People's Republic of Bangladesh
Ministry of Power, Energy and Meneral Resources

THE STUDY FOR MASTER PLAN ON COAL POWER DEVELOPMENT IN THE PEOPLE'S REPUBLIC OF BANGLADESH

Power System Master Plan 2010 (PSMP2010)

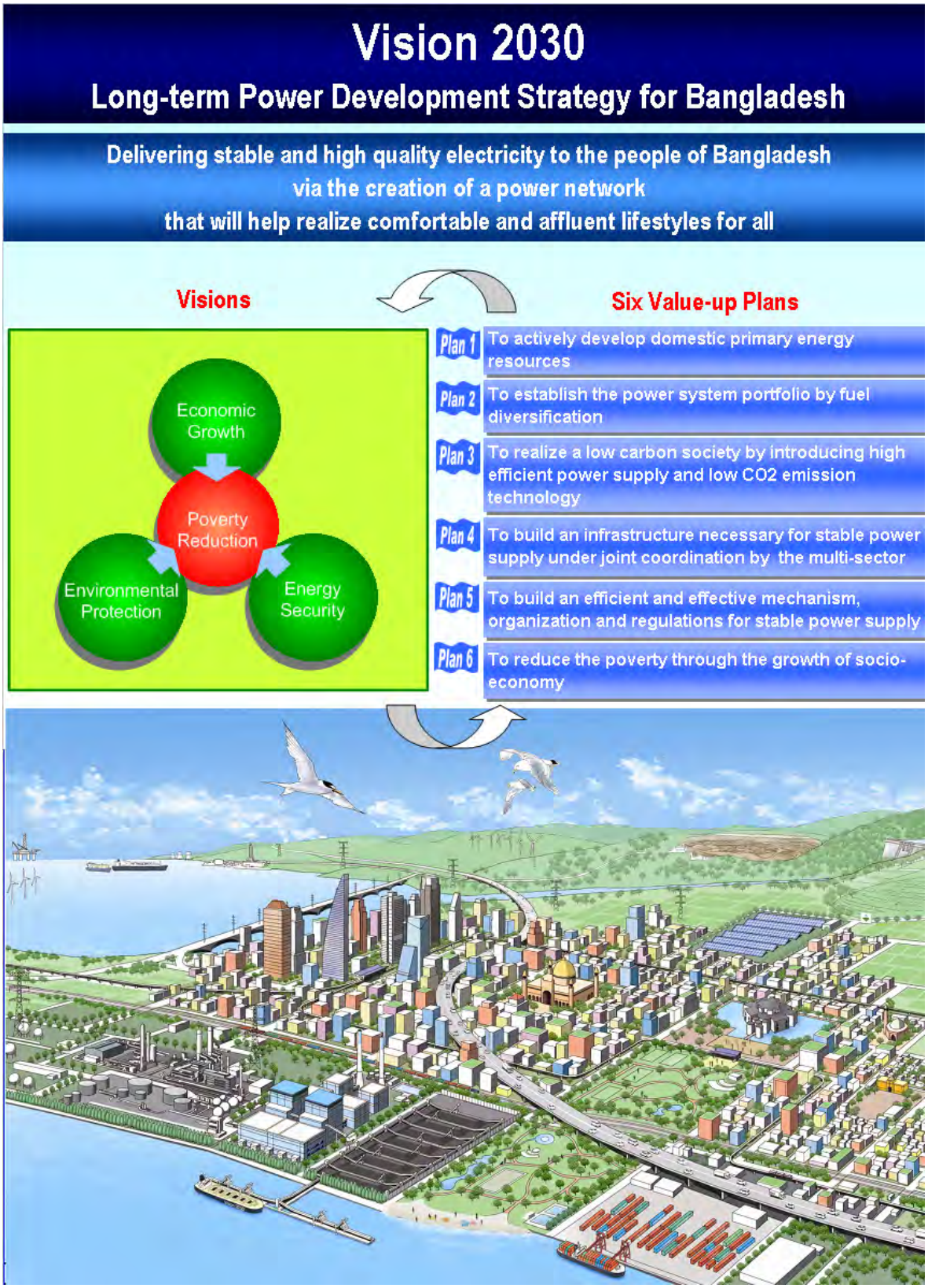
FINAL REPORT

(Summary)

February 2011

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company, Inc.



Source: PSMP Study Team

Multi-Sector Infrastructure Development for the Introduction of Clean Coal Technology in Bangladesh

Multi-Sector Infrastructure Development [Deep Sea Port + Power + Industry + Commercial Area]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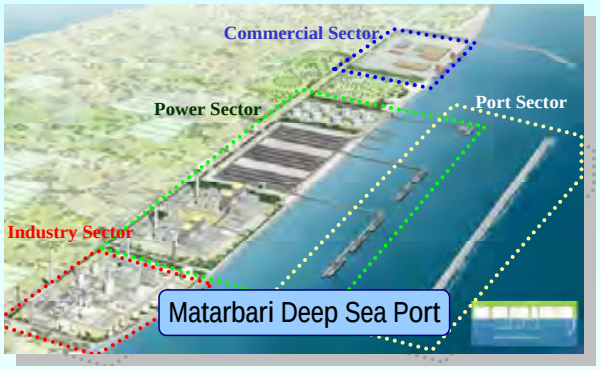
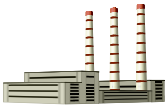
Long-term Multi-Sector Infrastructure Planning

Solving Huge Finance &Technical Difficulties



Clean Coal Technology Ultra-Efficient Coal-fired Power Station (USC)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Ultra-Efficient Facilities (USC)

Capacity Development (O&M)

Legal System Time&Condition based Maintenance for P/S

Realizing Comfortable & Affluent Lifestyles, and Preventing Global Warming

Source: PSMP Study Team

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Chