development) Guidelines mean "Arrangement on Officially Supported Export Credits" which is a gentleman agreement with a purpose of avoiding too excessive competition by export credit agencies when they provide credit, insurance or guarantee to developing countries. OECD guidelines thus stipulate minimum premium rate, down payment, maximum repayment period, minimum fixed interest rates, repayment terms and so on.

Participating countries to Guidelines are Australia, Canada, EU, Japan, Korea, New Zealand, Norway, Swiss and United States. There should not be much difference of conditions, therefore, among companies from these participating countries, when they propose officially supported export credits to be applied for financing infrastructure project. Non-participating countries of newly developing economies, namely China, can determine different export credit conditions without any restriction from OECD Guidelines. It is not indeed very easy to know the real and exact conditions of Chinese export credit, even though they comply artificially with Guidelines, since other official assistance may be

provided in connection with the export of infrastructure project.

Table 3-2 Export Credit Agencies of Japan, Korea and China

	Japan	Korea	China
Name of Export Credit Agency	Japan Bank for International Cooperation (JBIC)	Export-Import Bank of Korea (KEXIM)	Export-Import Bank of China (EIBC)
Name of Insurance Agency	Nippon Export and Investment Insurance (NEXI)	Korea Trade Insurance Corporation (KSURE)	China Export & Credit Insurance Corporation (SINOSURE)

Source: JICA Survey Team

3.1.3 Financial Assistance by Japan International Cooperation Agency (JICA)

(1) ODA Loan (Yen Loan)

ODA loans (Yen loans) have been provided to over 100 countries and areas in the world, namely to Asian countries with which Japan has strong geographical and historical relations, in order to finance socio-economic development projects including power plant construction. An ODA Loan with a long repayment period and a very low interest rate is qualified as a concessional loan, requiring, however, borrowing countries to secure efficient use and management of borrowed funds as well as appropriate discipline of project supervision. With a repayment obligation, ODA Loan places relatively small financial burden on the Japanese government, thus becoming a long-term sustainable financial instrument for developing countries.

Interest rates of ODA loans are determined taking into account various elements, namely GNI per capita of the borrowing country. Categories of developing countries are shown below in Table 5-2. As of November 2018, Bangladesh is classified among Low-income countries (GNI per Capita less than 1,025 US$) and conditions in Table 5-3 will be applied to ODA Loans to Bangladesh.

Table 3-3 Potential loan recipient countries by income categories (FY 2017)

Category	GNI per Capita (2015)	Countries
Least Developed Countries	less than US$1,025	Afghanistan, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Mozambique, Myanmar, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Tanzania, Togo, Uganda
Low-Income countries		Angola, Bangladesh, Bhutan, Cambodia, Djibouti, Equatorial Guinea, Kiribati, Laos, Lesotho, Mauritania, San Tome and Principe, Solomon Islands, Sudan, Timor-Leste, Tuvalu, Vanuatu, Yemen, Zambia, Zimbabwe
Lower-Middle-Income Countries	US$ 1,026 - US$ 4,035	Armenia, Bolivia, Cameroon, Cape Verde, Republic of Congo, Cote d'Ivoire, Egypt, El Salvador, Ghana, Guatemala, Honduras, India, Indonesia, Kenya, Kosovo, Kyrgyz Republic, Micronesia, Moldova, Mongolia, Morocco, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Samoa, Sri Lanka, Swaziland, Syria, Tajikistan, Tunisia, Ukraine, Uzbekistan, Viet Nam
Upper-Middle-Income Countries	US$ 4,036 - US$ 12,475	Albania, Algeria, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, Fiji, Gabon, Georgia, Grenada, Guyana, Iran, Jamaica, Jordan, Kazakhstan, Lebanon, Libya, Macedonia, Malaysia, Maldives, Marshall Islands, Mauritius, Mexico, Montenegro, Namibia, Palau, Panama, Paraguay, Peru, Romania, Saint Lucia, Serbia, South Africa, St. Vincent and the Granadines, Suriname, Thailand, Tonga, Turkmenistan, Turkey

Source: JICA Annual Report 2017

Table 3-4 Conditions of ODA Loans to Least Developed Countries and Low Income Countries

Category and GNI Per Capita (2015)	Terms	Fixed / Floating	Standard/ Option	Interest Rate(%)	Repayment Period (years)	Grace Period (Years)	Condition for Procurement
Least Developed Countries and Low Income Countries (less than US$ 1,025)	General Terms	Floating	Longer Option	¥LIBOR +45bp	40	12	Untied
			Standard	¥LIBOR +35bp	30	10	
			Option 1	¥LIBOR +30bp	25	7	
			Option 2	¥LIBOR +25bp	20	6	
			Option 3	¥LIBOR +20bp	15	5	
		Fixed	Standard	1.00	30	10	
			Option 1	0.85	25	7	
			Option 2	0.70	20	6	
			Option 3	0.50	15	5	
	Preferential Terms	Floating	Longer Option	¥LIBOR +35bp	40	12	Untied
			Standard	¥LIBOR +25bp	30	10	
			Option 1	¥LIBOR +20bp	25	7	
			Option 2	¥LIBOR +15bp	20	6	
			Option 3	¥LIBOR +10bp	15	5	
		Fixed	Standard	0.90	30	10	
			Option 1	0.75	25	7	
			Option 2	0.60	20	6	
			Option 3	0.40	15	5	
	Preferential Terms for High Specification	Fixed	Standard	0.25	30	10	Untied
			Option 1	0.20	25	7	
			Option 2	0.15	20	6	
			Option 3	0.10	15	5	
	STEP	Fixed	Standard	0.10	40	12	Tied

Source: JICA Annual Report 2017

There are four Terms of ODA Loans, i.e. 1) General Terms, 2) Preferential Terms, 3) Preferential Terms for High Specification and 4) Special Terms for Economic Partnership (STEP).
Preferential Terms can be applied to the sectors and fields such as Global Environmental and Climate Change related issues, Health and Medical Care and Services, Disaster Prevention and Reduction and Human Resource Development.
Preferential Terms for High Specification will be applicable to projects promoting infrastructure of high quality.
STEP is extended to projects for which Japanese technologies and know-how are substantially utilized, based on the recipient countries' request to utilize and transfer excellent technologies of Japan.
With regard to interest rate, we have fixed interest rate and floating interest rate with higher or lower interest rates combined with longer or shorter Repayment Period and Grace Period. Final condition of ODA Loan for respective project is decided by the Government of Japan based on the request of the Government of Borrowing Country and the appropriateness of the project to be financed.
From January 2013, the Government of Japan (Ministry of Foreign Affairs and JICA) extended a possibility to change, if the borrowing country may so wish, the repayment currency from Japanese Yen to US Dollars of those ODA Loans with repayment period 15 years and 20 years. Thus, we believe that Japanese ODA Loans become more flexible and attractive for recipient countries.

(2) Grant Aid

JICA also provides certain amount of grant aid not requiring repayment obligation. This form of financial assistance tends to be allocated, however, to sectors and projects not producing daily direct income. With bigger financial burden on Japanese government budget than ODA Loan, the amount of grant aid is in general far smaller compared with ODA Loan.

(3) Private Sector Investment Finance

This scheme is applied to private companies wishing to promote development projects in accordance with relevant policies of the recipient country. Theoretical possibility of applying this scheme to power and energy sector in Bangladesh will be explained in 1.5.

3.1.4 Financial instruments of Japan Bank for International Cooperation (JBIC)

(1) Export Loan

Export loans are provided to overseas importers or financial institutions to support financially import of Japanese equipment and/or technology to their countries. Not only machinery or vessels but also power plants or industrial facilities of high technology are eligible for export loans. Since the aim of export loans is to promote Japanese export, minimum percentage of 30% of Japanese products or components in the total contract amount used to be required, but taking into consideration of recent globalization, this minimum requirement is now lowered to 10%, if the total percentage of Japanese products to be imported directly from Japan and local products made by Japanese affiliated companies in the country exceeds 30%.
There are two schemes of export loans. Bank Loan is provided to financial institutions of the borrowing country which on lend the proceeds of the loan to importers. Buyer's Credit is provided directly to overseas importer or executing agency of the project. Since the project size in power and energy sector is in general large, Buyer's Credit with government guarantee of recipient country required by JBIC is commonly used. JBIC generally formulates a syndicate with private commercial banks. Therefore, Buyer's Credit takes the form of co-financing.
Terms and conditions of export loans are determined in principle based on the Arrangement on Officially Supported Export Credit (OECD).

- Currency: Japanese Yen, US Dollars or Euro

- Repayment Period: Repayment period for capital goods or plants is between 5 and 10 years depending on the recipient country. For power plants, except nuclear plants, this period can be up to 12 years regardless country classification.
- Interest rate: The structure of formulating the interest rate depends on the currency by which export loans are denominated. In case of Japanese Yen, one interest rate averaged by interest rate of JBIC portion as well as that of commercial banks will be proposed to the borrower. CIRR (Commercial Interest Reference Rate) as determined periodically by OECD for respective currency and as used by all ECA (Export Credit Agencies) plus risk premium of the borrowing country will be the final interest rate to be applied. As of October 15, 2018, CIRR of Japanese Yen is as follows.

Repayment period less than 5 years	0.91%
More than 5 years and less than 8.5years	0.94%
Longer than 8.5 years	1.00%

- In case of Japanese Yen, respective commercial banks propose interest rate of LIBOR plus spread, while JBIC proposes above fixed rate based on CIRR.
- In case of US Dollars, separate interest rates are shown for JBIC portion and for commercial banks' portion. Interest rate of JBIC portion will be a fixed rate based on CIRR plus JBIC risk premium as above. Interest rate of commercial banks' portion will be shown by respective bank in the form of LIBOR-6 month plus spread. As of end October 2018, LIBOR-6 month of US Dollars is around 2.8%.

(2) Overseas Investment Loan

Overseas Investment Loan will be provided 1) directly to Japanese companies (investors) carrying out an investment project in a developing country, 2) to Japanese subsidiaries (including joint ventures) in that country or 3) to foreign banks, government and others of that country who will lend and invest in these companies. Loan to Japanese affiliated companies for long-term funds necessary for the project is a direct way to assist Japanese investment. Loan to foreign companies / financial institutions or the relevant government etc. who intend to make equity investment or provide loans to the Japanese corporation, is an indirect way to support the investment. In line with the current situation where export destinations to third countries by Japanese local subsidiaries etc. are expanding in the local market as well as flexibility of the above 30% rule, JBIC has decided to provide local buyers' credit from February 2013. The system is a scheme to finance necessary funds for export and sale of facilities and technologies produced by Japanese local affiliates to business partners such as local subsidiaries or buyers in third countries. It aims to support Japanese companies' overseas production bases through loans to local buyers or buyers in third countries.

3.1.5 Financial Instruments of Other Asian Countries

(1) South Korea

Similar to Japan, there are government export credit agencies (ECAs) and trade insurance organizations in Korea as well as in China.
The Korean investment financial institution has two main roles of K - Exim and K - Sure as shown below. K - Exim is Export-Import Bank of Korea, which is a public export credit institution owned 100% by the Korean government. The bank was established in 1976 with a view to promote overseas business and foreign investment of Korean private companies by providing export credit and guarantee, together with specialized market research. Its function is similar to Japan's JBIC. K - Sure is the Korean Trade and Insurance Corporation, which is similar to Japan's NEXI.
In the case of Japan, JBIC is basically a contact point for ECA finance, and NEXI is in a supportive position in the form of securing insurance against loans provided by JBIC and commercial banks. It is also JBIC only without NEXI to carry out loan negotiations.
On the other hand, in the case of Korea, K-Exim is responsible for its direct lending portion, while K-Sure is responsible for portions not covered by K-Exim by providing guarantee on financing arrangements. Therefore, K-Sure plays an equal role to K-Exim and for this reason, it is said that not

only K-Exim, but also K-Sure participates in the loan negotiation.
Regarding the scope of financing, if a Japanese company (or companies) is under consortium with non-Japanese companies for one EPC contract, JBIC tries to secure the financing of not only Japanese company's portion but also other companies' portions, in interpreting with flexibility OECD guidelines. In case of Korea on the other hand, K - Exim / K - Sure cover only Korean company's portion leaving other portions uncovered. Therefore, for example, if the consortium is composed of three companies such as A, B and a Korean company, K - Exim / K - Sure will finance only the scope of Korean company. Furthermore, in the case of Japan, with respect to the ECA scope of financing, 60% is the direct loan of JBIC and 40% is in the form of lending by the commercial banks under the NEXI loan insurance, making always under the insurance / guarantee of JBIC and NEXI. In the case of Korea, K - Sure guaranteed only 95% of K Sure 's coordination part, so 5% of K Sure's portion is necessarily under naked risk.

(2) China

The Export-Import Bank of China (EIBC) is an organization supporting the financing of Chinese companies for their overseas business. While it is the Chinese government who has the function of providing loans to foreign countries, EIBC is the only point receiving interests and repayments of such loan assistance. Based on "State Council's decision on financial system reform" in December 1993, EIBC was established in 1994. It was also in 1994 that, from the viewpoint of separating commercial finance and policy finance, the National Development Bank and the China Agricultural Development Bank were established as policy financial institutions, in addition to EIBC.
As features of Chinese finance, it is said that financing in the currency of the borrower country is possible using international settlement function of EIBC which is endowed with foreign exchange reserves. Not confirmed information also says that finance composition under bold conditions is being done without seeking government guarantee of the borrower country.

3.1.6 Impacts of US policy change <The United States Climate Action Plan>

On June 25, 2013, President Obama announced the "Climate Action Plan", in which he ordered US Environmental Protection Agency (EPA) to establish newly the CO2 emission standards of thermal power plants in the US until September 2013 for new plants and by June 2014 for existing plants.

In response to this, EPA announced in September of the same year the CO2 emission limits of new facilities. They proposed to apply 0.499 CO 2 / kg / kWh as CO 2 emission upper limit. This value was based on the use of CCS technology, and it was very tough for business operators.

The power producers in the United States were particularly concerned about the CO2 emission standards for existing power plants. Since a little bit less than 40% of the electricity was generated by existing coal-fired power plants of rather old age, many of them would have to be abolished if emission control was done.

Also in this "Climate Action Plan", it was requested to "End public financial support for the construction of new overseas coal-fired power plants, except the cases of poorest countries where there is no other choice and the highest efficiency coal fired power or CCS is to be adopted. It was also requested to seek consent from other countries and international development banks (MDBs) to take similar measures as soon as possible ".

3.1.7 Discussions at OECD

Based on the request of the United States as mentioned above, Export Credit Group (ECG) of OECD started their discussions in November 2013 on a possible limitation of official export credit support for coal-fired power plants. On November 18, 2015, participants to the "Arrangement on Officially Supported Export Credits" have agreed new rules on official support for coal-fired plants.

The new rules distinguish between 1) Large (>500MW), Medium (>300MW to 500MW), and Small (<300MW) plants, 2) Technology types (ultra-super critical; super-critical; and sub-critical), and 3) Levels of development of the project country. As a result, ultra-super critical plants receive no restriction, while super-critical plants up to 500MW and sub-critical plants smaller than 300MW are admitted only for IDA-eligible countries, with exceptions on electrification rate of less than 90% and geographically isolated non-IDA-eligible countries.
Discussions are still continuing at ECG in a direction to restrict further.
It is also to be noted that following the discussions on climate change, namely Paris declaration, and ECG decision, certain number of private banks declared not to finance anymore coal-fired plants.

3.2 Assistance from Multilateral Development Banks (MDBs)

3.2.1 The Asian Development Bank (ADB)

(1) Gas Sector

ADB has been providing assistance to the development of gas supply infrastructure in Bangladesh since 1973, and the ADB officer who met the JICA Survey Team in Dhaka expressed its willingness to continue the support in this area, such as the development of gas transmission pipelines and gas-fired power generation.

ADB is not aware of the plan to establish an east-west linkage of gas transmission network through subsea pipelines but commented that this plan would be meaningful if the LNG terminals are established in the western region (e.g. Payra) and the cost-benefit balance of the overall project is assured.

(2) Power Sector

As for the development of coal-based energy supply in Bangladesh, ADB officer clearly stated that ADB will not support the development of coal-fired power generation because of its policy to stop financing coal projects. However, ADB officer also added that it will not flatly oppose the support of other international development agencies such as JICA to the development of coal-fired power generation and that ADB will not exclude the possibility of its assistance to the development of other infrastructure such as power transmission network considering the plan of developing the coal-fired power generation to be connected to the grid.

ADB officer also agreed to the importance of cross border power trade through the development of international grid connection though ADB hasn't decided on specific assistance in this area yet. ADB officer also pointed out the complexity of region-wide power trade in southern Asian region, where India has a dominant power and geographically stands between smaller countries. ADB officer suggested the framework of region-wide cooperation such as Greater Mekong Sub region (GMS) in Southeast Asia, which was established with the initiative of ADB, can be a good practice for reference.

ADB officer also agreed to extend the support more to the demand-side of the power supply system.

ADB's projects (both ongoing and in pipeline) are summarized in the table below.

Table 3-5 ADB's projects in the energy and power sector in Bangladesh

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Regional: South Asia Subregional Economic Cooperation Regional Energy Cooperation	Power trading	2018/9/10	2021/8/31	ongoing	Total Project Cost (TA): USD 2 million, Of which: ADB: USD 500,000.00 Cofinancing: USD 1,500,000.00	The regional knowledge and support technical assistance (TA) will prepare development master plans and enhance capacity development for the energy sector's regional cooperation and integration (RCI) under the South Asia Subregional Economic Cooperation (SASEC) program. It will cover Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, and Sri Lanka.
Bangladesh: Southwest Transmission Grid Expansion Project	Transmission	2018/7/31	2023/12/31	ongoing	Total Project Cost (Loan): USD 525 million Of which, ADB: USD 350 million Total Project Cost (Grant): USD 8 million Of which: ADB: 0 Cofinancing: USD 8 million	The project will improve the operational performance of the power sector and contribute to the Government of Bangladesh's target to achieve electricity for all by 2021 through (i) constructing (a) a 400/132-kilovolt (kV) substation at Gopalganj; (b) a 230 kV transmission line in the southern zone, from Barisal to Faridpur; and (c) a 400 kV transmission line in the western zone, from Bogra to Rohanpur; and (ii) implementing a capacity development program in the electric utility industry to promote socially and gender inclusive growth.
Bangladesh: Southwest Transmission Grid Expansion Project	Transmission	2017/7/14	2019/12/31	ongoing	Total Project Cost: USD 1,250,000.00 Of which: ADB: USD 1,250,000.00	The Government of Bangladesh has requested a transaction technical assistance (TRTA) from the Asian Development Bank (ADB) to prepare an investment project for developing and expanding the transmission network in southern and western zones of the country. This TRTA is required to prepare all documents for the core subprojects. To satisfy ADB's due diligence requirements, the depth and coverage of technical, financial, and economic analyses will be verified, reviewed, updated, strengthened, and presented in the prescribed format.
Bangladesh: Power System Efficiency Improvement (Off-grid Solar Photovoltaic Pumping Systems Component) - Additional Financing	Renewable energy	2018/7/5	2021/6/30	pipeline	Total Project Cost (Grant): USD 30 million Of which: ADB: 0 Cofinancing: USD 25 million	The impact and outcome of the overall project, with additional cofinancing, will remain the same as in the ongoing project, and the outputs from Part B(iv) will be enhanced. The respective outputs will be expanded through additional financing by (i) about 2,000 SPV water pumping systems installed with an estimated total 18.3 MW-peak of solar capacity; and (ii) development of a gender-related action plan for an awareness campaign and capacity development for SPV water pumping systems.
Bangladesh: Rupsha 800-	Generation	2018/6/26	2022/12/31	ongoing	Total Project Cost (Loan):	The project targets improving energy security in Bangladesh. It will

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Megawatt Combined Cycle Power Plant Project					USD 1,139 million Of which: ADB: USD 500 million Cofinancing: USD 300 million Total Project Cost (Grant): USD 2 million Of which: ADB: 0 Cofinancing: USD 2 million	increase availability of efficient and cleaner energy by developing a state-of-the-art power plant with 800-megawatt (MW) generation capacity using cleaner and highly efficient power generation technology. The project also envisages the construction of associated natural gas supply and power transmission infrastructure facilities, as well as strengthening of the institutional capacity and overall business process of the project's executing agency, North-West Power Generation Company Limited (NWPGCL), to efficiently plan and operate power plants.
Bangladesh: Cornerstone Investment in a Leading Power Developer	Generation	2018/3/28	-	pipeline	-	ADB will subscribe to Summit Power International Limited's common equity shares as a cornerstone investor for its initial public offering.
Regional: Sharing Development Knowledge Solutions in Asia and the Pacific	-	2017/9/26	2020/11/30	ongoing	Total Project Cost: USD 1,305,000.00 Of which: ADB: 555,000.00 Cofinancing: 750,000.00	DMCs access to knowledge solutions from ADB, other ADB members and knowledge partners improved.
Bangladesh: SASEC Third Bangladesh India Electrical Grid Interconnection Project	-	-	-	pipeline	Total Project Cost: USD 140 million	The proposed project is a part of Bangladesh's Power System Master Plan 2016. Analytical studies, including the SAARC's Regional Energy Trade Study 2010 proposed power transmission connectivity between India and Bangladesh. A regional SAARC grid will result in increased operational efficiency, tapping of new power resources and improved system reliability. It will also provide a platform to reduce the prevailing energy gap that hinders regional economic and social development.
Bangladesh: SASEC Second Bangladesh–India Electrical Grid Interconnection Project	Transmission	2015/9/29	2018/12/31	ongoing	Total Project Cost: USD 183 million Of which: ADB: USD 120 million	The Asian Development Bank is working with Bangladesh and India to increase the ability of the two countries to trade electricity. The project is allowing Bangladesh to better meet sharply rising power demand while assisting India in exporting excess electricity. This includes upgrading the power transmission capacity of the existing grid interconnection between the two countries from 500 megawatts to 1,000 megawatts.
Bangladesh: SASEC Bangladesh-India Electrical Grid	Power trading	2017/12/12	2018/12/31	ongoing	Total Project Cost: USD 225,000.00 Of which: ADB: USD 225,000.00	Support on cross border trading of power between India and Bangladesh for existing and planned interconnections

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Interconnection Project						
Bangladesh: Bangladesh Power System Enhancement and Efficiency Improvement Project	Transmission and distribution	2017/3/29	2020/12/31	ongoing	Total Project Cost (Loan): USD 1,057 million Of which: ADB: USD 616 million Total Project Cost (Grant): USD 2 million Of which: ADB: 0 Cofinancing: USD 2 million	The Asian Development Bank is helping Bangladesh upgrade electricity transmission and distribution systems to strengthen coverage and reliability of services, amidst fast rising power demand. The project will build a 174 km transmission line linking Dhaka to the southwest of the country and introduce new control systems and other improvements to distribution networks in Dhaka and rural areas.
Regional: Improving Institutional Capacity on Preparing Energy Efficiency Investments	Renewable energy	2016/12/6	2019/11/30	ongoing	USD 2 million Of which: ADB: 0 Cofinancing: USD 2 million	ADB has significant experience in supporting supply-side energy projects to address supply shortage, but it needs to build on this experience to strengthen synergies between supply-side and demand-side interventions. The proposed technical assistance (TA) aims to assist five developing member countries (DMCs) in South Asia (Bangladesh, Bhutan, the Maldives, Nepal, and Sri Lanka) in enhancing their capacity for energy efficiency development and increasing energy efficiency investments in a cost-effective manner to meet the energy demand in each country.
Regional: Promoting and Scaling Up Solar Photovoltaic Power through Knowledge Management and Pilot Testing in Bangladesh and Nepal	Renewable energy	2016/12/5	2019/9/30	ongoing	Total Project Cost: USD 1,814,000. Of which: ADB: USD 200,000.00 Cofinancing: USD 1,614,000.00	TA will promote development of solar power technologies in both off-grid and grid-connected areas of Bangladesh and Nepal by means of institutional and stakeholder capacity building, pilot-testing solar-pumping to increase agricultural production, developing women-led livelihood activities, as well as showcasing and sharing knowledge of good practices, solutions and lessons learned. Specifically, the TA will have following scope: Bangladesh component: The TA will be implemented in parallel to, and provide support and capacity development for beneficiaries of, the ongoing Loan 2769 BAN: Power System Efficiency Improvement Project, component Part B (iv) Solar Photovoltaic Pumping for Agricultural Irrigation. The subproject is composed by 1,500 off-grid SPV pumping systems for agriculture and aquaculture with a total capacity of 6.0 MWp to replace

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
						existing diesel-run irrigation, with a budget allocation of $20 million.
Bangladesh: Natural Gas Infrastructure and Efficiency Improvement Project	Natural Gas	2016/11/18	2022/6/30	ongoing	Total Project Cost: USD 453 million Of which: ADB: USD 167 million Cofinancing: USD 60 million	The project aims to (i) improve efficiency in natural gas production by installing seven wellhead gas compressors at location A of Titas gas field, and (ii) expand natural gas transmission pipeline capacity by constructing an approximately 181-kilometer, 36-inch parallel gas transmission pipeline from Chittagong through Feni to Bakhrabad.
Bangladesh: Khulna 800 MW LNG Based Power Plant Project	Generation	2016/9/1	2018/8/30	ongoing	Total Project Cost: USD 425,000.00 Of which: ADB: USD 425,000.00	In March 2016, the Government of Bangladesh requested the Asian Development Bank (ADB) for a loan to fund the Khulna 800 MW LNG Based Power Plant Project. Subsequently, in July 2016, the government requested ADB to provide a small-scale project preparatory technical assistance (TA) in an amount not exceeding $225,000 to help preparing the project. The TA will support the due diligence and preparatory work for the ensuing project. TA is not included in country operations business plan, 2016-2018 for Bangladesh. A fact-finding mission was not fielded as sufficient information had been gathered during previous consultation missions to proceed with TA processing.
Bangladesh: Study on Energy Security	Energy security	2014/12/17	2018/12/31	ongoing	Total Project Cost: USD 1.2 million Of which: ADB: USD 1 million	The proposed capacity development technical assistance (TA) will conduct a study on the security of energy supplies in Bangladesh. The study is extended by conducting feasibility studies on high priority power generation projects identified based on the recommendations.
Regional: Measuring the Development Effectiveness of Private Sector Operations	-	2014/12/15	-	ongoing	USD 1.20 million Approved	The TA will better capture and communicate (i) the direct effects of private sector operations (ii) the indirect effects and (iii) ensure consistency in reporting with other IFIs. The results captured will need to be reliable and of direct relevance to sponsors so that they continue using the systems developed. The TA is designed to address these aspects.
Regional: Action on Climate Change in South Asia	-	2013/12/13	2018/12/12	ongoing	Total Project Cost: USD 3 million Of which: ADB: USD 3 million	The TA aims to further enhance the capacity of South Asia DMCs in managing the impacts of climate change by effectively transitioning to a low-carbon and climate-resilient development path. This will be achieved through the following TA outputs: 1) strengthening screening of investment projects against

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
						climate risks, and 2) strengthening the DMCs' capacity to develop and implement climate change strategies and action plans.
Regional: Improving Procurement in South Asia	-	2013/12/12	2019/12/31	ongoing	Total Project Cost: USD 5 million Of which: ADB: USD 5 million	Experience from ADB-financed projects across DMCs shows that procurement takes a considerable amount of time and is often a source of delay in project implementation. Common causes of procurement delays are weak implementation capacity, especially in procurement and project management, unfamiliarity with ADB procurement processes and procedures, weak governance system and insufficient monitoring and progress reporting in procurement.
Bangladesh: Power System Expansion and Efficiency Improvement Investment Program - Tranche 3	Generation, transmission and distribution	2015/12/8	2021/6/30	ongoing	Total Project Cost: USD 530 million Of which: ADB: USD 205 million Cofinancing: USD 220 million	The Asian Development Bank is working with Bangladesh to boost the country's power supply. The project is working to reform and strengthen the power sector, using both public and private sector financing, to build and improve power plants, and expand power distribution lines. Tranche 3 will cover investments in generation system expansion and efficiency improvement, transmission system enhancement, and demand side energy efficiency improvement.
Bangladesh: Power System Expansion and Efficiency Improvement Investment Program - Tranche 2	Transmission and distribution	2013/12/9	2019/6/30	ongoing	Total Project Cost: USD 530 million Of which: ADB: USD 310 million Cofinancing: USD 220 million	ADB is helping Bangladesh boost power supply by enhancing its transmission and distribution network. The second tranche of the program will enable increased energy transfer from Ghorasal to Tongi and improve transmission capacity to meet growing power demand in the capital Dhaka, Chittagong, and Sylhet areas. It will also expand the capacity of the north and south Dhaka distribution network.
Bangladesh: Power System Expansion and Efficiency Improvement Investment Program - Tranche 1	Generation and transmission	2012/12/12	2018/12/31	ongoing	Total Project Cost (Loan): USD 393 million Of which: ADB: USD 185 million Cofinancing: USD 176 million Total Project Cost (Grant): USD 7 million Of which: ADB: 0 Cofinancing: USD 7 million	ADB is helping Bangladesh boost its power supply to reduce the outages and shortages that are crippling the economy. The first tranche of the program will add 235 megawatts to the system by converting four single cycle, gas-fired power plants into more efficient combined cycle plants at Khulna, Baghabari, Sylhet, and Shahjibazar. It will also build transmission lines and substations.

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Bangladesh: Power System Expansion and Efficiency Improvement Investment Program (Facility Concept)	Generation, transmission and distribution	2012/11/28	-	ongoing	Total Project Cost (Loan): USD 1,402 million Of which: ADB: USD 700 million Cofinancing: USD 480 million Total Project Cost (Grant): USD 7 million Of which: ADB: 0 Cofinancing: USD 7 million	The proposed investment program includes three tranches encompassing generation expansion and associated transmission and distribution improvements. Tranche 1 mainly focuses on generation expansion. Tranche 2 focuses on transmission and distribution improvement together with a pilot solar irrigation component. Tranche 3 also invests on generation expansion. Generation expansion in the MFF will be undertaken through supply side energy efficiency improvement so that about 50% power can be generated without burning additional gas. Given the acute gas shortages in Bangladesh, conversion of single cycle gas fired power plants to combined cycle plants the technology adopted in the investment program is the best way to expand the generation capacity. The sequencing of the tranches is well aligned with the sector needs and the government program.
Bangladesh: Natural Gas Access Improvement Project (formerly Clean Fuel Development Project)	Natural Gas	2010/3/26	2018/12/30	ongoing	Total Project Cost (Loan): USD 542 million Of which: ADB: USD 266 million	The objective of the Project is to increase access to, and reliability of, natural gas supply in Bangladesh through capacity expansion and efficiency improvements in natural gas production, transmission and distribution systems.
Bangladesh: Bibiyana II Gas Power Project	Generation	2014/12/5	-	ongoing	(Loan) USD 73 million committed	The Project involves design, engineering, construction and operation of a 341MW combined cycle gas-fired power plant. The Project will alleviate a severe power shortage adversely impacting the country's economic growth and poverty reduction efforts by adding 341 MW of greenfield power capacity generating cleaner, efficient, reliable and affordable electricity. The Project will also stimulate the economy by purchasing local goods and services and creating jobs for qualified locals in the Project area and in the country.
Regional: Smart Grid Capacity Development	Renewable energy	2011/12/7	2018/6/30	ongoing	Total Project Cost: USD 1.4 million Of which: ADB: 0 Cofinancing: USD 1.4 million	In facing the challenges of energy security and climate change, some developing member countries (DMCs) have taken the lead in promoting renewable energy. At the same time, expectations are raised for smart grid technology out of concern that unstable output of renewable energy will adversely affect the power systems which the power from renewable energy will be fed into. In this context, during the

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
						second meeting of the Asia Solar Energy Forum in Tokyo, Japan, in December 2010, several South Asia DMCs asked the Asian Development Bank (ADB) to provide capacity development technical assistance (TA) for developing the smart grid.
Bangladesh: Power System Efficiency Improvement Project	Renewable energy	2011/8/11	2021/6/30	ongoing	Total Project Cost: USD 581 million Of which: ADB: USD 300 million Cofinancing: USD 200 million	The draft power sector master plan update 2010 identifies the need to add 11 CCPPs each with 450 MW capacity in 2010 2016. The proposed Ashuganj 450 MW plant (part A) can be considered one of these CCPPs. Further, the government has identified the proposed plant as a priority project in its expansion plan. The economic cost of electricity supply from the Ashuganj CCPP is similar to or lower than those of a coal-fired power plant (based on the costs taken from the master plan), confirming that the proposed plant is among the least-cost options for generating new capacity. CCPP design will use the latest commercially available technology to harness the maximum benefit of energy efficiency.
Bangladesh: Dhaka Power Systems Upgrade	Transmission and distribution	1999/12/21	-	pipeline	-	The objectives of the Project are (i) corporatization of part of the generation assets of BPDB; (ii) completion of the 230kV ring around Dhaka city and strengthening of the 132kV network; (iii) upgrading of distribution in the Dhaka area; and (iv) assist in project preparation for a training and development institute for the sector. The Project comprises the following: Part A - 230-132kV Transmission System around Dhaka; Part B - Upgrading of the Distribution System in Dhaka; and Part C - Project Preparation for a Training and Development Institute.
Bangladesh: Capacity Development for Renewable Energy Investment Programming and Implementation	Renewable energy	-	-	pipeline	-	The proposed knowledge and support technical assistance (TA) will support preparing a renewable energy (RE) investment plan for Bangladesh and improve capacity of the government and other stakeholders in large-scale renewable energy project programming and implementation. The outcome of the TA will inform ADB"s interventions in energy sector of the country. This proposed TA is listed in the country operations business plan for Bangladesh, (2018-2020).
Bangladesh: Reliance Bangladesh Liquefied	Generation	-	-	pipeline	USD 330 million Guarantee Approved	The proposed Project will include a natural gas fired power plant (CCPP) and a liquefied natural gas (LNG) terminal. The LNG terminal, located

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Natural Gas and Power Project						near Kutubdia Island, consists of a mooring point, jetty and pipeline infrastructure to connect an off-shore FSRU to the mainland. The 718 MW CCPP, utilizing regasified LNG (RLNG) as fuel, is proposed to be located on land allotted by Bangladesh Power Development Board (BPDB), in Meghnaghat, Narayanganj District.

Source: JICA Survey Team

3.2.2 The World Bank (WB)

Drawing upon from the systematic country diagnostic, the World Bank lists energy sector as one of the five priority areas. In the energy sector, key priorities include increasing the supply of electricity and natural gas, diversifying sources of power supply, retiring polluting and expensive emergency diesel generators, and reducing energy subsidies (and the resulting significant fiscal burden).

In power generation, International Development Association (IDA), International Finance Corporation (IFC) and Multilateral Investment Guarantee Agency (MIGA) are supporting new gas-fired generation capacity as well as the repowering of existing gas-fired plants to enhance their efficiency. In addition, IDA is supporting off-grid rural electrification through solar home systems program that has reached more than three million households. IDA and IFC, along with ADB, will work to scale up renewable energy investments.

In transmission and distribution, the World Bank Group is strengthening rural transmission and distribution networks to reduce losses and increase carrying capacity in rural areas, supporting efforts to improve the financial and operational efficiency of the Power Grid Company of Bangladesh (PGCB), and also seeking to help finance cross-border transmission lines with the ultimate goal of building a regional power pool covering Bangladesh, Bhutan, India and Nepal. To this end, the IFC is supporting the Government of Bangladesh to purchase hydropower from private developers in Nepal, to be wheeled through India.

In the gas sector, the WBG will support Bangladesh's efforts to utilize limited gas resources efficiently and development new sources of gas. IFC is supporting the construction of LNG regasification infrastructure to supplement domestic gas supply with imported LNG.

Table 3-6 WB's projects in the energy and power sector in Bangladesh

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Additional Financing II for Rural Electrification and Renewable Energy Development II	Rural electrification Renewable energy	2018/4/10	N/A	ongoing	Total Project Cost: USD 179 million Commitment Amount: USD 55 million	The objective is to increase access to clean energy through renewable energy in rural areas. The additional financing will finance following components: (i) access to electricity; (ii) household energy component; and (iii) sector technical assistance.
Enhancement and Strengthening of Power Transmission Network in	Transmission	2018/3/29	2022/12/31	ongoing	Total Project Cost: USD 718 million Commitment Amount: USD 451 million	The objective is to increase the transmission capacity and reliability of the electricity network in the eastern region and strengthen the institutional capacity of the Power Grid Company of Bangladesh

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Eastern Region						Limited (PGCB). The project comprises of two components. The first component is enhancement and strengthening of power network; and the second component is institutional development and implementation support.
Power System Reliability and Efficiency Improvement Project	Transmission	2017/4/26	2021/12/31	ongoing	Total Project Cost: USD 77 million Commitment Amount: USD 59 million	The objective is to improve the reliability and efficiency of the power system in Bangladesh through optimization of dispatch operation. The project comprises of three components. The first component is technical assistance; the second component is operational enhancements; and the third component is removal of transmission bottlenecks and improvement of voltage quality.
Bangladesh Ghorashal Unit 4 Repowering Project	Generation	2015/12/21	2022/3/31	ongoing	Total Project Cost: USD 263 million Commitment Amount: USD 217 million	The objective is to increase generation capacity and efficiency of the targeted power plant. The first component is re-powering of the target unit and will finance all the required plant equipment and auxiliaries, design and installations services for the full repowering of unit four. The second component is the technical assistance for institutional strengthening support.
Siddhirganj Power Project Additional Financing	Generation	2015/11/13	N/A	ongoing	Total Project Cost: USD 205 million Commitment Amount: USD 177 million	The objective is to increase supply of electricity to Bangladesh grid network. The additional financing (AF) will fill the financing gap associated with the design, procurement, construction, and commissioning of a 335 megawatt (MW) combined cycle power plant at Siddhirganj.
GPOBA Scale-up for Bangladesh RERED II	Renewable energy	2015/2/13	2018/6/30	ongoing	Total Project Cost: USD 15 million Commitment Amount: USD 0 million	This project supports SHS installations and other renewable energy options (mini-grids, solar irrigation pumps and others) for scaling up access to electricity.
RERED II Additional Financing	Renewable energy	2014/6/19	N/A	ongoing	Total Project Cost: USD 152 million Commitment Amount: USD 78 million	The objectives are to increase access to clean energy in rural areas through renewable energy and to promote more efficient energy consumption. This project paper seeks the approval of the Executive Directors to provide an additional credit to the Bangladesh Rural Electrification and Renewable Energy Development II (RERED II) Project. The additional financing is required to scale up the access to electricity component supporting installation of solar home systems (SHS) in rural areas of Bangladesh.
Rural Electrification and Renewable	Renewable energy	2012/9/20	2021/12/31	ongoing	Total Project Cost: USD 386 million Commitment Amount:	The objectives are to increase access to clean energy in rural areas through renewable energy and promote more efficient energy consumption. This

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Energy Development II (RERED II) Project					USD 155 million	restructuring will revise the targeted number of beneficiaries to 1,600 from the original target of 5,000 connections from mini-grids and solar irrigation pumps to reflect the increased capital buy-down grant requirements for each connection under GPOBA RERED mini grid project; and extend the grant closing date by six months to December 31, 2014 for mini grid project to complete the activities supported under the project and to fully utilize the grant fund.
Bangladesh: Rural Electricity Transmission and Distribution Project	Transmission and distribution	2014/2/27	2020/6/30	ongoing	Total Project Cost: USD 837 million Commitment Amount: USD 600 million	The objectives are to reduce system losses and enhance capacity in the rural distribution network of primarily the eastern part of the country. The project is implemented through the following components: 1) rural grid augmentation and rehabilitation; 2) transmission enhancement; and 3) institutional strengthening.
Bangladesh Scaling-up Renewable Energy Project	Renewable energy	N/A	N/A	pipeline	Total Project Cost: USD 414 million Commitment Amount: USD 156 million	The Project is aimed at supporting the development of grid-connected renewable energy, particularly solar PV and wind, and waste-to-energy through a combination of investment financing and technical assistance by matching availability of public lands with the interest and expertise of the private sector in installation, operation and maintenance of utility scale renewable energy. It will also address the barriers by providing access to capital, de-risking investments, and conducting resource assessments.

Source: JICA Survey Team

3.2.3 The Islamic Development Bank (IDB)

The Islamic Development Bank (IsDB) opened its new regional hub in Dhaka, Bangladesh in September, 2018, as part of its continued commitment to support sustainable socio-economic development in the region. The new regional hub will facilitate various projects in Bangladesh, as it is the largest beneficiary of financing. Their projects in the energy and power sectors are now in pipeline. They will cover construction and renovation of power plants, and enhancement of transmission and distribution lines.

Table 3-7 IDB's projects in the energy and power sector in Bangladesh

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Summit Barisal Power Plant (SBPL)	Generation	2016/6/19	-	pipeline	-	Summit Barisal Power Plant (SBPL) Sector: Energy (Leasing)
Bhola 220 MW Dual Fuel Combined Cycle Power	Generation	2018/5/7	-	pipeline	-	The project involves the construction and operation of a 225 MW dual fuel Combined Cycle power plant at Bhola, an island situated 250 km

Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Plant Project						south of Dhaka in Bangladesh. The project will provide strong development impact in terms of enhancing the power generation capacity in Bangladesh; Energy being a major pillar of government's seventh Five-Year Plan 2016-2021. The project is in line with Pillar 1 in the MCPS 2013-2016 and with IDB Vision/Mission of 1440H, which emphasize "Improving Infrastructure Development"
Power Grid Expansion Project	Transmission and distribution	2015/4/23	-	pipeline	-	The project will support the country's economic development by expanding the power grid infrastructure to facilitate the efficient and reliable transmission and distribution of the electricity that will be generated by new 1,250 MW power plants, envisioned to be operational by 2019. The project includes the construction of new 400kV, 230kV and 132kV transmission lines and substations as well as strengthening of the distribution network in Dhaka (eighth largest city in the world with a population of more than 15 million people). Upon completion, the project will enable 770,000 new electricity connections.
400 MW Ashuganj East Power Plant Efficiency Improvement	Generation and transmission	2017/10/5	-	pipeline	-	The project aims at satisfying the increasing demand of electricity through improving the efficiency of the generation system by replacing old and inefficient power plant units at Ashuganj power plant complex by a modern and efficient 400 MW CCPP. In addition, the project will also include expansion of the high voltage 132 kV transmission infrastructure in the country and installation of 700,000 new pre-paid meters.
Crude Oil and Refined Petroleum Products	Oil	2017/8/1	-	pipeline	-	Crude Oil and Refined Petroleum Products Sector: Energy (Trade (Murabaha))

Source: JICA Survey Team

3.2.4 The Asian Infrastructure Investment Bank (AIIB)

Bangladesh was one of the first countries to have projects approved by the Asian Infrastructure Investment Bank (AIIB) in 2016. In the energy and power sectors, there are three on-going projects and one project in pipeline. The power sector covers generation (IPP), and enhancement of transmission and distribution line. The gas sector has only one project which is about enhancement of gas transmission.

Table 3-8 AIIBs projects in the energy and power sector in Bangladesh

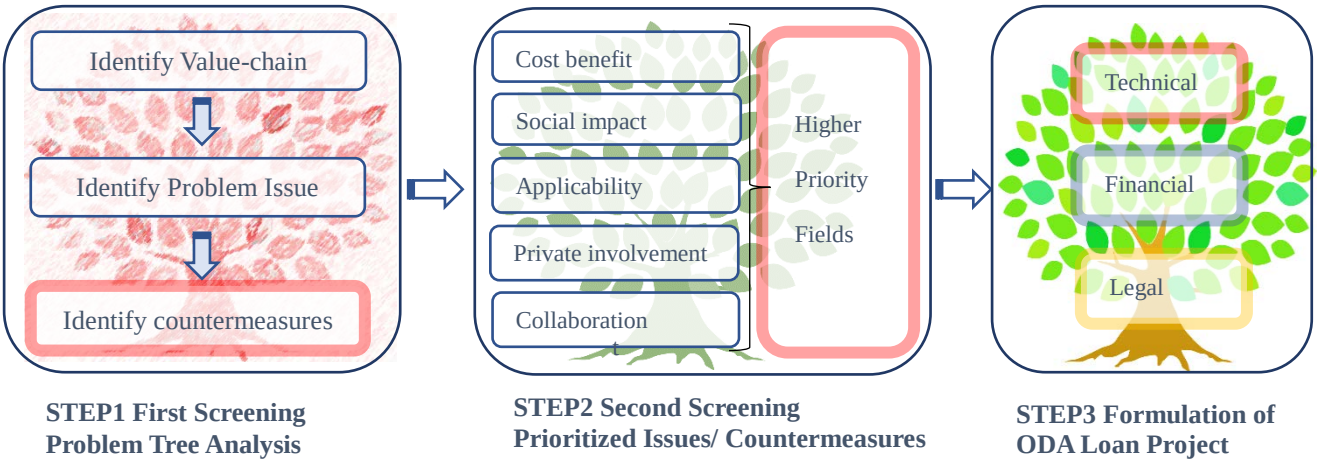
Project title	Theme	Period		Status	Amount	Project summary
		From	To			
Bangladesh: Bangladesh Bhola IPP	Generation	2018/2/9	-	ongoing	USD 60 million	The objective of the project is to increase power generation capacity in Bangladesh to help meet its power demands as it faces acute power shortages. Upon completion, the project will increase power generation by around 1,300 gigawatt hours annually.
Bangladesh: Natural Gas Infrastructure and Efficiency Improvement Project	Natural Gas	2017/3/22	-	ongoing	Total Project Cost: USD 453 million > ADB: USD 167 million	The Project includes two components. Under component one, seven wellhead compressors (five operating and two stand-by) will be installed in Titas Gas Field. It is to help improve gas production efficiency to maximize recovery from Titas Gas Field. Under component two, a 181 km, 36-inch gas transmission pipeline will be constructed. The proposed pipeline will constitute a trunk transmission pipeline between Chittagong and Bakhrabad to transport regasified LNG to central and west gas markets.
Bangladesh: Distribution System Upgrade and Expansion Project	Distribution	2016/6/24	2019/6/1	ongoing	USD 165 million	The Project will enhance power distribution capacity and increase the number of rural and urban electricity consumers in Bangladesh, and is comprised of two components: (1) provision of about 2.5 million service connections to rural consumers; (2) upgrading two grid substations and conversion of 85 km overhead distribution lines into underground cables in north Dhaka. The Bangladesh Rural Electrification Board (BREB) and Dhaka Electric Supply Company Limited (DESCO) are the project implementation agencies.
Bangladesh: Power System Upgrade and Expansion Project	Transmission	2019/4/1	2022/12/31	pipeline	USD 120 million	The objective is to upgrade and expand the power transmission system in the Chittagong region to ensure adequate and reliable power supply in the south eastern region of Bangladesh. Upon completion, the capacity of the transmission network in the Chittagong region will be enhanced, load shedding will be reduced, and new consumers will be connected to the grid. This will further create some cascading benefits to the 132 kilovolts (kV) and 33 kV secondary networks with respect to the quality of power supply in the region, such as improved voltage stability and reduced voltage fluctuation.

Source: JICA Survey Team

Chapter 4 Issues Identification and Selection of Projects for ODA Assistance

In this chapter, issues that need to be addressed with priority for improving the energy and power supply in Bangladesh are identified, following the observation of the current status of the energy and power sector as discussed in the previous Chapter. The prioritized issues are shortlisted in this process.

In step 1, a problem tree analysis is examined to identify problem issues in energy and power sector on a value chain as a first screening. In step 2, a Prioritized issues/ countermeasures are screened through five criteria; Cost benefit, Social impact, Applicability of experience, Private sector involvement, and Collaboration with other development partners. In the final step, the JICA Survey Team proposes one of the highest prioritized scheme, having technical, financial, and legal aspects as an ODA loan scheme.



Source: JICA Survey Team

Figure 4-1 Screening process flow

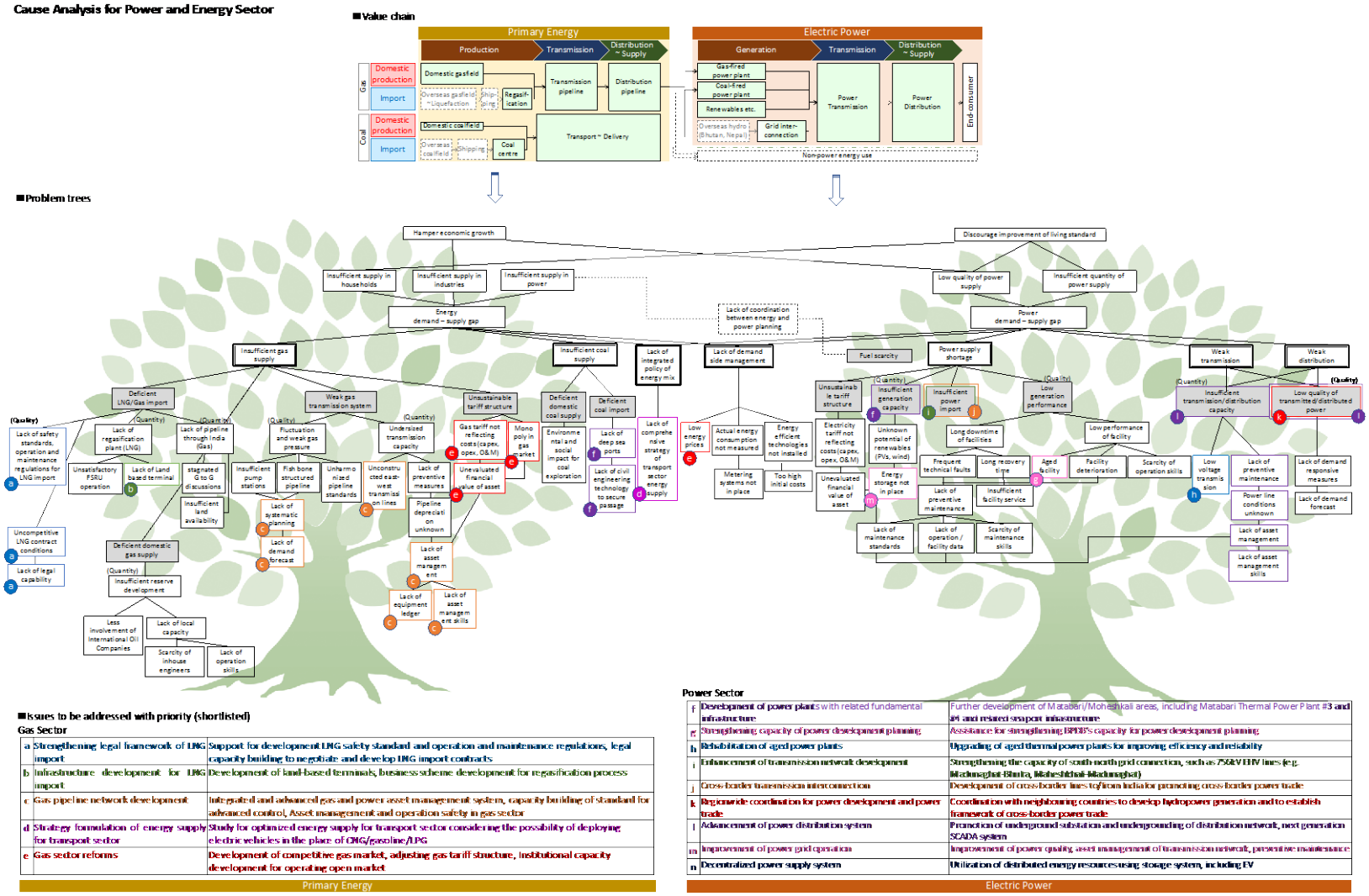
4.1 Step 1: First Screening with Problem Tree Analysis

Based on the discussions with the stakeholders in Bangladesh, problems that the energy and power sector are facing today are summarized in the following figure. A “problem tree” analysis is employed for grasping the issues comprehensively in a MECE (mutually exclusive and collectively exhaustive) manner and relating the issues in a cause-result structure.

The energy and power sector have a complicated supply chain from upstream (supply-side) to downstream (demand-side). The supply chain of primary energy supply and that of power supply have some common structure and are also related with each other in that there is a junction between the downstream of primary energy supply and the upstream of power supply. This analysis diagram considers not only the vertical relation of cause and results, but also the horizontal relation of supply chain from left to right.

The analysis of primary energy supply in this diagram focuses on natural gas and coal only, considering the situation of energy supply in Bangladesh.

Following the analysis in the diagram, fourteen “core” issues are shortlisted as the prioritized issues, five from primary energy supply and nine from power supply.



Source: JICA Survey Team

Figure 4-2 Problem tree analysis to identify prioritized issues

4.1.1 Problem Tree Analysis of the Energy Sector

For the primary energy supply, five “core” issues were identified.

The first one regards LNG import from the legal aspect. The JICA Survey Team understood that at the moment there exist no safety standards nor operation and maintenance regulations specifically for imported LNG. Moreover, in making a contract with an exporting country, protective measures need to be embedded in the contract over contract negotiations. A few international legal advisors are now looking after the contract, but more comprehensive and careful consideration should be given.

The second problem is LNG import from facility aspect. Bangladesh, after experiencing unsatisfactory FSRUs operation, will no longer build FSRUs, and rather will focus on land-based terminals. The process should be expediated since land-based terminal takes a long time to develop. The private sector involvement is also essential. The public sector should support preparing the common infrastructure facility as well as improvement of gas transmission.

The third issue is the gas pipeline system. The current pipeline and its operation system will not stand for expanded gas supply after LNG import. The basic documents and drawings are missing, and it is difficult to grasp the pipeline conditions. Important documents such as process flow diagrams are not available either. By digitalizing the documents and introducing the integrated asset management system, it will contribute to modernize the gas and power sector. Another problem to address in gas transmission is safety. Currently the design standard for gas transmission pipeline is not universal but varies depending on the transmission line. Capacity development is needed on planning, design, maintenance, and operation.

The fourth issue deals with the energy supply for the transport sector. As already discussed in the PSMP2016 study report, energy demand for transport sector in Bangladesh is expected to grow rapidly and the policy vision of energy source to feed this demand is not confirmed yet. Possibility of electric vehicles (EV) depending on the prospects of cost reduction, can also be taken into account. This is also related with the issue of “decentralized power supply system” in the power sector.

The fifth and last issue addressed here is gas sector reform. As described in the problem tree analysis, the rigid tariff structure and underlying gas market mechanism, is a cause to multiple problems. A competitive gas market needs to be established with pricing mechanisms. To realize such market, technical support should be provided to develop and operate necessary market legislations.

4.1.2 Problem Tree Analysis of the Power Sector

For the power sector, nine “core” issues were identified from power generation, transmission and distribution.

For power generation, five issues are discussed. The first one is development of coal/gas power plants along with the fundamental infrastructure to support this such as the development of ports. Especially various stakeholders expect further support from JICA to develop Matabari/Moheshkali areas.

Secondly, for supporting the recent initiative of Bangladesh stakeholders to revisit the PSMP on their own, technical assistance for routinizing and upgrading this process to make it built-in is worth considering.

Thirdly, renovation of old power plant nearby Dhaka requires urgent support, as it not only contributes to increased generation capacity but to improve the frequency control.

Fourthly, given the continuing supply-demand gap of power, power import from India and other

neighbouring countries is an essential task to be looked into, Support can be provided in developing necessary connection lines and facilitating discussion with other countries by developing an international coordination body.

Fifthly, other form of power supply, i.e. decentralized power supply system can be introduced by utilizing electric vehicles and electricity storage technology as an example.

For transmission and distribution, four issues are identified both in terms of quantity and quality.

Quantity needs to be increase by developing high voltage transmission lines to bridge the geographical distance between the demand-centre (Dhaka) and the supply centres. Domestically, the centre of power generation has been established in the southern region and strengthening the transmission system to connect between north and south has become an urgent issue. In addition, the interconnection at the north-end of the country also needs to be considered to establish power import from neighbouring countries.

Quality-wise improvement of power network system has been achieved in recent years by introducing basic management system such as SCADA. Further support can enhance more of its stability and reliability, such as implementing automated control of distribution network and improving the asset management of network system.

4.1.3 Prioritization of issues and countermeasures

These fourteen prioritized issues that are identified in the problem tree analysis are summarized in the following table.

Table 4-1 Issues to be addressed with priority in energy and power sector (short list)

Primary Energy Supply		
1	Strengthening Legal Framework of LNG Import	Support for development LNG safety standard and operation and maintenance regulations, Legal capacity building to negotiate and develop LNG import contracts
2	Facility development for LNG import	Development of land-based terminals, Business scheme development for regasification process
3	Gas pipeline network development	Integrated and advanced gas and power asset management system, Capacity building, Development of standard for advanced control, Asset management and operation safety in gas sector
4	Strategy formulation of energy supply for transport sector	Study for optimized energy supply for transport sector considering the possibility of deploying electric vehicles in the place of CNG/gasoline/LPG
5	Gas sector reforms	Development of competitive gas market, adjusting gas tariff structure, Institutional capacity development for operating open market
Power Supply		
6	Development of power plants with related fundamental infrastructure	Further development of Matabari/Moheshkali areas, including Matabari Thermal Power Plant #3 and #4 and related sea port infrastructure
7	Strengthening capacity of power development planning	Assistance for strengthening BPDB's capacity for power development planning, grid code, tariff reforms
8	Rehabilitation of aged power plants	Upgrading of aged thermal power plants for improving efficiency and reliability
9	Enhancement of transmission network development	Strengthening the capacity of south-north grid connection, such as 756kV EHV lines (e.g. Madunaghat-Bhulta, Maheshkhali-Madunaghat)

10	Cross-border transmission interconnection	Development of cross-border lines to/from India, for promoting cross-border power trade
11	Region wide coordination for power development and power trade	Coordination with neighboring countries to develop hydropower generation and to establish framework of cross-border power trade
12	Advancement of power distribution system	Promotion of underground substation and undergrounding of distribution network, next generation SCADA system
13	Improvement of power grid operation	Improvement of power quality, asset management of transmission network, preventive maintenance
14	Decentralized power supply system	Utilization of distributed energy resources using storage system, including electric vehicles

Source: JICA Survey Team

4.2 Step 2 Second Screening Prioritized Issues/ Countermeasures

4.2.1 Methodology of evaluation

Five criteria are set to prioritize the projects.

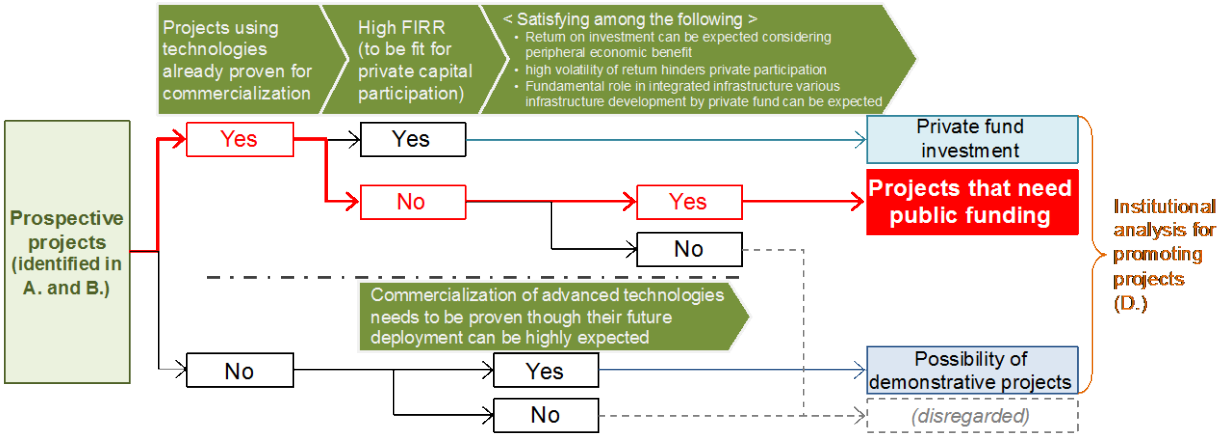
- Cost benefit:
  This criterion aims to identify a project which develops infrastructure that cannot expect the entry of private capital because the investment profitability (FIRR) as a single project is not high enough but that should be promoted with public funding as its cost benefits are high. For example, an initiative to improve power quality is not profitable for distribution companies. However, as a result of such initiative, high tech industries which require high quality power will be developed contributing economic growth of country.

- Social impact:
  This criterion evaluates the impacts that selected project may bring about. By examining problem trees, it is notable that some issues serve as causes to various problems. By addressing such fundamental issues, solution will be provided to wide range of problems.

- Applicability of Japanese experience:
  This criterion examines whether Japan has relevant experience or technologies which can be utilized in the selected project.

- Private sector involvement:
  This criterion examines whether public funding proposed in the selected project works as an incentive to encourage investment from the private sector. For example, if the public funding contributes to reduce volatility of return on investment due to external factors, it will lower barriers for the private sector involvement.

- Collaboration with other development partners:
  This criterion evaluates possibility to involve other development partners.



Source: JICA Survey Team

Figure 4-3 The role of public funding

4.2.2 Results of project selection

The fourteen items that are identified as issues to be addressed with priority in energy and power sector in the section 4.1.3 are further evaluated for selecting projects for which Japan's assistance with ODA funds is expected to take a high effect.

For each of these fourteen issues, a rough concept of projects for solution is formulated and these projects are evaluated with the following five criteria, where "○" is the highest mark, followed by "△" and "×".

(a) Cost-benefit
(b) Social impact
(c) Applicability of Japanese experience
(d) Private sector involvement
(e) Collaboration with other development partners

The results of evaluating the fourteen projects are summarized in the following table.

Table 4-2 Result of project evaluation

No.	Project	Criteria				
		(a)	(b)	(c)	(d)	(e)
Energy sector						
1.	Strengthening legal framework of LNG import	○	○	○	○	△
2.	Facility development for LNG import	△	○	△	○	○
3.	Gas pipeline network development	○	○	△	×	△
4.	Strategy formulation of energy supply for transport sector	×	△	△	△	×
5.	Gas sector reforms	○	○	○	○	○
Power sector						
6.	Development of power plants with related fundamental infrastructure	△	○	○	○	△
7.	Strengthening capacity of power development planning	○	○	○	△	○
8.	Rehabilitation of aged power plants	○	○	○	△	△
9.	Enhancement of transmission network development	○	△	△	×	△
10.	Cross-border transmission interconnection	○	○	△	×	○
11.	Regionwide coordination for power development and power trade	○	×	○	×	△
12.	Advancement of power distribution system	△	○	○	×	△
13.	Improvement of power grid operation	△	○	○	×	△
14.	Decentralized power supply system	×	△	△	○	×

Source: JICA Survey Team

As a result, the following six projects are given high marks;

1. Strengthening legal framework of LNG import;
2. Facility development for LNG import;
5. Gas sector reforms
6. Development of power plants with related fundamental infrastructure
7. Strengthening capacity of power development planning
8. Rehabilitation of aged power plants

These six projects can be roughly divided into “soft component” projects and “hard component” projects. Projects number 1., 5. and 7. are “soft component” projects to support strengthening the institutional capacity of the energy and power sector. For these projects, application of the program loan is expected to serve as an incentive to motivate the government of Bangladesh to carry out sector reforms.

The other three projects, i.e. number 2., 6., and 8, are “hard component” projects to deal with installing and upgrading the infrastructure. Conventionally, public sector utilities such as Petrobangla in the energy sector and BPDB in the power sector, have been the key players in developing infrastructure and financial assistance from abroad, if needed, has been provided to these public sector utilities. Considering that the economic level in Bangladesh has reached certain level of development and private investors have shown stronger interest in participating in the business of energy and power supply, the JICA Study Team supposes that it’s time for the energy and power sector consider that the assistance from public fund should be provided for promoting private sector participation rather than only focusing on the conventional ODA loan. New types of ODA loan such as equity back finance (EBF) and viability gap finance (VGF) are the options to serve for this.

The outline of the above finance schemes is explained in the following section, and this study’s proposal of the selected projects is discussed specifically in the section 4.4

4.2.3 Brief Outline of the Candidate Projects

Besides the abovementioned six projects, another eight projects are also worth consideration as future candidates for ODA support. A brief outline of these projects is given below.

■ Gas pipeline network development (Project #3)

Table 4-3 Outline of "Gas pipeline network development" project

Project name	Technical Cooperation (T/C) on Gas and Power Network Infrastructure Management System (NIMS)
Project type	Technical assistance
Finance scheme	Grant
Goal	Enhanced reliability of energy infrastructure through the introduction of advanced operation systems with a network infrastructure management system (NIMS) to support the economic growth of Bangladesh.
Project summary	・ Building Gas/Power NIMS system for pilot area (ex. Dhaka area) ・ Preparation of standard contracts/designs/specifications for gas facilities in Bangladesh ・ Preparation of NIMS management organization ・ Formulation of national LNG/Gas supply plan and human resource development

Source: JICA Survey Team

< Current status and issues >
There are challenges facing the Bangladesh energy sector, as in the following areas:

(1) Lack of system integrity and design standards
The integrity of the gas transmission and distribution system has not been reviewed in the past. There are no common design philosophies or standards commonly applied in all organizations in Bangladesh.

For applicable standards and designs, different philosophies are selected from project to project.
There is no centralized information management system, no asset register is maintained, and no system for physical asset verification is in place, and therefore there is no way to assess the integrity of the infrastructure. An advanced infrastructure management system, including asset and document management, should be introduced.

(2) Operation mode
Operation mode will change from the current "Gas Allocation System" to "Supply to Demand Base System". Operators on the gas supply side need to know the gas demand profile beforehand and send the gas to meet the actual demand profile. The advanced operation system must be designed to integrate the system from the gas fields/LNG terminals to downstream customers. The current Fish Bone system should be modified to a Loop System.

(3) Insufficient pipeline capacity for future LNG imports
The current pipeline system will be insufficient once a large amount of gas from LNG imports is injected. The pipeline expansion plan should be consistent with the LNG import plan.

(4) Absence of LNG import regulations
LNG will be supplied by several different entities. The nature of the LNG may also differ from source to source. These gases also mix with domestic gases in the gas transmission system. Unlike electricity transmission, gas flow speed is slow. Due to gas delivery time lags created by the pipeline transmission system, the proportions of the gas mixture may change with the supply profile. Supply profile is the variation of supply to cope with different types of demand, such as peak demand and base load demand. LNG may be used to supply to a base load profile, while domestic gas may be used to fill out a middle/peak shaving profile portion. To accommodate these issues, a central monitoring and control system should be introduced. As the minimum requirement, the following system should be introduced: Capacity Right for gas transmission by each supplier.

Quality Bank to rationalize the difference in specifications and pricing.
System design must be done by professionals in this sector.

(5) Lack of integrated gas and power infrastructure plan
The current pipeline development plan does not consider the gas power and industry development plan. The infrastructure development plan should be coordinated among the gas, power, and industry sectors considering future demand and supply quantity. A system for sector-wise infrastructure planning should be introduced.

(6) Lack of centralized data and document management system
There is no centralized data and document management system, and thus important drawings, specifications, and other technical documents become dispersed and lost.

(7) Insufficient readiness for introduction of ERP
Introducing ERP should be designed to solve the issues above. However, ERP needs to be designed and customized according to each organization's requirements, and system elaboration is necessary. It will be a long-term effort to build ERP and this can be achieved through the framework of a technical cooperation project.

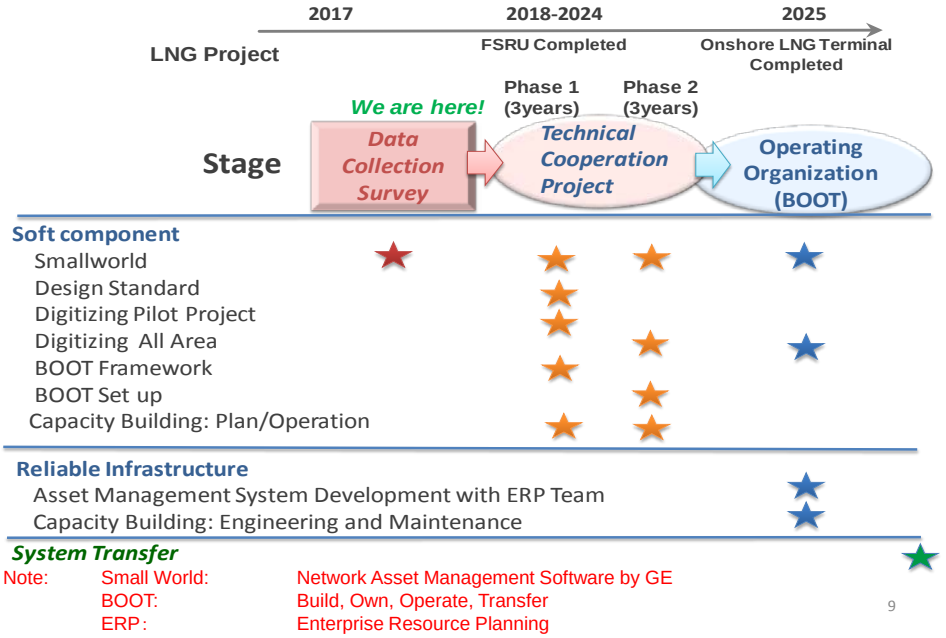
(8) Insufficient coordination of infrastructure plans among donors
Donor coordination in the infrastructure development area is insufficient, especially with regard to sharing common specifications and design standards. It is necessary firstly to determine the most suitable and efficient specifications for gas transmission pipelines in Bangladesh and secondly to introduce and apply such specifications in all future related projects either financed by international donors or via the Bangladesh Government's own funds.
< Target to achieve >
Enhanced reliability of energy infrastructure through the introduction of advanced operation systems with a network infrastructure management system (NIMS) to support the economic growth of Bangladesh.
A Gas/Power asset management system is to be established with NIMS. Standard contracts/designs/specifications are to be prepared, and human resources are to be developed.

< Expected tasks >
1) Building Gas/Power NIMS system for pilot area (ex. Dhaka area)
2) Preparation of standard contracts/designs/specifications for gas facilities in Bangladesh
3) Preparation of NIMS management organization
4) Formulation of national LNG/Gas supply plan and human resource development

Table 4-4 Expected tasks

Output	Activity
1) Building Gas/Power NIMS system for pilot area	1-1: Geographical and asset data collection for gas and power facilities 1-2 : Prepare modeling and input NIMS for gas and power distribution in pilot areas 1-3: Prepare alignment drawings for existing unknown pipes with pipe locator 1-4: Incorporate information from SCADA in NIMS 1-5: Prepare gas-power integrated NIMS model
2) Preparation of standard contracts/designs/ specifications for gas facilities in Bangladesh	2-1: Collect and assemble process flow drawings 2-2: Prepare standard contracts/designs/specifications 2-3: Prepare safety and cathodic protection plan 2-4: Collect accident data, and prepare emergency plan and preventive maintenance plan 2-5: Prepare Guidelines for the above
3) Preparation of NIMS management organization	3-1: Proposal for NIMS management BOOT institutional structure 3-2: Financial and budgeting study for NIMS management organization
4) Formulation of national LNG/Gas supply plan	4-1: Review of LNG supply plan 4-2: Gas flow simulation and Pipeline development plan 4-3: Standard LNG contract, system for Capacity Right and Quality Bank

Sources: JICA Data collection survey on computerization of gas and power network infrastructure in Bangladesh, Jan. 2018



Source: JICA Data collection survey on computerization of gas and power network infrastructure, Jan. 2018

Figure 4-4 Road Map toward sustainable management of advanced system

■ Strategy formulation of energy supply for transport sector (Project #4)

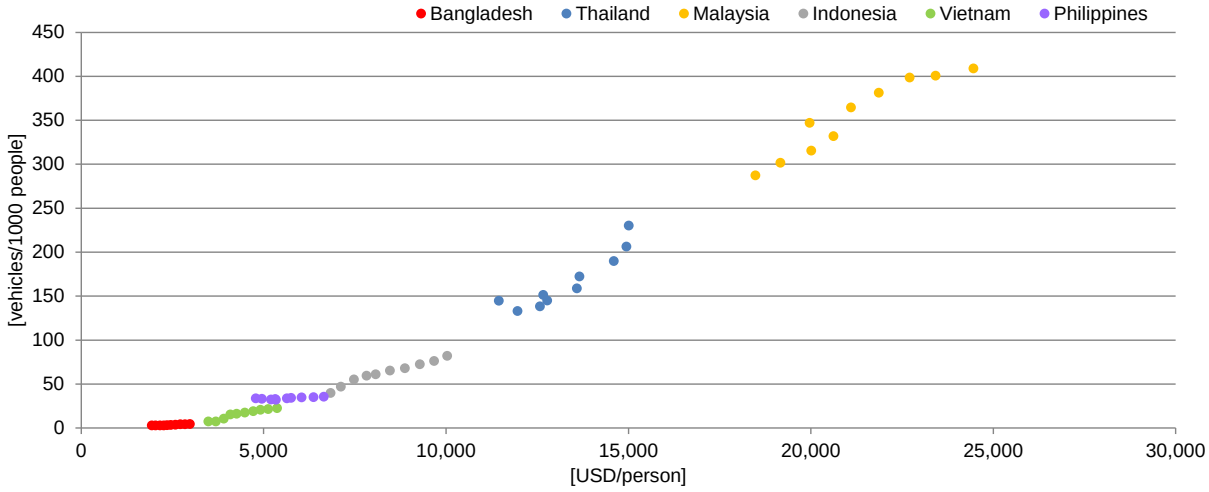
Table 4-5 Outline of "Strategy formulation of energy supply for transport sector2 project

Project name	Study on developing long-term strategy of transport sector energy supply
Project type	Technical assistance
Finance scheme	Grant
Goal	Formulation of long-term strategy of transport sector energy supply considering the deployment of electric vehicles (EVs)
Project summary	・ Updating the energy demand projection for the transport sector reflecting the progress of public transport development projects etc. ・ Discussion with stakeholders in Bangladesh on the long-term plan of utilizing CNG and LPG as energy source for vehicles. ・ Analysis on the prospects of EV deployment, referring to the practices in other countries. ・ Formulating a set of policy recommendation in the roadmap;

Source: JICA Survey Team

< Current status and issues >

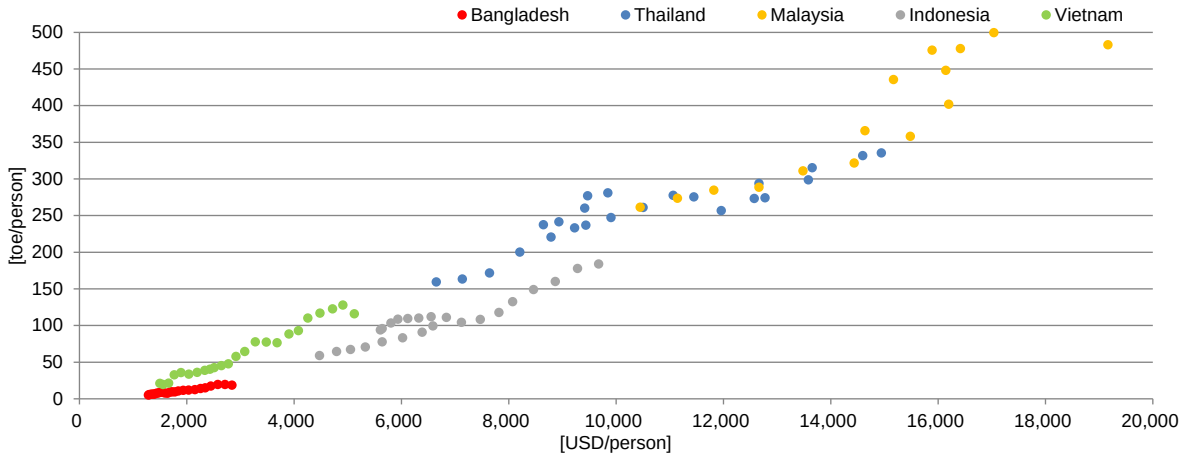
As analyzed in the PSMP2016 study report, the historical trend of southeast Asian countries shows that a country's motorization rate, i.e. car ownership per population, shows a clear correlation with the stage of economic development, i.e. GDP per capita (PPP based). An important characteristic to be noted is that the trend curve takes an S-shape, with the slope getting steep when the GDP per capita reaches about 5,000 USD and getting moderate when the GDP per capita becomes higher than 20,000 USD.



Source: PSMP2016 Final Report (analysis based on World Bank database and OICA statistics)

Figure 4-5 Historical Trend of GDP per Capita and Motorization Rate

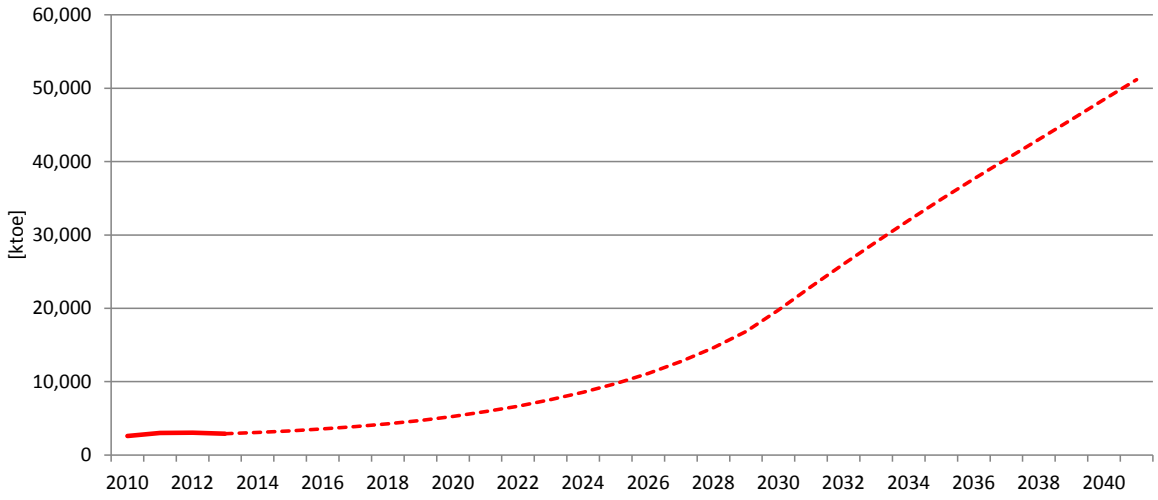
Reflecting the motorization rate, the historical trend of transport sector's energy consumption per capita also shows a similar correlation with GDP per capita, though the correlation becomes a little rougher.



Source: PSMP2016 Final Report (based on World Bank database and IEA energy balances)

Figure 4-6 Historical Trend of GDP per Capita and Transport Sector's Energy Consumption

Considering these trends, the PSMP2016 assumed that the car ownership will grow very rapidly in Bangladesh, especially after mid-2020s, and projected the energy consumption of the transport sector as follows. The trend curve takes a steeper slope after mid-2020s, even considering the advancement of energy efficiency in the sector.



Source: PSMP2016

Figure 4-7 Projection of Transport Sector's Energy Consumption in PSMP2016

Since early 2000s, the Government of Bangladesh has promoted the conversion from gasoline to CNG (compressed natural gas) for utilizing the domestically produced natural gas. However, the government recently changed this policy and started to promote the utilization of LNG instead, but this does not appear to be a long-term strategy. Hence the PSMP2016 tentatively assume that the current share of natural gas and petroleum products including LPG, which is about half and half, will be maintained.

Because the selection of fuel also affects the development of fuel supply station that may require high initial cost for capital investment, it is time for Bangladesh to formulate a scenario on how to feed the energy demand of this sector, while promoting the development of public transport to mitigate the increase of energy demand.

Another factor that may strongly affect the future of transport sector is the possibility of deploying

electric vehicles (EVs), depending on the prospects of cost reduction. India set an ambitious target that 30% of vehicles sold in the country will be EVs by 2030, and this may also affect the neighboring countries like Bangladesh. The advantage of EV in terms of energy supply is that more flexibility in selecting primary energy source can be assured, which is especially attractive for countries like Bangladesh that will be more dependent on energy import for any kind of primary energy sources. In the meanwhile, drawbacks of EVs also still exist, such as the higher production cost and the shorter travel distance per one charging, and they need to be studied carefully to confirm whether they will remain critical in the future.

< Target to achieve >
To assist the Energy and Mineral Resources Division (EMRD) under the Ministry of Power, Energy and Mineral Resources (MPEMR) to formulate a long-term strategy of energy supply for transport sector in coordination with relevant stakeholders such as Power Division under MPEMR (especially in terms of EV deployment) and government agencies responsible for road transport and land development.

< Expected tasks >
- Updating the energy demand projection for the transport sector based on the projection methodology of PSMP2016.
  - ✓ The progress of public transport development projects etc. are also considered for estimating the impact of developing public transport such as train affects the total energy demand;
- Conducting a stakeholder meeting on the long-term plan of utilizing CNG and LPG as energy source for vehicles, either collectively or individually for each stakeholder.
  - ✓ The stakeholder covers not only those from EMRD and related state enterprise such as Petrobangla, but also those from the power sector, government agencies in charge of road transport and land development and so on;
- Review on the practices in other countries for EV deployment;
- Scenario analysis on the prospects of EV deployment in Bangladesh;
- Formulating a set of policy recommendation in the roadmap;
-

■ Enhancement of transmission network development (Project #9)

Table 4-6 Outline of "Enhancement of transmission network development" project

Project name	Power transmission expansion projects
Project type	Technical assistance and loan execution
Finance scheme	Grant / Loan
Goal	Expansion of power transmission network in Bangladesh to meet the increasing power demand and power development planning
Project summary	・ Review and analysis of the existing power transmission plans; ・ Recommendation for additional projects for future expansion of the grid system that need assistance from international development agencies; ・ Feasibility study on the selected projects; ・ Engineering services and execution of loan projects;

Source: JICA Survey Team

< Current status and issues >
As discussed in section 2.4.1 the transmission network system in Bangladesh needs to be expanded and upgraded to meet the rapidly increasing power demand, and the increasing the capacity of transmission lines to connect between the southern region, where many of the planned power plants are located, and the northern region to feed the power demand in Dhaka and its surroundings.

Financial assistance from international development agencies on some planned projects is assured, such as Dhaka-Chittagong transmission line project that is financed by ODA yen-loan. Further assistance for future plans of grid expansion is anticipated.

< Target to achieve >
Power transmission network in Bangladesh will be expanded timely in accordance with the rapidly growing demand and the power development plan.

< Expected tasks >
- Review and analysis of existing power transmission plans;
  - ✓ Power network analysis to identify the problems and weaknesses of the current network system, taking also into account the projection of power demand and the power development plan (geographical location, generation capacity and fuel source of planned power plants);
  - ✓ Review of ongoing projects to evaluate the relevance and hurdles for implementing these projects as expected (if any);
  - ✓ Identifying additional projects that need to be considered for strengthening the power transmission network in the future;
  - ✓ Feasibility study on the selected projects;
  - ✓ Engineering services for detailed design, bidding preparation and project management;
  - ✓ Execution of loan projects;

■ Cross-border transmission interconnection (Project #10)

Table 4-7 Outline of "Cross-border transmission interconnection" project

Project name	Cross-border transmission interconnection projects between Bangladesh and India
Project type	Technical assistance and loan execution
Finance scheme	Grant / Loan
Goal	Establishing cross-border transmission interconnection for promoting power import from neighboring countries
Project summary	・ Review of the existing plan of cross-border interconnection; ・ Evaluation of feasibility of each project, taking also into consideration the feasibility of cross-border power trade to use the planned grid interconnection; ・ Engineering services and execution of loan projects;

Source: JICA Survey Team

< Current status and issues >
As discussed in section 2.4.1 expansion of power transmission network in Bangladesh beyond its border to neighboring countries also needs to be considered, considering the promotion of power import, especially the potential of hydropower generation in India, Bhutan and Nepal.

PGCB is planning to develop a 765kV grid interconnection in the northern region, which is expected to connect with India at both eastern and western side of Bangladesh. A joint technical team consisting of experts from Bangladesh and India was established and a technical report on the feasibility of grid interconnection was prepared in July 2016.

Source: PGCB Annual Report

Figure 4-8 Interconnection Plan in Northern Bangladesh

However, this 765kV transmission plan has not been progressed to actual implementation. Considering the principle that the beneficiary should be responsible for the cost, Bangladesh, which is supposed to be the sole beneficiary of this project and hence is required to bear mostly the cost of interconnection, though the east-west interconnection may also contribute to the stability of power supply in India more or less.

While the grid interconnection between neighboring countries brings about benefit, it may also lead to a wide-area collapse of grid stability one a big accident occurs on the network. For preventing a chain of such of accidents, interconnection with HVDC that can minimize such negative effect is considered appropriate.

Another thing to be noted is the necessity to formulate institutional framework of cross-border power trade, because the political intervention into international trade of goods like electricity that is essential for basic human may easily deteriorate the national economy of a country. And because the power flow on this interconnection is expected to be mostly an inflow for Bangladesh, i.e. Bangladesh mostly imports electricity and exports quite a little, the country might become vulnerable to international negotiation on power trade.

Establishing a regional framework of cooperation to facilitate this is expected along with hardware installation. An officer from ADB who was interviewed by the JICA Survey Team in the study suggested that the framework of GMS (Greater Mekong Sub region) that was established upon the initiative of ABD can be a good practice for reference. An officer from the Planning Commission under the Ministry of Planning of Bangladesh also suggested that the existing framework of regional cooperation called BIMSTEC (Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation), which consists of Bangladesh, India, Myanmar, Sri Lanka, Thailand, Nepal and Nepal, can be extended to deal with this.

< Target to achieve >
Establishing the 765kV HVDC interconnection system in northern Bangladesh, taking also into consideration the institutional framework of cross-border power trade in the region.

< Expected tasks >

- Reviewing the overall situation to evaluate the necessity of grid interconnection, taking also into account the status of hydropower development in India, Bhutan and Nepal;
- Technical review on the feasibility study prepared by the joint technical team of Bangladesh and India;
- Assisting the cooperation between Bangladesh in India in promoting the grid interconnection (if needed);
- Carrying out additional survey for supplementing the existing feasibility study (if needed);
  - ✓ Selection of route of transmission lines;
  - ✓ Conceptual design of AC/DC converter;
  - ✓ Analysis of the grid system in Bangladesh to grasp the necessity of expanding the grid system;
  - ✓ Cost estimation;
- Study on the institutional framework of regional cooperation to support the grid interconnection;
  - ✓ Review of existing framework of regional cooperation;
  - ✓ Review of good practices in other regions;
  - ✓ Recommendation for a suitable option;

■ Region wide coordination for power development and power trade (Project #11)

Table 4-8 Outline of "Cross-border transmission interconnection" project

Project name	Study on the development of hydropower generation in neighboring country considering the cross-border power trade with Bangladesh
Project type	Technical assistance
Finance scheme	Grant
Goal	Project formulation of hydropower generation that serves for cross-border power trade
Project summary	・ Pre-feasibility study on the potential of hydropower generation for project formulation;

Source: JICA Survey Team

< Current status and issues, Target to achieve >
In relation to the cross-border grid interconnection as discussed in (10), pre-feasibility study on the potential hydropower generation that serves for cross-border power trade with Bangladesh.

Potential of hydropower exists in India, Bhutan and Nepal, but considering the complexity of coordination involving three or more countries, it is recommended to start with the study on the hydropower potential in India for facilitating the framework of cross-border trade.

There is a good potential of developing hydropower generation in the state of Meghalaya in India, whereas developing thermal power generation is not suitable in this area considering the transport of fuel. This results in the difficulty of balancing between supply and demand because the power generation of hydropower fluctuates depending on seasons. Power trade through grid interconnection with Bangladesh, where power supply mainly depends on thermal power generation, can be mutually beneficial.

To serve for the stability of power supply, development of pumped-storage hydropower generation in this area is worth considering, and assistance from Japan on the technologies of pumped-storage hydropower can also be expected.

< Expected tasks >
- Reviewing the overall situation to evaluate the necessity of developing (pumped-storage) hydropower generation in Meghalaya state;
- Proposing the formulation of development involving India and Bangladesh, and assisting the cooperation between these two countries;
- Selection of prominent sites for development;
  - ✓ Following the shortlist of prominent sites for hydropower development, the most preferred sites will be selected based on the criteria in terms of environmental impact, economic feasibility and so on;
- Conceptual designing at the selected site that also includes construction work plan and budgeting, and evaluation of project feasibility;

Source: PSMP2016

Figure 4-9 Topographical map of Bangladesh-India border area

■ Advancement of power distribution system (Project #12)

Table 4-9 Outline of "Advancement of power distribution system" project

Project name	Upgrading the distribution network system in Dhaka area
Project type	Technical assistance
Finance scheme	Grant
Goal	Formulation of plans to upgrade the distribution network in Dhaka area for improving the quality of power supply
Project summary	・ Development of mid- and long-term plan comprising the following three components: ➢ Distribution automation with sequential fault location methods ➢ Distribution line fault detection method for overhead MV lines ➢ Distribution undergrounding ・ Selection of pilot projects;

Source: JICA Survey Team

< Current status and issues, Target to achieve >
Dhaka has already been growing up as a city with very high population density and still sees an increase of population. Considering the rapid growth of economic activities, the power demand in this area is expected to grow still faster. In addition, as the advancement of economic standard of the country, the necessity for improving the quality of power supply as well as securing the quantity has become an important issue. As discussed in section 2.4.2 the distribution sector in Bangladesh has seen a good improvement in performance indicators such as SAIFI, SAIDI and distribution system loss, but further improvement will be required especially in reducing power interruption.

In this study, the JICA Survey Team made a series of discussion with power distribution companies in Dhaka, namely DESCO and DPDC, and found they have been making efforts for upgrading their network system, such as the installation of SCADA system and AMI system. The upgrading will serve for enhancing remote monitoring of the status of distribution network.
As the next step to follow this, the JICA Survey Team recommends that distribution companies consider improving their capability of detecting the fault point on the network once an accident occurs, for minimizing the effect of power outage incidents.

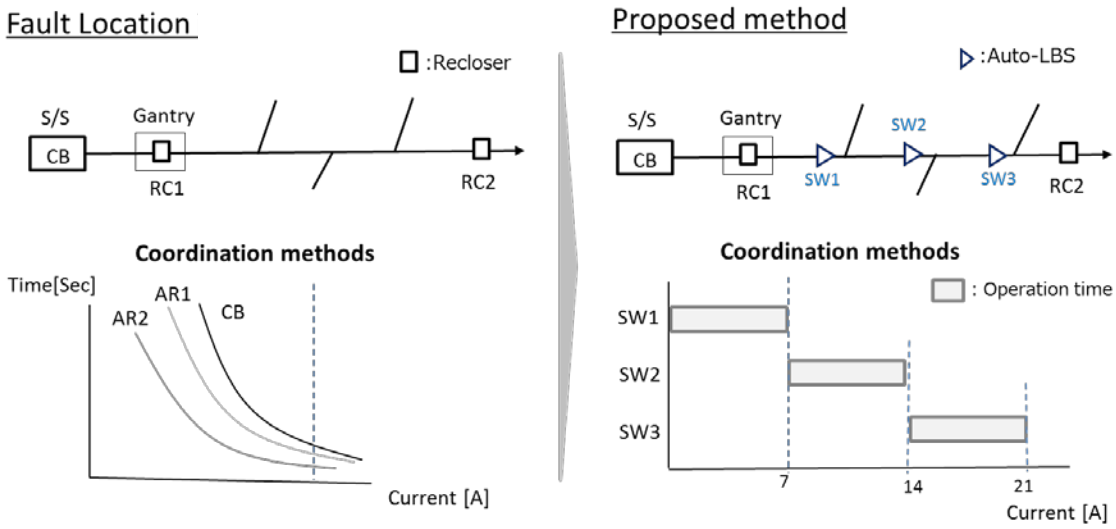
In addition, considering that the population density of Dhaka is getting very high and there's little land availability for expanding and upgrading the distribution network, it is time for Dhaka city to consider promoting the distribution undergrounding for securing more space for this.
The JICA Study Team proposes that a comprehensive plan for upgrading the distribution network system in Dhaka area, which targets at implementing the following three components of solution; "Distribution automation with sequential fault location methods", "Distribution line fault detection method for overhead MV lines" and "Distribution undergrounding".

Distribution Automation with Sequential Fault Location Methods
As a measure for improving power supply reliability, it is considered desirable to introduce Japan's timed delivery method in combination with the reclosing method. In the timed delivery method, switchgears are controlled automatically in the following manner.

- When a fault occurs, the circuit breaker (CB) of a feeder that is located at the secondary point of substation (CB in Figure 4-10) opens in order to protect the appliances connected to this feeder, and all of the switches are set open automatically.
- The CB is closed, and the switchgears are then closed one by one. When a switchgear detects a voltage at its primary side, it closes automatically after seven seconds.
- If a fault occurs again within 5 seconds of closing, it is considered that the fault point exists at its secondary side of the switchgear and the switchgear returns to the open position (lockout).
- The power supply to the areas that are not damaged is restored.

In this manner, protection coordination is characterized by simple time setting alone. It is more effective in connecting a plurality of automatic switches in series and has high expandability for long distance distribution lines. However, since reclosers have already been installed, by applying this method on the load side of the recloser, it will be a more effective facility configuration method as it utilizes the existing facilities.

When applying this to distribution lines in Bangladesh, it is also necessary to establish a time setting related to the length of the distribution line and to verify its effects, such as proper operation. Confirmation of the coordination verification is also important for practical application in protection relays at substations with the proposed system.

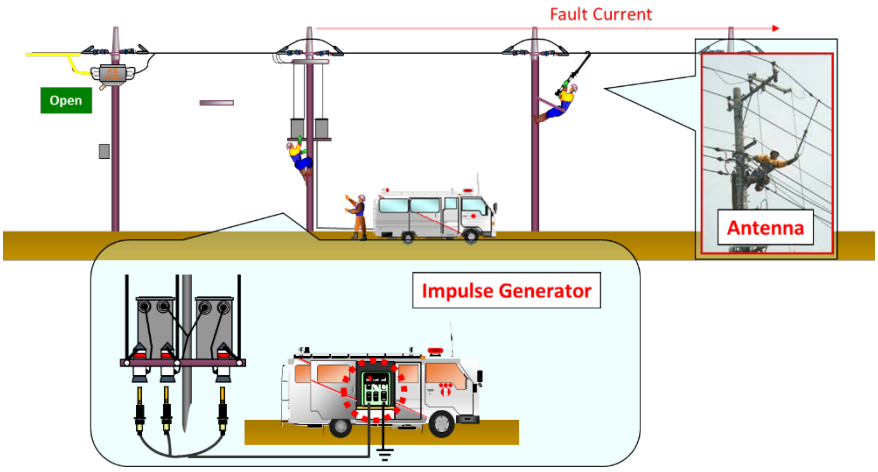


Source: JICA Survey Team

Figure 4-10 Fault location methods

Distribution Line Fault Detection Method for Overhead MV Lines

At present, each distribution company uses a fault indicator which detects the fault current to effectively patrol the MV feeders. However, as it is fixed at a specific point on the MV feeders, it is not effectively utilized in some situations. Therefore, a fault detection method using a portable generator and antenna is recommended. This method will contribute to the quick detection of fault points. The fault detection method is as follows.



Source: JICA Survey Team

Figure 4-11 Fault point detection method adopted by TEPCO

In this manner, the fault current is generated by applying a DC voltage up to 15kV with a portable generator to the outage line. Then, field crews put an antenna, which is equipped with a highly sensitive current transformer, to the line and find the direction and the phase of the fault point. This method can identify invisible fault points such as insulator cracks and internal faults in lightning arresters.

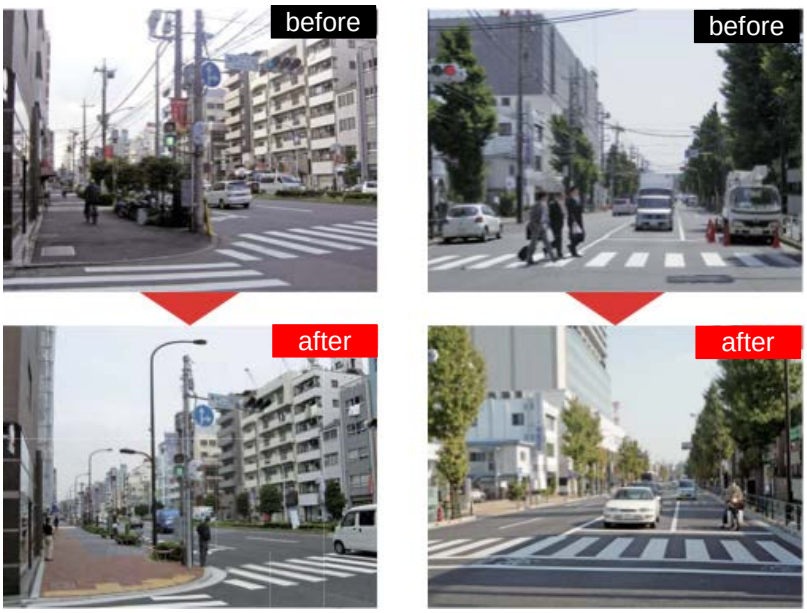
Distribution Undergrounding

Even in the centre of Dhaka city, power distribution network has been installed as overhead facility with electric poles and wires/cables and expanding the capacity of network based on the existing network hardware may have limitation, or at least may result in the waste of land availability. Like in other cities in the world with very high population density, undergrounding of distribution network in central Dhaka as a part of plans to expand the capacity of distribution network for the future demand growth is worth considering.

In fact, the government of Bangladesh declared, as a part of "Vision 2041", "to develop underground distribution system in major cities" "to provide the facility of modern cities with an advance electricity supply system". Following this, power distribution companies such as DPDC, DESCO started formulating plans to implement underground distribution substations and underground distribution system.

Benefits of distribution undergrounding can be described more specifically as follows.

- Improved landscape and less environmental burden;
- Improved traffic of pedestrians and vehicles;
- Avoidance of electric poles that may fall to the ground and block the traffic on the road, which facilitates the restoration from natural disaster;
- Improved reliability of power supply by reducing the accidents from lightning, tree touch and touch of flying objects, and reduction of public accidents;
- Expanding the capacity of distribution network not confined to the capacity of existing overhead network;



Source: Tokyo Metropolitan Government brochure

Figure 4-12 Improved landscape as a result of distribution undergrounding (Tokyo's case)

Needless to say, the drawbacks of distribution undergrounding also need to be pointed out. First, the installation cost becomes much higher than the overhead system and it has discouraged the promotion

of undergrounding. Considering that, distribution undergrounding needs be confined to the centre of big cities and financial support from government and public authorities to the distribution utility companies needs to be considered. In addition, once an accident occurs on distribution network, detecting a fault point on the underground system might be a little more difficult than on the overhead system and restoration from accident may take longer time.

Another thing to be noted in promoting the distribution undergrounding is that, while other utility facilities such as gas pipeline, water supply and sewerage are already installed underground, no systematic rules on how to install such objects under the ground in an integrated manner, except for very limited regulations about safety requirement.

Undergrounding of distribution network without advanced management of utility hardware under the ground may result in a disastrous confusion and high costs for restoration once a huge accident occurs. It is highly recommended to establish a standardized rule to arrange the location of underground objects among utilities and to introduce an advanced system to administrate the underground objects along with a plan to develop distribution undergrounding.

< Expected tasks >
Main tasks of the technical assistance for upgrading the distribution network system in Dhaka area, which consists of the three components of solution, e.g. “Distribution automation with sequential fault location methods”, “Distribution line fault detection method for overhead MV lines” and “Distribution undergrounding”, are as follows.

- Review of the existing power distribution network system in central Dhaka area;
- Review of the ongoing projects for upgrading the distribution network system, e.g. projects to deploy SCADA, AMI etc.
- Coordination with public authorities in developing distribution undergrounding also considering the coordination with other utilities such as gas, water supply, sewerage and telecom etc., and formulating the standards and rules of installing underground objects;
  - ✓ Japan’s experience of standard formulation can be introduced;
- Developing mid- and long-term plan of upgrading distribution network and cost estimation as well as conceptual designing;
- Capacity development program to assist the skills of designing the upgraded distribution network system;
- Proposal of pilot projects upon selecting the pilot site where high benefit against the cost of implementation can be expected;

■ Improvement of power grid operation (Project #13)

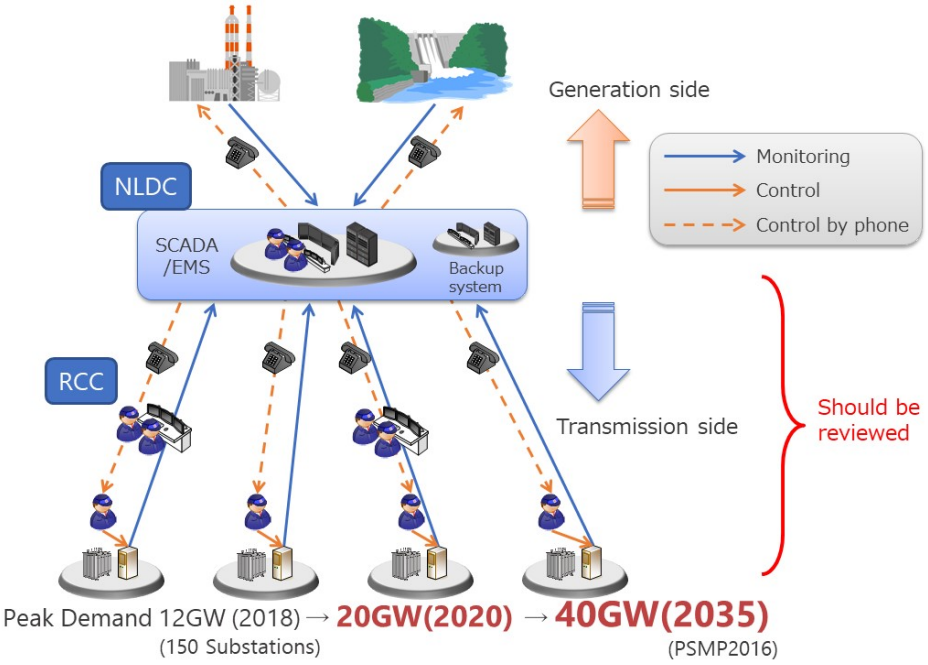
Table 4-10 Outline of "Improvement of power grid operation" project

Project name	Operational efficiency improvement of electricity transmission grid
Project type	Technical assistance
Finance scheme	Grant
Goal	Improvement of power supply efficiency and quality by modernizing the monitoring and control organization and system for power transmission and distribution grid
Project summary	・ Establish the grid monitoring and control organization adapted to future grid expansion. ・ Introduce SCADA optimized for the future grid monitoring and control organization. ・ Training for improvement power efficiency and quality through efficient operation and for efficient operator addition to prepare for future grid reinforcement.

Source: JICA Survey Team

< Current status and issues >

Power demand in Bangladesh is increasing rapidly. To transmit and distribute evacuate the huge amount of electricity power, power grid must be expanded. In order to distribute electricity to customers, operation of transmission and distribution grid requires careful attention from ability to smoothly stop and recover, safety and Environmental and social consideration. Bangladesh has one control centre that not only adjusts generation output to meet constantly changing demand but also operates the transmission power grid (see Source: JICA Survey Team
Figure 4-13).



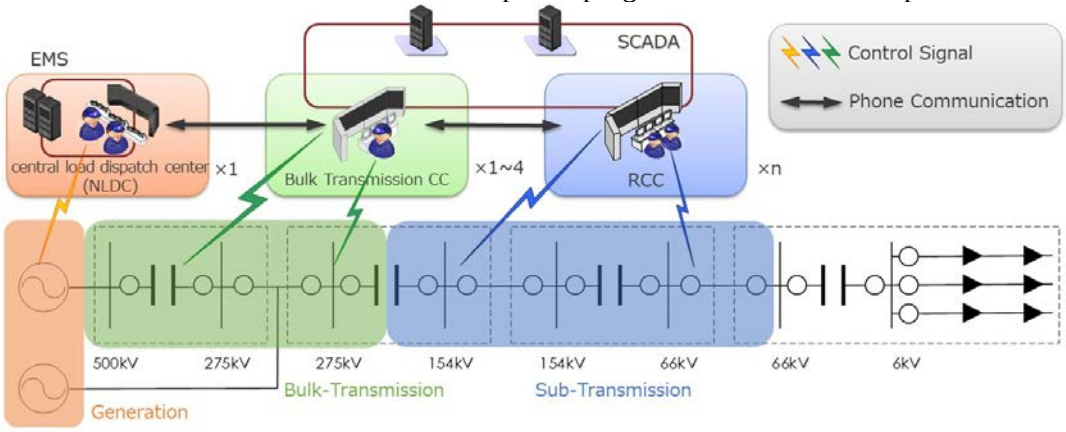
Source: JICA Survey Team

Figure 4-13 Current grid monitoring and control organization in Bangladesh

There is a limit to the range that each operator can operate. Unless systematically strengthening the grid monitoring and control organization, it can lead to excessive investment in human resources or degradation of power quality due to shortage of human resources. Moreover, even if the organization is improved, proper operation cannot be carried out unless human resources are increased and trained.
In Japan, Restructuring and integration of the grid monitoring and control organization for has been repeated (see Source: JICA Survey Team
Figure 4-14).

SCADA optimal for the organization has been designed each time. In addition, operators are developed by a systematic human resource development program and training facilities, and operations that

transmit and distribute high quality electricity are realized (see Source: JICA Survey Team Figure 4-15).
Bangladesh does not appear to have specific plans on future grid monitoring and control organization and system. There are no human resource development program and facilities for operators.



Source: JICA Survey Team

Figure 4-14 An example of grid monitoring and control organization in Japan

Source: JICA Survey Team

Figure 4-15 Training centre with grid monitoring and control simulator in Japan

< Suggestion >
Matters that need to be prepared to properly operate the expanding power system are as follows.

- To improve power quality: As the reinforcement of power generation and expansion of grid, it is estimable that the current organization monitoring and controlling both the generation side and the transmission side will be reached to the limit. The current grid monitoring and control organization should be reviewed.
- To properly allocate personnel: When substations and transmission lines increase, control centre on the power transmission side should be increased and the roadmap should be created at an early stage.
- To introduce the appropriate system: In restructuring and increase of the control centre, it is necessary to design a grid monitoring and control system that can be flexible to organizational change.
- To develop human resources: To increase the number of control centres will require more human resources to operate. It will be important to prepare a human resource development program and the training environment.

< Expected tasks >
After investigating the current grid monitoring and control organization and system, next steps to be carried out in order to efficiently operate the transmission grid are shown below.

- Future grid monitoring and control organization design
  - ✓ Evaluate the current grid monitoring and control organization and examine the future organization based on the future grid reinforcement plan.
  - ✓ Examine the development plan of organization consistent with the development plan of grid expansion.
- Design of future grid monitoring and control system
  - ✓ Design a grid monitoring and control system that adapts to future organization and its deployment plan.
- Consideration of human resource development system
  - ✓ Examine plans to develop human resources that are necessary for the future grid monitoring and control organization.
  - ✓ Examine the design and installation process of facilities necessary for human resource development.

■ Decentralized power supply system (Project #14)

Table 4-11 Outline of "Decentralized power supply system" project

Project name	Plan to develop next-generation grid system considering the deployment of distributed energy resources and electric vehicles
Project type	Technical assistance
Finance scheme	Grant
Goal	Preparing the roadmap of developing next-generation grid system
Project summary	・

Source: JICA Survey Team

< Current status and issues >
Considering the world-wide trend that the cost of renewable energy has been declining rapidly, the share of renewable energy in total energy supply is also expected to increase in Bangladesh. If the generation cost of small DERs can be reduced, which might be the biggest challenge for their diffusion, they are expected to play a significant role in supply power in Bangladesh, the country with a large continuous growth potential in electricity demand.

In the meanwhile, considering the high population density and limitation in land availability of the country, focusing on the promotion of small distributed energy resources (DERs) including rooftop PV rather than large-scale mega solar and wind parks is recommended as its long-term strategy.

There are concerns that if small PVs with unstable output are disseminated, the power flow in the network system may become complicated, especially at the lower-end distribution network, to place heavier burden on the country's distribution system which is vulnerable even today. This will cause an increased need for supply-demand control at the distribution system level in the future.

It is also expected that as the end-consumers own PV, batteries and other DERs, it will lead to the necessity to build a platform to trade available supply power at distribution system level. In other words, end-consumers will also become the provider themselves, which is "prosumer". Studies on the introduction of grid control technology based on DER dissemination have already started in developed countries. As long-term challenge after strengthening the fundamental capability of power distribution network in Bangladesh, the necessity to upgrade the network system to come up with such new technologies of DER should also be considered.

As already discussed in (4), Bangladesh has a good potential of deploying electric vehicles (EVs) depending on the cost reduction in the future. EVs may be a deteriorating factor the power supply system if EV charging adds to the rapid increase of peak demand in the evening. However, EVs also have a potential to contribute to the stability of power supply if their batteries that are connected to the grid are controlled to provide balancing power, a.k.a. ancillary services, with the support of smart charging systems and V2G (vehicle to the grid) technologies.

< Target to achieve >
Long-term plan of next-generation grid system considering the deployment of distributed energy resources and electric vehicles is prepared. A pilot project to evaluate its feasibility is proposed.

< Expected tasks >
- Study on the worldwide trend of deploying DERs;
- Study on the worldwide trend of smart charging system and V2G technologies;
- Formulating a future scenario for developing next-generation grid system in Bangladesh and a roadmap;
- Identification of pilot projects to evaluate the feasibility;

4.3 Step3: Formulation of ODA Loan for Power and Energy Sector Infrastructure Project

Power and Energy sectors in Bangladesh are currently experiencing a very rapid transformation. Economic growth needs massive increase of energy and power supply while domestic natural gas is supposed to come to a depletion in coming future, obliging Bangladesh to rely more and more on overseas source of energy. Private investments including foreign investments are also expected to expand rapidly.

Taking into account all these new elements, this study carried out a preliminary analysis of Japanese financial tools so that Bangladesh can make most advantageous use of them. It goes without saying that this information is just an example and specifications for actual implementation will be determined following the official discussion between the two governments.

4.3.1 Conventional ODA Loan

One of the largest projects JICA has approved until now for Bangladesh is “Matarbari Ultra Super Critical (USC) Coal-Fired Power Project” that adopted Japan’s advanced USC (Ultra-super critical) technologies. For this project, good conditions of ODA loan were provided, such as the interest rate of 1.0%, repayment period of 30 years including 10 years of grace period, as far as OECD won’t take further restriction measures on the financial assistance to coal-based energy infrastructure as discussed in the section 3.1.2 . Since the technology of USC aims at most efficient power generation with far less CO2 production than conventional coal fired power plants, it would be worth providing ODA loan on preferential terms emphasizing good cost-benefit performance and reduction of CO2 emission.

Construction of transmission lines, international connecting transmission lines in particular, as well as underground distribution lines and sub-stations, should be similarly eligible for ODA loans on general terms. Provision of ODA loans on general terms for securing necessary funds is also worth considering for the construction of gas-pipelines (new pipelines, formation of circle network and sub-marine pipeline).

4.3.2 Program Loans

As a recent trend of international assistance for development, loan provider sometimes proposes to the loan receiver (developing country) to offer a financial scheme so that a loan will be provided in accordance with the borrower’s achievement of target that are agreed between both parties in advance. Such types of loan are called program loan.

In the scheme of program loan, an expert project is set up to decide on the program as the condition for loan provision to be accepted by the borrowing country, i.e. Bangladesh government. Examples of program are tariff reforms (removal of subsidies), legislation for introducing market competition, sector restructuring for improving efficiency and so. When the targets that are stipulated in the program loan agreement, Bangladesh government can receive the loan.

In general, the borrowing country has more discretion in the usage of such program loan as the incentive for target achievement than the conventional ODA loan that is bound to a specific project.

As briefly shown in the problem tree analysis, a considerable part of problems in the energy and power sector in Bangladesh are caused institutional factors. Sector reforms need to be implemented to meet the stage of development, but the government can be very careful in implementing such reforms because they will negatively affect some stakeholders in the sector. Providing incentives in exchange for the pain is expected to work as a driving force for carrying out reforms.

4.3.3 Equity Back Finance (EBF) and Gap Viability Fund (GVF)

With the advancement of a country's economic development, funding source of for infrastructure development is expected to shift from public fund sources to private investment. However, there are often a case where the hurdle for private fund's participation for an infrastructure project is still high because of reasons such as very huge initial cost, high volatility of return, external factors (e.g. social, political) for private investors to control, etc.

To bridge between such projects and private investment, new types of ODA loans that are expected to be suitable for securing finance for a project under public-private partnership (PPP). Indeed, in power and energy sectors, formulation of projects in collaboration between public sector and private sector is prominent because some projects require very huge capital investment and involvement of public sector in operating the infrastructure.

Here, two examples are presented as the new types of financing utilizing ODA loan: equity back finance (EBA) and viability gap finance (VGF).

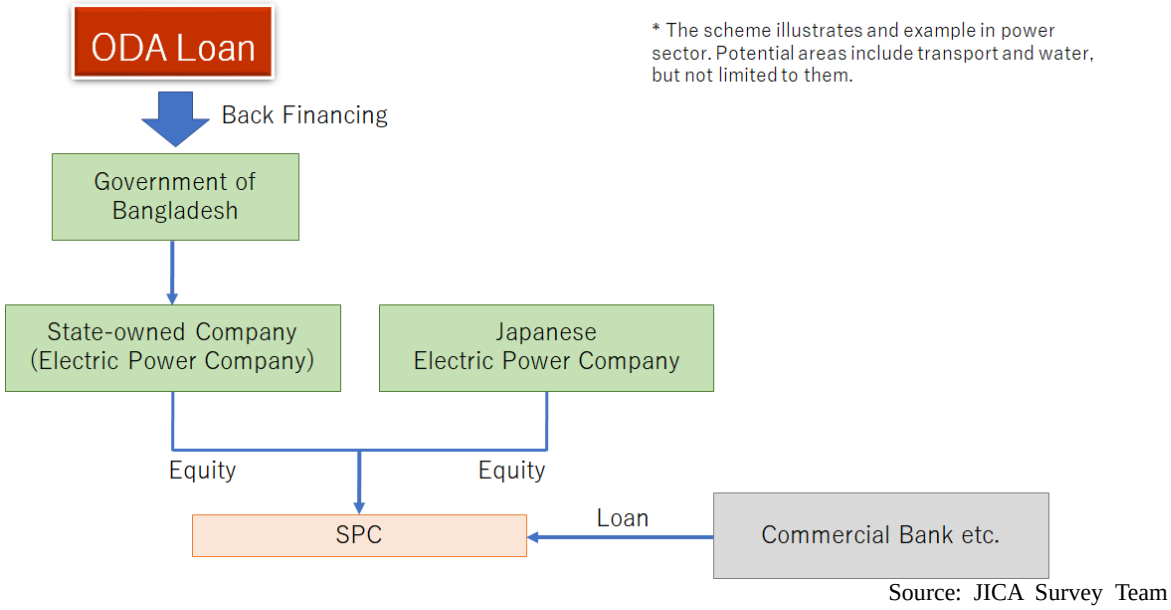
(1) Equity Back Finance (EBF)

Equity back finance (EBF) is a kind of financial scheme where ODA loan is provided to government agencies or state-owned enterprise who utilize this as a part of equity finance in a special purpose company (SPC).

In combination between such public fund and equity participation from private sector, SPC is established as the execution body to implement and operate infrastructure project such as electricity generation, water supply, public transportation system etc.

If necessary, JBIC can also extend necessary funds to SPC in the form of equity or loans, and this scheme therefore does not require huge initial fund for Bangladesh government to prepare on its own for realizing the PPP project. From the viewpoint of Japan, this scheme serves for providing support for infrastructure development in Bangladesh and for attracting Japanese private investors' participation in infrastructure business.

One candidate project where this EBF might be applicable is a project to construct land-based LNG terminal.



Source: JICA Survey Team

Figure 4-16 Flow diagram of equity back Finance (EBF)

(2) Viability Gap Funding (VGF)

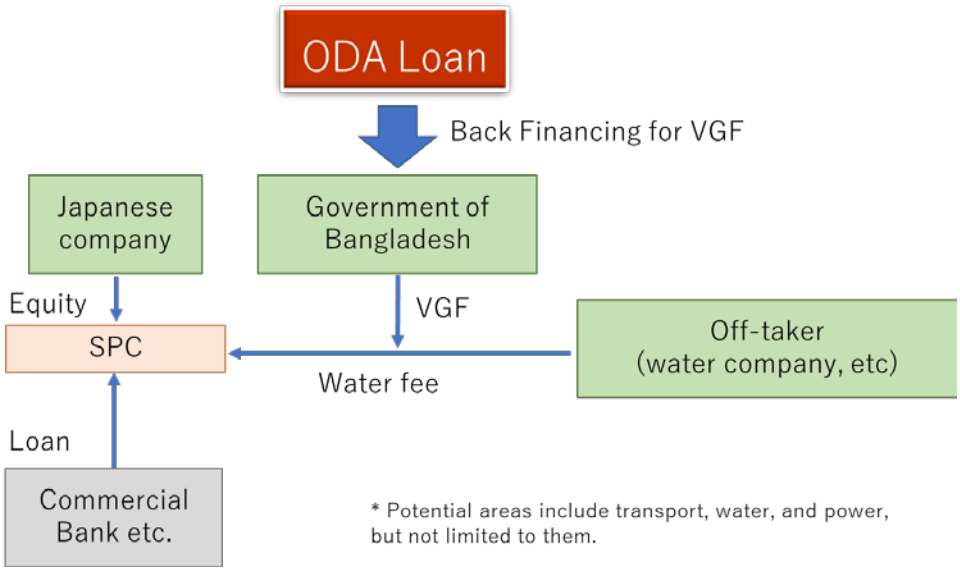
Viability gap funding (VGF) is also a type of financing utilizing ODA loan to infrastructure projects such as electricity generation, water supply, transportation system etc.

Assuming the establishment of SPC to implement and operate such PPP project, in which Japanese firm(s) (and local firms) participates with equity finance. However, in the case where purely private investment may not sustain this project under the existing institutional framework such as low energy prices regulated by the government of a developing country, this government may be expected to provide subsidies to assure sustainable continuation of this project. And this government utilizes VGF as a source of such subsidies.

As the condition for receiving VGF, the government is expected to carry out tariff reforms so that the tariff will be increased gradually and sufficiently in the future, and the excessive profit when the tariff reaches certain level will be allocated to repayment of ODA loan.

Like EBF, JBIC or private commercial banks can supplement the financing of project by providing loans to SPC. Therefore, this scheme is suitable for supporting PPP project with Japanese private investor's participation in overseas infrastructure business while tentatively allowing the subsidies to supplement low energy price regulated by the government.

An example of candidate project for VGF is LNG wholesaling project or IPP power generation project.



Source: JICA Survey Team

Figure 4-17 Flow diagram of viability gap funding (VGF)

4.4 Proposal of Project for Energy and Power Sector in Bangladesh Using Japan's ODA Funds

As the conclusion of this study, the JICA Survey Team proposes on projects for energy and power sector in Bangladesh with highest priority using Japan's ODA funds. Following the project evaluation in the section 4.2.2 this study identified six projects for which Japan's assistance with ODA funds is expected to take a high effect.

An as also discussed in the same section, these projects can be classified into "soft component" projects and "hard component" projects. Three projects, i.e. "1. Strengthening legal framework of LNG import", "5. Gas sector reforms" and "7. Strengthening capacity of power development planning" are categorized as "soft component" projects to support strengthening institutional capacity of the energy and power sector. For these projects, application of program loan scheme as an incentive to motivate sector reforms is considered.

The remaining three projects, i.e. "2. Facility development for LNG import", "6. Development of power plants with related fundamental infrastructure", and "8. Rehabilitation of aged power plants" are categorized as "hard component" projects that deal with installing and upgrading the infrastructure. For these projects, applying a new type of ODA loan called equity back finance (EBF) is worth considering.

In addition, the JICA Survey Team proposes to combine the seven "hard component" projects 2., 6., 8.,9.,10.,12.,13. Into one single project, considering the effectiveness of implementing the upstream project (LNG/Coal import) and downstream project (generation/transmission/distribution/load dispatch operation) in an integrated supply chain. This can be called "value chain" project.

The JICA Survey Team's proposal of three "soft component" projects with program loan and an integrated "hard component" project with EBF are specified in the following section.

4.4.1 Strengthening Legal Framework of LNG Import with Program Loan (Project #1)

Table 4-12 Outline of "Strengthening Legal Framework of LNG Import" project

Project name	Program loan project to support developing institutional framework to address LNG import
Project type	Loan with technical assistance
Finance scheme	Loan
Goal	Provision of sector loan in accordance with the achievement of gas/LNG related legislation. Provision of technical assistance to support this.
Project summary	・ Main tasks of the technical assistance project are as follows; ➢ Analysis of current laws and regulations in Bangladesh and identification of issues; ➢ Comparison with laws and regulations in Japan and USA as benchmark; ➢ Drafting laws and regulations following the discussion with stakeholders in Bangladesh on the results of analysis;

Source: JICA Survey Team

< Current status and issues >
As Bangladesh start importing LNG, it is important to note that the laws and regulations in Bangladesh applicable to LNG import, storage, regasification and delivery of re-gasified gas through pipelines across the country appropriately and sufficiently set out safety, environmental and operationally efficient standards.
Introduction of LNG import should be perceived as an important step for Bangladesh to boost its economy and join the advanced economy. Demonstration of its ability and commitment in safe and environmental handling of LNG is critical in obtaining support from Japan and other countries that are willing to make investments in Bangladesh energy sector. Establishment of global standard in the handling of gas/LNG would contribute to that purpose.

Imported LNG will be stored at the point of FSRUs or land-based LNG receiving terminals, thereafter delivered through domestic pipeline systems. It needs to be noted especially that specifications of imported LNG would vary depending on origin of the LNG and will be different from those of natural gas produced domestically in Bangladesh. Co-mingling of these different specification gases would need to be carried out with carefully crafted heightened level of operational and safety standards, matching those of major LNG importing countries.

Since Bangladesh just started importing LNG for the first time in its history, it will need to deploy the highest level of standards as a pre-caution to avoid any accidents or mishaps in the handling of LNG throughout the process of importing LNG and delivery of re-gasified gas to the point of use. Any accidents or false rumours as to the safety of LNG could provoke protest by the public against the importation of LNG.

In a brief research of this study, it does not appear that current laws and regulations in Bangladesh prescribe provisions adequately address above issues associated with LNG import and distributions. For example, Bangladesh Regulatory Commission Act of 2003 sets out regulating power and functions of the Commission, however, it does not provide for detailed operational and safety standards of the facilities.

The JICA Survey Team recommends that Bangladesh shall review and analyze gas/LNG related laws and regulations in Japan, which is the largest importer of LNG in the world having proven track record of safety in handling LNG for decades, as well as those in the U.S., which is the largest producer of natural gas in the world with the pipeline network running across the country.

(1) Practices in Japan

Laws and regulations on gas/LNG in Japan are set forth based on several perspectives: regulators have prepared regulations from safety, environmental, and import or international competition perspectives. For example, Japan has regulations on gas/LNG business under Gas Business Act and High Pressure Gas Safety Act which are set forth mostly from safety perspective.

Some of the provisions that may be relevant to Bangladesh LNG import are as follows:

- Gas Business Act (title only)
  Article 3 (Registration of Business)
  Article 13 (Security of Supply)
  Article 18 (Obligation to Inspect Calorific Value)
  Article 19 (Supply Plan)
  Article 21 (Maintenance of Gas Facilities)
  Article 23 (Obligation to Inspect Gas Quality)
  Article 24 (Maintenance Standard)
  Article 25 (Chief Engineer)
  Article 26 (Chief Engineer License)
  Article 29 (Chief Engineer Qualification Test)
  Article 32 (Construction Plan)
- Regulation for Enforcement of Gas Business Act (brief translation only)
  Article 24 (Maintenance Standard)
  - Personnel responsible for the construction and maintenance of gas facilities
  - Alternative personnel to Chief Gas Engineer when he/she is not able to perform the duty
  - Educational matter of personnel responsible for the construction and maintenance of gas facilities
  - Inspection and maintenance of gas facilities
  - Operation of gas facilities
  - Construction standard of gas pipeline
  - Responsible personnel for ensuring the safety of construction of gas pipeline
  - Maintenance issues when constructions are conducted adjacent to gas facilities
  - Emergency responses
  - Recording of gas facility construction and maintenance
  - Penalty of personnel who violated construction and maintenance standard
  - Other matters relevant to the construction and maintenance of gas facilities

(2) Practices in the United States

The United States similarly bases its regulations of gas and LNG on multiple perspectives. Initially, the U.S. Federal Energy Regulatory Commission (“FERC”) regulated the rates and terms and conditions of service associated with LNG import service and required terminals to provide open access service. Through the Energy Policy Act of 2005, the U.S. Congress removed regulation of the rates and terms and conditions of service and allowed for private terminals (though these provisions have a sunset provision).

FERC also regulates the construction of interstate natural gas pipelines, including the rates and terms of service. Pipeline and Hazardous Materials Safety Administration regulates to safety of pipelines and has created a partnership program under which participating states may regulate intrastate pipelines within their states and receive federal funding for such programs. In order to qualify for such partnership, a state’s safety regulations must be at least as stringent as the minimum federal safety requirements.

The U.S. Department of Energy regulates imports and exports of the commodity itself and focuses on U.S. economic impacts when considering an LNG import or export application. The U.S. Coast Guard regulates waterway usage.

Some of the provisions that may be relevant to Bangladesh LNG import are as follows:

- Natural Gas Act (title only)
  - Section 3 (Exportation or Importation of Natural Gas, LNG terminals)
  - Section 4 (Rates and Charges)
  - Section 7 (Construction, Extension, or Abandonment of Facilities)
- Regulations
  - 18 CFR 153 (Applications for Authorization to Construct, Operate, or Modify Facilities used for the Export or Import of Natural Gas)
  - 18 CFR 157 (Applications for Certificates of Public Convenience and Necessity)
  - 33 CFR 197 (Waterfront Facilities Handling LNG)
  - 49 CFR 192 (Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards)
  - 49 CFR 193 (Liquefied Natural Gas Facilities: Federal Safety Standards)
- National Environmental Policy Act
  - Section 4332 (Cooperation of agencies)
- Clean Water Act
  - Section 401 (Water Quality Certification)
  - Section 404 (Permit Program)

< Target to achieve >

The JICA Survey Team recommends that GoB enact a set of new laws and regulations that apply to LNG import and re-gasified gas distributions in Bangladesh. It is expected that LNG import volumes in Bangladesh reach significant amount in the next couple years. Early adoption of new laws and regulations is essential to help implement safe and smooth introduction of LNG import to Bangladesh.

The recommended goal of drafting new laws and regulations is by the end of 2020 at the latest. Technical assistance project will also be provided to GoB to achieve this.

As an incentive for GoB to enact such legislation, providing program loan is worth considering so that a low-interest loan will be provided for gas infrastructure development, over which GoB has certain level of discretion, in accordance with GoB's achievement of a program, i.e. legislation of such laws and regulation.

< Expected tasks >

The outline of the proposed technical assistance can be summarized as follows.

- Review of the current situation and identification of issues with the current systems
  - ✓ Consider the optimal legal system for Bangladesh after a comparative examination in reference to LNG and natural gas pipeline, storage, maintenance and management, and safety standards in Japanese and US legal systems
    (Emergency response systems related to crust vibrations, natural disasters (tsunami, etc.), terrorism, and LNG accidents)
- Identification of issues related to legal systems and regulation proposals concerning LNG imports, regasification, and delivery
  - ✓ Consideration of distinction between regulations related to land (under jurisdiction of Federal Energy Regulatory Commission) and sea (under jurisdiction of US Maritime Administration) acceptance bases in reference to examples in the US
- Identification of issues related to legal organization function proposals
  - ✓ Reference to organizations equivalent to the Federal Energy Regulatory Commission in the US
- Identification of issues related to legal proposals concerning domestic pipeline delivery
  - ✓ Setting of quality standards that contribute to safe gas delivery while also taking into consideration the range of gas quality acceptable for end users

  - ✓ Set standards and regulations related to gas pipeline capacity and availability for important infrastructure (power generation facilities, etc.) in reference to the Firm/Non-Firm Transportation Services distinction in the US
- Identification of issues related to safety standard proposals for LNG ship import terminal clearance
  - ✓ Survey on current maritime law and regulations and safety standard related to LNG ship import terminal clearance
  - ✓ Regulations related to tag use and waterway maintenance and management
  - ✓ Required safety standards when assuming risks (terrorism, etc.) related to LNG ships in waterway
  - ✓ Refer to US Coast Guard Waterway Suitability Assessment, etc. in the US

As a starting point of this project, it is important to review current laws and regulations in Bangladesh and determine what additional issues need to be addressed in the existing laws and regulations. Depending on the extent of the changes needed, recommendation will be made for amendments to the existing laws and regulations or re-writing of the laws and regulations anew.

a) Bangladesh Energy Regulatory Commission

Section 4 of Bangladesh Energy Regulatory Commission Act of 2003 (the "BERC Act") established Bangladesh Energy Regulatory Commission ("BERC"). Pursuant to the BERC Act, BERC may issue licenses for power generation, energy transmission, energy distribution and marketing, energy supply, and energy storage (see Section 27 & 28).

We assume that BERC may regulate these activities in Bangladesh by issuing and administering licenses, however there are no specific descriptions as to how and in what areas BERC may regulate these activities (for example, designing and maintenance of the facilities, certification of personnel responsible for safety etc.). It is necessary to find out if there are any published regulations or orders under the BERC Act.

b) Other Laws and Regulations

Although we could not find English versions, it seems that there are several other regulatory acts such as Bangladesh Gas Act of 2010 and Electricity and Energy Rapid Supply Increase (Special) Act of 2015 with regard to gas/LNG. For reviewing them, full English translation of these Acts. It also needs to be confirmed if there are any other laws that may apply to gas/LNG business, because it seems that there may be subordinate regulations or orders under these laws setting forth standards for regulators.

Then, in order to establish a legal system in Bangladesh that is considered a global standard, the laws and regulations in Japan and the USA will reviewed as benchmark.

After completing the analysis of current laws and regulations in Bangladesh, and comparison of them with laws and regulations in Japan and USA, the technical assistance will recommend a set of gas/LNG laws and regulations for Bangladesh. Once the key principles of new laws and regulations are agreed to by MPEMR and BERC, drafting laws and regulations will be conducted for their review.

The expected duration of the technical assistance project is about two years, with breakdown as follows, considering that the draft laws and regulations will be completed by the end of 2020.

- Review of existing Bangladesh laws and regulations: 2-3 months
- Comparison with laws and regulations in Japan and the USA: 2-3 months
- Discussions with MPEMR/BERC on recommended framework of new laws and regulations in Bangladesh: 2-3 months
- Drafting of new laws and regulations: 2-3 months
- Review and comment by MPEMRBERC to the draft laws and regulations: 4-6 months
- Finalizing and fine tuning of the draft laws and regulations: 2-3 months
- Adoption and enactment of new laws and regulations: In 3-4 months

4.4.2 Gas Sector Reforms with Program Loan (Project #5)

Table 4-13 Outline of "Gas Sector Reforms" project

Project name	Program loan project to support gas sector reforms
Project type	Loan with technical assistance
Finance scheme	Loan
Goal	Provision of sector loan in accordance with the achievement of sector restructuring such as tariff reforms and sector restructuring. Provision of technical assistance to support this.
Project summary	・ Main tasks of the technical assistance project are as follows; ➢ Analysis of current cost structure of gas supply and future prospects; ➢ Drafting roadmap for gas tariff reforms; ➢ Prepare a sector restructuring plan to introduce market competition in the sector;

Source: JICA Survey Team

< Current status and issues >
As often observed in emerging countries that can produce fossil fuel for domestic energy demand, energy prices in Bangladesh has been set at a level that is far lower than international prices.

Petrobangla, the single buyer and wholesaler of natural gas, apparently has been making profit on its income statement despite the low tariff rates of natural gas supply for end-consumers. This is due to the low costs of domestic gas production and the revenues from PSC (production sharing contract) that Petrobangla concluded with exploration companies such as IOCs (international oil companies). In other words, Petrobangla's profit and loss balance has been barely sustained because of subsidies.

However, as the domestic gas production is supposed to decline and the country's dependence on imported LNG increases, which is in general far more costly than domestic gas production, Petrobangla will be faced with difficulty in sustaining profitability under the current natural gas tariff rates. In other words, unless the natural gas prices are raised to match the international price level, Petrobangla's contribution to natural budget will decline and in the future Petrobangla's financial conditions may become unsustainable without subsidies, as BPDB has already been in the situation.

The government of Bangladesh is also aware of this situation and has taken measures to address this. Bangladesh Energy Regulatory Commission (BERC) raised the gas tariff in March 2017 and June 2017, which, in combination, will be the increase by 22.7%.

Further steps of tariff reforms still need to follow for eventually balancing the tariff and the actual cost of supply, but it may take a long way forward because energy prices can be a sensitive issue. BERC planned to raise the gas price again in 2018 but recently concluded that "In the present situation we find no reason to raise the gas price" according to news sources[4].

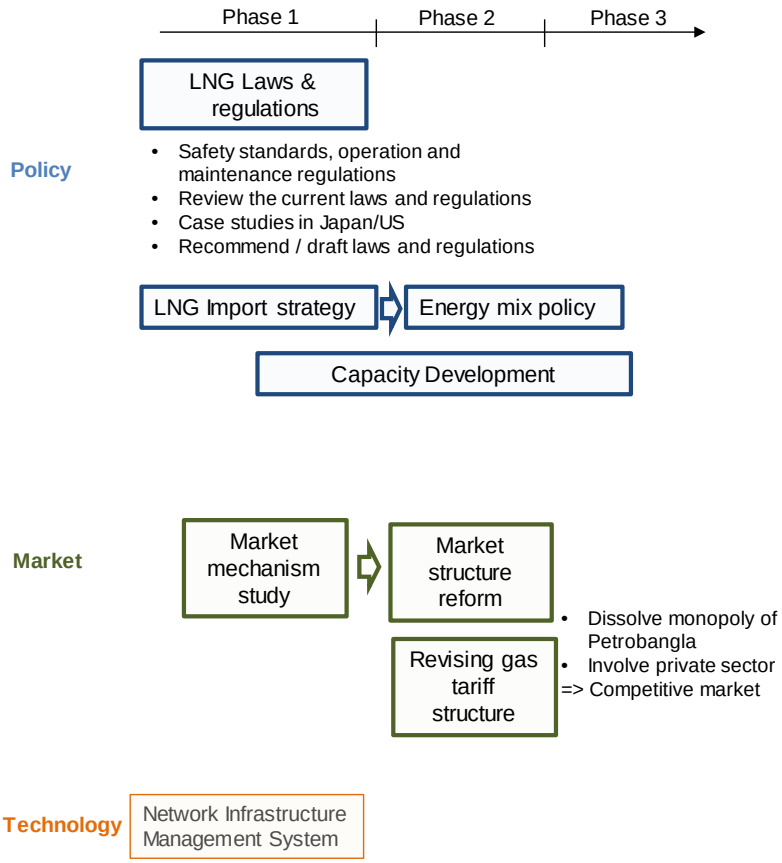
While the gas tariff needs to be raised continuously so that Petrobangla can recover the actual cost of gas supply without subsidies, market competition in gas supply also needs to be in place, especially in wholesaling, so that the cost structure under Petrobangla's monopoly will be reformed. Implementation of market competition may cause financial difficulty on some part of the supply chain that has enjoyed the benefit of monopoly and hence policymakers are reluctant to carry this out.

Like the case of LNG-related legislation project, provision of program loan as an incentive is worth considering. The program loan fund can also be utilized to support the gas sector restructuring so that

[4] Dhaka Tribune "BERC decides against raising gas prices for now", 17th October 2018 (https://www.dhakatribune.com/bangladesh/nation/2018/10/17/berc-decides-against-raising-gas-prices-for-now)

the stranded costs resulting from the introduction of market competition will be mitigated with temporary subsidies.

The JICA Survey Team recommends that the aforementioned project of LNG-related legislation and the project for gas sector reforms will be implemented in an integrated manner to gain the maximum effect. The entire image of integrating these two projects are illustrated in the following diagram.



Source: JICA Survey Team

Figure 4-18 Integration of program loan projects: LNG-related legislation and gas sector reforms

< Target to achieve >
With the provision of program loan as the driving force, GoB will implement new policies on gas supply tariff and market competition in Bangladesh.

< Expected tasks >
As the benchmark for providing loan for expanding and upgrading the gas supply in Bangladesh, the progress of gas sector reforms is monitored. Technical assistance to support the progress will also be provided.

- Analysis of the current structure of the cost of gas supply, as well the future prospects considering the increase of LNG import;
- Evaluation of gap between the cost of gas supply and tariff;
- Policy formulation of introducing market competition in gas supply, especially in wholesaling;
- Drafting roadmap of gas sector reforms;

4.4.3 Strengthening Capacity of Power Development Planning with Program Loan (Project #7)

Table 4-14 Outline of "Strengthening Capacity of Power Development Planning" project

Project name	Project for strengthening the capacity of power development planning
Project type	Loan with technical assistance
Finance scheme	Loan
Goal	Provision of sector loan in accordance with the achievement of the following; • Capacity development for power development planning so that PSMP can be updated autonomously and regularly; • Power sector reforms such as tariff reforms and sector restructuring. Provision of technical assistance to support this.
Project summary	・ Capacity development program for key stakeholders (BPDB etc.) to update PSMP regularly; ・ Technical assistance for power sector reforms; ➢ Analysis of current cost structure of electricity supply and future prospects; ➢ Drafting roadmap for power tariff reforms; ➢ Prepare a sector restructuring plan to introduce market competition in the sector;

Source: JICA Survey Team

< Current status and issues >

a) Revision of PSMP

The JICA Survey Team observed that the local stakeholders in Bangladesh power sector such as BPDB currently have been working on the revision of PSMP2016, so-called "PSMP Revisited", considering the updates since the completion of PSMP2016. This is considered a great step ahead in that it may be the first time that these stakeholders started developing a long-term plan of power and energy supply on their own.

However, it has to be pointed out that this is a minor revision of PSMP2016 and the local stakeholders admitted that they may not have enough capacity to totally revise the plan, from economic projection, to demand projection, formulation of energy supply scenario, simulation of optimal balancing between supply and demand, cost estimation and so on. In fact, it was observed in this study that local stakeholders expect further technical assistance from Japan for improving the skills of power development planning.

From another aspect, there is also a necessity of strengthening organizational capacity for periodical update of PSMP. The ongoing works of revisiting PSMP, i.e. minor revision of long-term plan in a shorter interval than the interval of its major update (every five years in the case of PSMP), is considered a good practice. The current status of power and energy sector inevitably deviates from what was expected a few years ago due to the changes in external and/or internal factors, and this deviation may also affect the projection in the future.

However, it also has to be pointed out that the revisiting work of PSMP has not been routinized yet. The revisiting works are almost reaching the stage of final approval, but it took more than two years since the completion of PSMP2016 and the scheduling of next revision has not been confirmed. Ideally the minor update works like that should be carried out annually as a rolling plan so that the long-term plan can be consistent with a short-term plan, i.e. annual budgeting.

b) Power tariff reforms

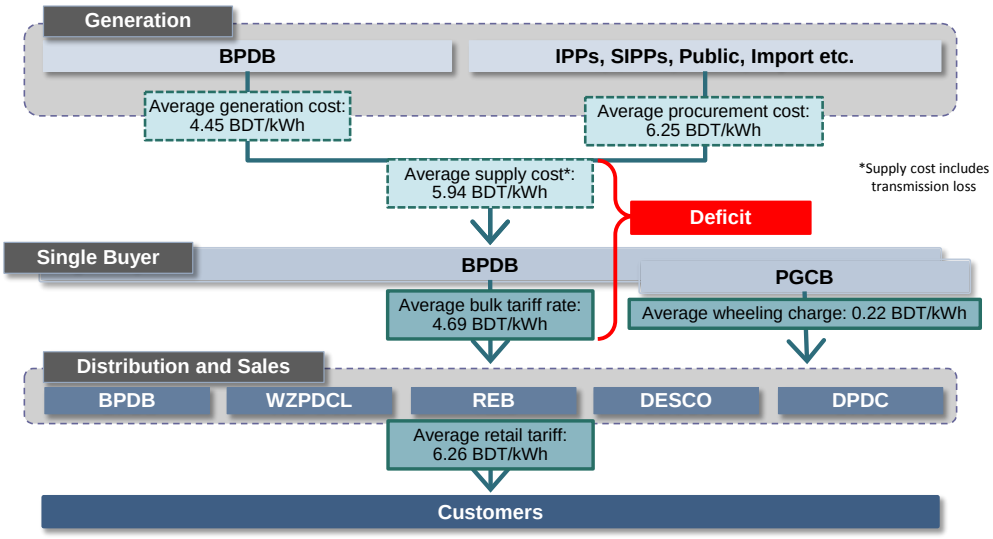
Like the case of gas supply tariff, electricity tariff structure in Bangladesh has been regulated so that the tariff does not recover the cost of power supply properly and the power sector as a whole has been shouldering a burden of deficit. The PSMP2016 analyzed the cost structure of the power sector in Bangladesh and identified that there is a significantly negative price gap between the cost of generation

procured by BPDB and the wholesale price from BPDB to distribution companies.

Table 4-15 Generation Cost, Supply Cost, and Bulk Supply Tariff

Particulars	Unit	FY2013-14	FY2014-15
a) Procurement cost (without general administration cost)	BDT/kWh	5.81	5.78
b) Procurement cost (including general administration cost)	BDT/kWh	5.96	5.94
c) Bulk supply tariff	BDT/kWh	4.71	4.69
c)-b) Difference between bulk supply tariff and procurement cost	BDT/kWh	-1.25	-1.25

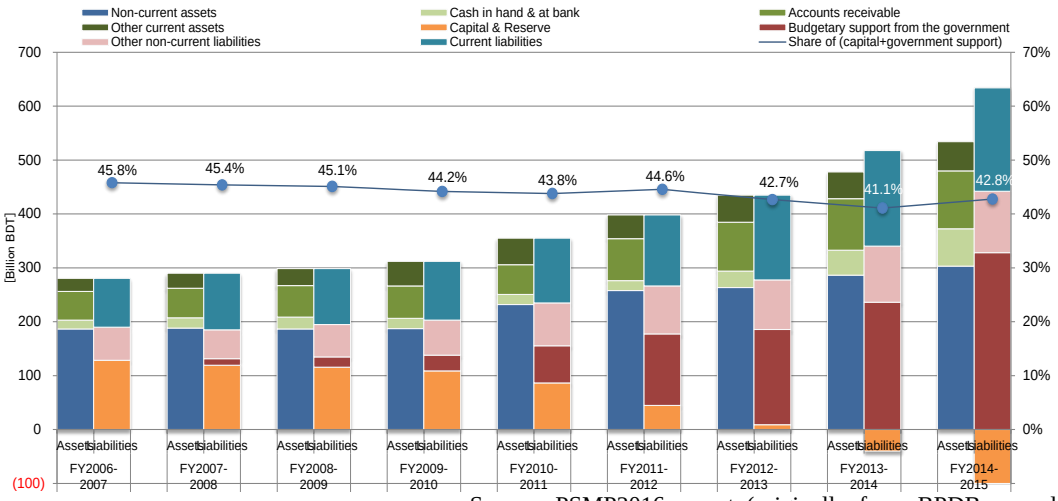
Source: PSMP2016 report (originally from BPDB, PGCB, WZPDCL, DESCO, and DPDC annual reports)



Source: PSMP2016 reports

Figure 4-19 Supply Cost, Bulk Supply Tariff, and Retail Tariff of Electricity (FY2014-2015)

The balance sheet of BPDB, the single buyer and wholesaler of power supply from the grid, clearly shows that the utility company has already been in the status of insolvency if it were a private firm and can only survive with the budgetary support from the government. The financial conditions of BPDB will be worsened acceleratedly unless drastic reforms of electricity tariff are in place.



Source: PSMP2016 report (originally from BPDB annual report)

Figure 4-20 Balance Sheet of BPDB

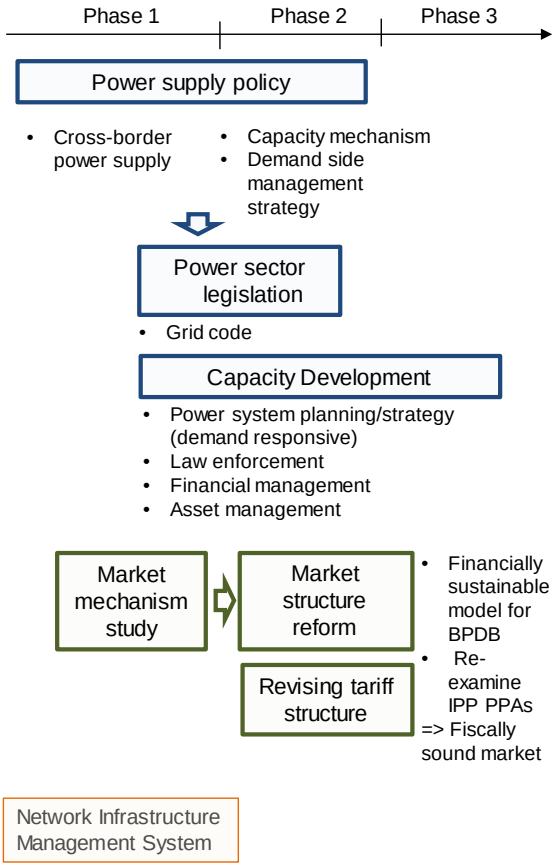
Like in the gas sector, raising tariff to recover the cost of power supply appropriately needs to be achieved together with the introduction of market competition, i.e. at least BPDB's monopoly in the power wholesale will need to be introduced.

< Target to achieve >
Provide technical assistance to local stakeholders related to power development planning in Bangladesh so that they will be able to formulate PSMP in full scale on their own every five years and to routinize the revisiting works (minor revisions) periodically during the interval of major updates.

In addition, technical assistance is also provided for restructuring the electricity tariff system so that it will appropriately recover the cost of supply.

< Expected tasks >

- Capacity development for Bangladesh stakeholders in formulating a full-scale PSMP;
  - ✓ Economic projection, considering the long-term transition of national economy;
  - ✓ Demand projection of power and primary energy supply;
  - ✓ Various options of energy supply scenario and simulation of optimal energy mix;
  - ✓ Cost estimation etc.;
- Technical assistance for strengthening institutional framework on power tariff reforms;
  - ✓ Analysis of cost structure, both for individual utility company and for entire power sector;
  - ✓ Analysis of power load for identifying the responsibility of each sector (industrial, commercial, residential etc.) for the cost of power supply;
  - ✓ Calculation of tariff rates that appropriately reflect the cost of supply;
  - ✓ Facilitating a stakeholder meeting for gaining consensus;
  - ✓ Formulation a roadmap for tariff reforms;



Source: JICA Survey Team

Figure 4-21 Flow of power sector reforms (example)

4.4.4 Value Chain Projects with ODA Loan (Project #2,6,8,9,10,12,13)

Table 4-16 Outline of "Value Chain" projects

Project name	Value Chain Projects
Project type	Grant/Loan with technical assistance
Finance scheme	Grant/Loan
Goal	Provision of sector loan in accordance with achievement of the following: • Coal-based Generation Project • LNG-based Generation Project • Transmission Project, including cross-border and PSPP • Distribution Project • SCADA/EMS Project
Project summary	・ Procurement of imported fuel (coal and gas) ・ Coal generation for base load ・ Gas generation for middle/peak load ・ Construction of power and gas transmission infrastructure on time with generation, LNG and gas pipeline plan ・ Improvement of distribution system ・ Improvement of power quality

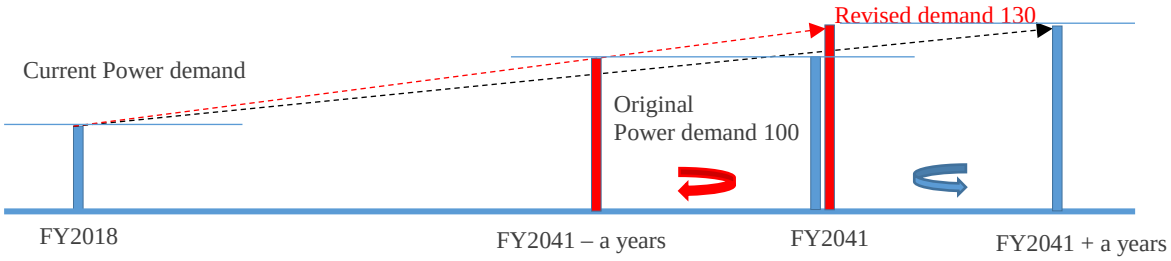
Source: JICA Survey Team

< Current status and issues >

The Government is now finalizing a revision of PSMP2016. Since the JICA Survey Team has not obtained detailed data, the team confirmed that its direction has not changed and it is proceeding in the same direction as PSMP2016, on which the JICA team and the government worked together.

a) Demand forecast

For instance, power demand has been carefully examined and economic conditions are to be changed. Power demand increases by over 30 per cent in 2041. However, in general, a change in the power demand value 25 years later does not greatly affect short to mid-term development planning.
For instance, an upward demand forecast pushes the "FY2041" time some years ahead. However, the system requires its capacity by FY2041 for the original demand and by "FY2041-a" for the revised demand. Thus, the planner shall establish how to supply and satisfy demand 100, and demand 130, either off or on with different velocity. This means that the most important field to be strengthened when making a revision of the power demand is how to accelerate the implementation process for approval of the project, securing the finance and investment environment, rather than discussing the optimum fuel-wise compositions.



Source: JICA Survey Team

Figure 4-22 Concept of power demand change

In addition, as a result of consultation with related organizations concerning the background that the demand assumption increased in the first place, two aspects have come to light. One is that the demand for electricity has also increased with the upward revision of the economic growth outlook and the other is because demand forecast has been made by accumulating value of a regional demand forecasted by each distribution company. Compared to the "macro method" which is considered as one grid for the whole national grid, the accumulation in each region, that is, "micro method" tends to show a larger value than the macro method.

b) Development plan

Although details of Revisiting PSMP 2016 are not published at the present stage, the general power supply composition in the 2041 year section is as follows. The composition ratio of base power supply such as coal and international interconnection, or cross border, is almost the same as PSMP 2016. As the plan to cover the increase in necessary supply capacity due to demand increase mainly by LNG-fire thermal power generation, the composition ratio of gas fire power is rising.

There might be two reasons for this background. Firstly, the discussion exists in that what kind of fuel types generation can be supplied or fulfilled for an upward revision of demand. Cross border, renewable energy introduction has technical restrictions and potential limit, so it is not expected to increase significantly. Therefore it would depend heavily on coal and gas fired thermal powers.

Second, because discussion in that burning coal emits carbon dioxide, which contributes to global warming, prevents from newly constructing coal-fired power, except for existing plans with high possibility of reality. Since there is a limit to piling up of a new coal fired power, the number of coal fired power is reduced, and the gas fired power is correspondingly increased.

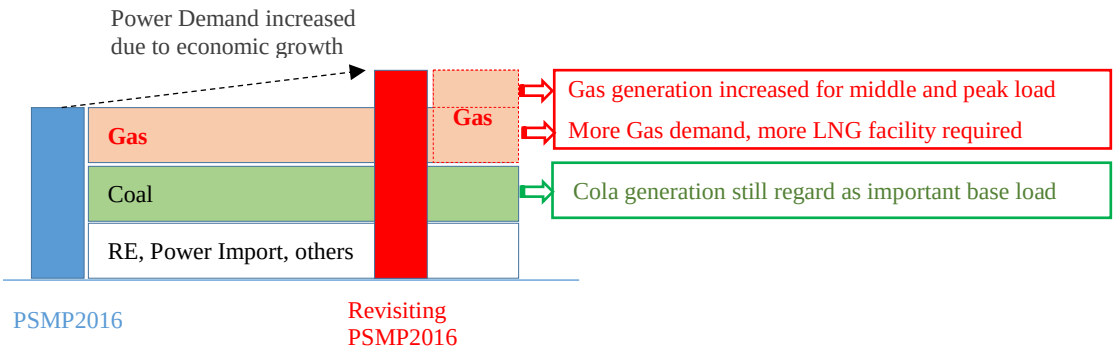
Therefore, similar to PSMP 2016, Revisiting PSMP 2016 aims for the best mix of fuel diversification, and develops coal development as much as possible, however, plans to focus on gas fired power that private funds are likely to gather.
In general, gas or LNG price would be linked with crude oil price at world market. When LNG to be the main power supply in Bangladesh, a cost of power generation has more sensitive cost structure due to world economy and energy price trend, detailed examination of electricity tariff system is also an important issue to be recognized.

Table 4-17 Comparison of fuel-wise compositions in PSMP2016/ Revisiting PSMP2016

(MW basis, Per cent)

Type/Plan	Existing 2017	PSMP2016	Revisiting PSMP2016	(B)-(A) Difference
Gas/ LNG	62	35	45	+10
Coal	1	35	30	-5
Power Import	5	15	15	0
Others	32	15	10	-5
Total	100	100	100	0

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4-23 Concept illustration for revisiting PSMP2016

< Target to achieve >
From the viewpoint of energy best mix, construction of coal fired power as a base load and gas fired for middle and peak load with power transmission line is very much essential as well as fuel supply network infrastructure such as land based LNG and gas pipeline and power transmission infrastructure are to be expanded for supplying stable electricity at a reasonable low price.

< Expected tasks >

a) Coal-based Generation Project

Regarding the construction of Matabari Unit 1&2 currently under construction in the Matabari region, Ultra Super Critical (USC) pressure coal-fired power plants, as well as construction of Units 3&4 as planned, it is necessary to secure base power supply at the earliest pace and help reduce weighted average generation cost, and the continued financial and technical support on funds with public-private partnership schemes are highly expected.

The Merits, in case Matabari unit 3 and 4 with same specifications of unit 1&2 as a complex development are examined as follows:

<Merit for cost reduction>
- Cost reduction of design & engineering for construction/equipment is available.
- Cost reduction of new construction buildings for office / accommodation is available.
- Cost reduction of new construction for temporally facilities is available.
- Cost reduction of new simulator for training is available.
- Cost reduction of spare parts is available due to common spare parts management is possible.
- Cost reduction of training for O&M engineer/operator is available due to same equipment was installed for unit1 & 2.

<Merit for shorter construction period>
- Construction/commissioning period reduction is available.
- Shorter period of contract preparation/negotiation is available.
- Reduction/optimization of engineering work is available.

<Merit for quality improvement>
- Quality improvement for construction/install work can be available.
- Technical specification can be improved due to experiences of unit1&2.
- More stable operation can be available due to same equipment is installed for unit1 & 2.
- O&M know-how from unit1 & 2 operation experiences can be available.
- Maintenance plan can be made more efficiently with unit1&2 experiences.

<Merit for risk management during construction period>
- Optimization of construction schedule/heavy equipment management can be available.
- Experienced contractor/worker for unit1&2 can be available for unit3&4.
- Know-how of local permits is available due to experience of unit1&2 can be reused.

b) LNG-based Generation Project

Since gas fired power plant projects by import LNG are newly developed in Bangladesh, ODA to surrounding infrastructures such as onshore LNG receiving terminal and gas pipeline projects are expected for realizing new gas fired power plant projects.

LNG-based gas fired power will increase in the future, however, the legal development related to LNG is aimed at making a mechanism, (i) to legally and firmly protect the government itself, and (ii) to legally support and promote public-private partnership investment. In particular, it is more important to strengthen infrastructure development such as land based LNG base, gas pipeline, and to promote public-private

partnerships such gas fired generation for middle peak (Gas to Power), and Scrap and Build (S&B) of existing gas fired power plant.

- Promoting comprehensive development of land-based LNG base and gas-fired power source (Gas to Power project)
- Existing gas fire Scrap and Build (S&B) (as an example of Old Haripur Power Station, 99MW, to 225MW with same gas consumptions with higher thermal efficiency as proposed on PSMP2016.)

c) Region wide coordination for power, transmission development and power trade

As detailed in the previous section, although there are a number of new power development plan, the plan concerning the transmission network has not been fully implemented. Considering the construction of future power plant groups in Matabari region in particular, it is necessary to provide assistance by the ODA to strengthen the transmission grid.

In addition, from now on, systematization of balancing demand and supply in one country would be shifted from balancing within one country to balancing through the region-wide within the neighbouring countries Therefore, establishment and examination of the possibility of hydropower development (including international pumped storage power plant (PSPP) with India and Bangladesh, and cross border trade with India, Bhutan and Nepal in neighbouring countries, would be a key issue. The establishment of an organizational framework also becomes important issue. (Refer to 4.2.3 for details)

- Development of long distance transmission line form energy hub at Matabari region to Demand center at the capital of Dhaka.
- Package development of cross border interconnections in northern Bangladesh with India, with hydropower development in India, Bhutan, and Nepal.
- Development of pumped-storage power plants located at the border of India and Bangladesh.

d) Advancement of power distribution system

As discussed in the previous clause, Dhaka has already been growing up as a city with very high population density and still sees an increase of population. Considering the rapid growth of economic activities, the power demand in this area is expected to grow still faster. In addition, as the advancement of economic standard of the country, the necessity for improving the quality of power supply as well as securing the quantity has become an important issue, as follows; (Refer to 4.2.3)

e) Improvement of power grid operation

As discussed in the previous clause, in order to distribute electricity to customers, operation of transmission and distribution grid requires careful attention from ability to smoothly stop and recover. Bangladesh has one control centre that not only adjusts generation output to meet constantly changing demand but also operates the transmission power grid. However, there is a limit to the range that each operator can operate. The following reinforcements are required. (Refer to 4.2.3)

- Future grid monitoring and control organization design
- Design of future grid monitoring and control system
- Consideration of human resource development system

Chapter 5 Conclusions and Recommendations

5.1 Conclusions

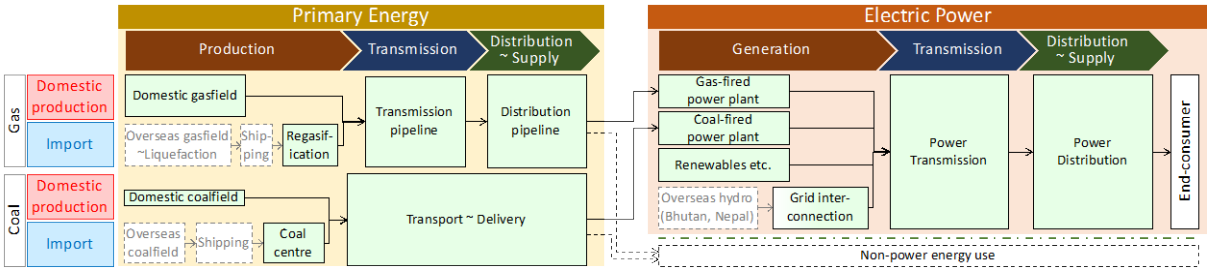
As discussed in the previous chapter, the **Four Major Fields** have been identified, and they are to be reinforced in the Value Chain of both the Energy and Power Division, as follows:

1. **LNG Legal Structure** establishment for proper fuel procurement and supply
   Procure stable natural gas from abroad to provide supply both for non-power uses, such as commercial, industrial, and residential areas, and for power generation.

2. **Gas Sector Reforms** for proper fuel procurement and supply
   Foster financially self-sufficient energy utility management in procurement, supplemented with natural gas imports that are stable in volume and price.

3. **Power Development Planning Capacity Building** for proper planning and construction
   Continue efforts to strengthen and modify infrastructure development planning in order to promote a flexible response to rapid changes in financial, political and social market mechanisms at short-term, periodic intervals to revise master plan as rolling plan.

4. **Continuous Infrastructure Development for fuel diversification**
   Construction, operation and maintenance to provide appropriate and stable power.
   Construct generation, transmission, and distribution power facility infrastructure, and LNG and gas pipeline expansion are to be well coordinated, so that gas imported properly and efficiently can be supplied to the appropriate customers, markets and generation facilities in order to contribute to a maximization of national economic growth.



Source: JICA Survey Team

Figure 5-1 Value chain concept in Energy and Power Sector

5.2 Recommendations

The JICA Survey Team recognized the energy and power sector as an area to be enhanced during the discussion and exchange of opinions with the Bangladesh Government. The Team has identified focal points in the recommendations as follows.

Legal: Technical assistance for legal structure development

- Review of existing Bangladeshi Laws and Regulations
- Comparison with Laws and Regulations in Japan and the USA
- Discussions with Ministry of Energy/BERC on recommended framework for new Laws and Regulations in Bangladesh
- Drafting of New Laws and Regulations
- Review and comments by Ministry of Energy/BERC on the draft Laws and Regulations
- Finalizing and fine tuning of the draft Laws and Regulations
- Adoption and Enactment of New Laws and Regulations

Sector Reform: Technical assistance for gas sector reforms

- Policy reforms: establishment of safety standards, laws and regulations to meet the increased amount of LNG imports
- Market reforms: tariff reform, introduction of market competition

Planning: Technical assistance for power development planning capacity building

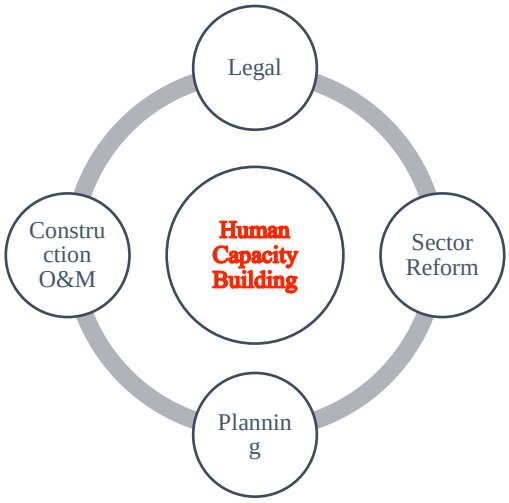
- Capacity development program for key stakeholders (BPDB etc.) to formulate PSMP comprehensively and revise it regularly
- Assistance in order to restructure power tariff system so that the power sector as a whole can recover the cost of supplying power in an appropriate manner

Construction: Technical assistance for construction of power infrastructure

- Construct coal-based power generation facilities for base load. (ODA and PPP)
- LNG-based power plants for middle load. (PPP)
- Implement renewal of existing gas-fired generation facilities at power demand center to utilize existing facilities to the maximum via efficiency improvements. (As an example, Old Haripur Power Station: 99MW to 225MW with the same gas consumption and higher thermal efficiency, as proposed in PSMP2016.)
- Packaged development of cross border interconnections in northern Bangladesh with India, with hydropower development in India, Bhutan, and Nepal. Development of pumped-storage power plants.
- Promotion of gas pipeline and transmission network infrastructure linked with power development.
- Improvement of power system reliability (transmission and distribution operations) with EMS/SCADA, and underground distribution.
- In terms of energy best mix, construction of coal-fired power for base load and gas-fired for middle and peak load with power transmission lines is essential. Fuel supply network infrastructure, such as land-based LNG and gas pipelines, and power transmission infrastructure, are also to be expanded to supply stable electricity at a reasonably low price.

Human Capacity Building/Training: Technical assistance for power sector training program

- Power Division constructed the Power Sector Training Policy (PSTP) in September 2018.
- Capacity building is the most important factor in order to properly implement “Legal”, “Sector Reform”, “Planning”, “Construction”, and “Operation and Maintenance”.
- Support for installing hardware facilities such as the simulator for the under-construction Matabari Ultra Super Critical (USC) coal-fired power plant, and SCADA/EMS simulator for system operation is an important tool to foster capacity building. In particular, how to train instructors, who teach not only the above-mentioned hardware facilities but also the content for the above, is key in building a sustainable human resource development/training center.
- In the medium to long term, although there is an aim to foster or implement capacity development via direct management, it seems this will be difficult in the short term, so it is also possible to commission part of the operation to companies, organizations etc. that have sufficient know-how in this field as an alternative option.



Source: JICA Survey Team

Figure 5-2 Importance of capacity building

5.3 Acknowledgements

The LNG legal development is a particularly urgent matter and the JICA survey team has acknowledged that the need for support in this field from the government of Bangladesh is extremely high for the reasons described below.

- Bangladesh has just started importing LNG for the first time in history, and importing LNG is an important step to further accelerate its economic development.
- Demonstrating the ability to properly handle LNG from the safety and environmental aspects, and showing a commitment to it results in the establishment of a global standard and the attainment of a very important level.
- There are no existing laws or regulations that set provisions dealing with LNG imports or transport issues in the country. In order to secure stable resources from the international market over the long term, development of international law is an urgent task in order to improve the legal environment regarding conformity.
- In view of these circumstances, it is necessary to promptly provide assistance in this field, such as dispatching experts and providing technical cooperation support, using loan capital in order to support the legal environment improvements related to LNG imports.

The JICA survey team also recognizes that for realization of the base load power supply and accompanying transmission line construction, system operation/distribution network improvement is an urgent issue. In particular, coal-fired power supply is regarded as an important power source in terms of best mix in both PSMP and the Revisited PSMP 2016. However, considering climate change issues, it is likely to be difficult to secure private funds on a long-term basis for coal power generation construction.

In terms of energy security and economy, with regard to coal power supply, for which it is difficult to acquire private finance compared with gas power supply driven by private funds, state-of-the-art, highly efficient coal-fired technology can be considered for public support with public finances.

For Bangladesh, which will become a major importer of natural gas for the long term in the future, the development of the legal structure concerning LNG imports and operation will require the establishment of a mechanism to legally and firmly protect the government via legal support, and promotion of private and public investment for LNG trading and related facility constructions.

In addition to providing technical support in order to comprehensively develop sophistication in coal power for base load, gas power for middle load and the existing power supply for peak, along with international interconnections and improvements in the transmission and distribution network for expansion of the power system network in line with urban development, public support is greatly anticipated regarding the legal structure

Chapter 6 Collected Data

The collected data during the surveys are shown as follows.

Table 6-1 Collected data

Sl. No.	Title / File Name	Source/ Folder	File type
1	APSCL Annual Report 2010	APSCL	PDF
2	APSCL Annual Report 2011	APSCL	PDF
3	APSCL Annual Report 2012	APSCL	PDF
4	APSCL Annual Report 2013	APSCL	PDF
5	APSCL Annual Report 2014	APSCL	PDF
6	APSCL Annual Report 2015	APSCL	PDF
7	APSCL Annual Report 2016	APSCL	PDF
8	APSCL Annual Report 2017	APSCL	PDF
9	APSCL Organogram	APSCL	JPEG
10	BERC Act 2003 (Bangla)	BERC	PDF
11	BERC Act 2003 (English)	BERC	PDF
12	Gas Regulation of Bangladesh (English)	BERC	Word
13	New Tariff Rate in Bangla	BERC	PDF
14	Policy Guidelines for Commercial IPP, 2008 (Bangla)	BERC	PDF
15	Policy Guidelines for Commercial IPP, 2008 (English)	BERC	PDF
16	The Bangladesh Gas Act 2010 (Bangla)	BERC	PDF
17	BEZA Brochure	BEZA	Book
18	(Executive Summary) Commercial Operation Statistics, BPDB	BPDB	Book/PDF
19	APA Contract (2018-2019) Chairman & Member Admin	BPDB	PDF
20	APA Contract (2018-2019) Chairman & Member Company Affairs	BPDB	PDF
21	APA Contract (2018-2019) Chairman & Member Distribution	BPDB	PDF
22	APA Contract (2018-2019) Chairman & Member Finance	BPDB	PDF
23	APA Contract (2018-2019) Chairman & Member Generation	BPDB	PDF
24	APA Contract (2018-2019) Chairman & Member P&D	BPDB	PDF
25	BPDB Annual Report 2008	BPDB	Book/PDF
26	BPDB Annual Report 2009	BPDB	Book/PDF
27	BPDB Annual Report 2010	BPDB	Book/PDF
28	BPDB Annual Report 2011	BPDB	Book/PDF
29	BPDB Annual Report 2012	BPDB	Book/PDF
30	BPDB Annual Report 2013	BPDB	Book/PDF
31	BPDB Annual Report 2014	BPDB	Book/PDF
32	BPDB Annual Report 2015	BPDB	Book/PDF
33	BPDB Annual Report 2016	BPDB	Book/PDF
34	BPDB Annual Report 2017	BPDB	Book/PDF
35	BPDB Board Organogram 2013	BPDB	JPEG
36	BPDB Organization Chart - June 2017	BPDB	PDF

Sl. No.	Title / File Name	Source/ Folder	File type
37	BPDB Primary Grid Map 2017	BPDB	PDF
38	KPI May - 2015 - BPDB	BPDB	PDF
39	Loss, SAIDI & SAIFI of BPDB	BPDB	Excel
40	Organogram Member Admin June 2013	BPDB	JPEG
41	Organogram Member Company Affairs	BPDB	JPEG
42	Organogram Member Distribution June 2013	BPDB	JPEG
43	Organogram Member Finance	BPDB	JPEG
44	Organogram Member Generation	BPDB	JPEG
45	Organogram Member P&D	BPDB	JPEG
46	BREB Annual Report 2016	BREB	PDF
47	BREB Annual Report 2017	BREB	PDF
48	BREB Organogram	BREB	PDF
49	CPGCBL Annual Report 2015	CPGCBL	PDF
50	CPGCBL Annual Report 2016	CPGCBL	PDF
51	CPGCBL Annual Report 2017	CPGCBL	PDF
52	DESCO Annual Report 2007	DESCO	Book/PDF
53	DESCO Annual Report 2008	DESCO	Book/PDF
54	DESCO Annual Report 2009	DESCO	PDF
55	DESCO Annual Report 2010	DESCO	PDF
56	DESCO Annual Report 2011	DESCO	PDF
57	DESCO Annual Report 2012	DESCO	PDF
58	DESCO Annual Report 2013	DESCO	PDF
59	DESCO Annual Report 2015	DESCO	PDF
60	DESCO Annual Report 2016	DESCO	PDF
61	DESCO Annual Report 2017	DESCO	PDF
62	DESCO Organogram	DESCO	Word
63	June 2018 DESCO	DESCO	PDF
64	Review of Load demand forecast (DESCO) upto 2041	DESCO	Excel
65	SAIDI & SAIFI - 12-18 DESCO	DESCO	Excel
66	10 year data (Loss, SAIDI & SAIFI) of DPDC - Revised	DPDC	Word
67	APA 2018 - 2019	DPDC	PDF
68	DPDC Annual Report 2011	DPDC	PDF
69	DPDC Annual Report 2012	DPDC	PDF
70	DPDC Annual Report 2013	DPDC	PDF
71	DPDC Annual Report 2014	DPDC	PDF
72	DPDC Annual Report 2015	DPDC	PDF
73	DPDC Annual Report 2016	DPDC	PDF
74	DPDC Annual Report 2017	DPDC	PDF
75	DPDC Executive Summary June-2018	DPDC	PDF
76	DPDC Load Forecast up to 2030	DPDC	Excel
77	DPDC Organogram	DPDC	JPEG
78	New Tariff Rate in English	DPDC	PDF
79	EGCB Annual Report 2013	EGCB	PDF

Sl. No.	Title / File Name	Source/ Folder	File type
80	EGCB Annual Report 2014	EGCB	PDF
81	EGCB Annual Report 2015	EGCB	PDF
82	EGCB Annual Report 2016	EGCB	PDF
83	EGCB Annual Report 2017	EGCB	PDF
84	Organogram of EGCB Corporate Office	EGCB	PDF
85	Organogram of Haripur 412 MW CCPP	EGCB	PDF
86	Organogram of Siddirganj 2X120 MW PPP	EGCB	PDF
87	EMRD Annual Report 2018	EMRD	PDF
88	Organogram EMRD	EMRD	JPEG
89	Energy & Power Magazine (Vol 1 to Vol 16)	Energy & Power	PDF
90	GTCL Annual Report 2017	GTCL	PDF
91	GTCL Existing Pipeline	GTCL	PDF
92	GTCL Future Development plan of Pipelines	GTCL	PDF
93	GTCL Gas Transmission Network Map	GTCL	JPEG
94	GTCL Organogram	GTCL	PNG
95	GTCL SCADA System	GTCL	JPEG
96	KGDCL Annual Report 2012	KGDCL	PDF
97	KGDCL Annual Report 2013	KGDCL	PDF
98	KGDCL Annual Report 2014	KGDCL	PDF
99	KGDCL Annual Report 2015	KGDCL	PDF
100	KGDCL Annual Report 2016 - Part 1	KGDCL	PDF
101	KGDCL Annual Report 2016 - Part 2	KGDCL	PDF
102	KGDCL Annual Report 2017 - Part 1	KGDCL	PDF
103	KGDCL Annual Report 2017 - Part 2	KGDCL	PDF
104	"The Independent" Newspaper Report Compiled	Newspaper	Word
105	PSMP-2016 update - 2018 (Newspaper Reports)	Newspaper	Word
106	LNG Terminal Status in Bangladesh (Newspaper Reports)	Newspaper	Word
107	Govt. Plan Projects 2018 (Newspaper Reports)	Newspaper	Word
108	Organogram of NWPGCL	NWPGCL	PDF
109	Bangladesh GSMP Final Report - Revision 3_2018_03_01	Petrobangla	PDF
110	Gas Demand Forecast -2017 - 22	Petrobangla	JPEG
111	LNG Value Chain Training Program	Petrobangla	PDF
112	Petrobangla Annual Report 2013	Petrobangla	PDF
113	Petrobangla Annual Report 2014	Petrobangla	PDF
114	Petrobangla Annual Report 2015	Petrobangla	PDF
115	Petrobangla Annual Report 2016	Petrobangla	PDF
116	Petrobangla Annual Report 2017	Petrobangla	PDF
117	Petrobangla Organogram	Petrobangla	JPEG
118	Ongoing & Planned Projects of PGCB September, 2018	PGCB	Excel
119	PGCB Annual Report 2010	PGCB	PDF
120	PGCB Annual Report 2011	PGCB	PDF
121	PGCB Annual Report 2012	PGCB	PDF
122	PGCB Annual Report 2013	PGCB	PDF

Sl. No.	Title / File Name	Source/ Folder	File type
123	PGCB Annual Report 2014	PGCB	PDF
124	PGCB Annual Report 2015	PGCB	PDF
125	PGCB Annual Report 2016	PGCB	PDF
126	PGCB Annual Report 2017	PGCB	PDF
127	PGCB Organogram	PGCB	JPG
128	Status of on-going Projects of PGCB	PGCB	Excel
129	Glimmpses of Bangadesh Power Sector, August 2018	Power Cell	Book/PDF
130	Power & Energy Week 2018 (Bangladesh High Performance Bright Future)	Power Cell	PDF
131	Power & Energy Week 2018 intro	Power Cell	PDF
132	Power & Energy Week 2018 speakers profile	Power Cell	PDF
133	Power & Energy Week 2018, Bengali (Anirban Agami)	Power Cell	PDF
134	Power & Energy Week sovinier (Summary in English by EAL)	Power Cell	Word
135	Power Cell Organogram	Power Cell	PDF
136	Annual Performance Agreement (APA) Between MD, DPDC and Secretary, Power Division, 2018-2019 (Photograph)	Power Division	JPEG
137	Annual_Performance_Agreement_2018 between DPDC and Power Division	Power Division	PDF
138	APA 2018-2019 Amendment_revised between BPDB & Power Division	Power Division	PDF
139	APA between Power Division and Cabinet Division	Power Division	PDF
140	APA Contract 2018-19 between BPDB & Power Division	Power Division	PDF
141	Different Target of KPI by Power Division (56_Power_English)	Power Division	PDF
142	Office Order PSMP 2016 revisiting (review) in English (Transleted by EAL)	Power Division	Word
143	Power Division Organogram (approved)	Power Division	PDF
144	Power Division Organogram (present setup)	Power Division	BMP
145	Power Division Annual Report 2017	Power Division	PDF
146	RPCL Annual Report 2017	RPCL	PDF
147	RPCL Gazipur PP Organogram	RPCL	PDF
148	RPCL HQ Organogram	RPCL	PDF
149	RPCL Mymensingh PP Organogram	RPCL	PDF
150	English_Organogram_SREDA Board	SREDA	PNG
151	SREDA approved Organogram	SREDA	PNG
152	Gas Demand Forecast -2041	TGTDCL	PDF
153	Titas Annual Report 2012	TGTDCL	PDF
154	Titas Annual Report 2013	TGTDCL	PDF
155	Titas Annual Report 2014	TGTDCL	PDF
156	Titas Annual Report 2015	TGTDCL	PDF
157	Titas Annual Report 2016	TGTDCL	PDF
158	Titas Annual Report 2017	TGTDCL	PDF
159	Titas Organogram	TGTDCL	PPT
160	Load Demand of WZPDCL	WZPDCL	Excel
161	Organogram-1_WZPDCL	WZPDCL	JPEG
162	Organogram-2_WZPDCL	WZPDCL	JPEG
163	Organogram-3_WZPDCL	WZPDCL	JPEG

Sl. No.	Title / File Name	Source/ Folder	File type
164	Project status of WZPDCL upto September,2018	WZPDCL	Excel
165	Projects requires JICA Assistance	WZPDCL	Excel
166	SAIDI AND SAIFI OF WZPDCL	WZPDCL	Excel
167	System loss of WZPDCL	WZPDCL	Excel
168	WZPDCL Annual Report 2011	WZPDCL	PDF
169	WZPDCL Annual Report 2012	WZPDCL	PDF
170	WZPDCL Annual Report 2013	WZPDCL	PDF
171	WZPDCL Annual Report 2014	WZPDCL	PDF
172	WZPDCL Annual Report 2015	WZPDCL	PDF
173	WZPDCL Annual Report 2016	WZPDCL	PDF
174	WZPDCL Annual Report 2017	WZPDCL	PDF

Source: JICA Survey Team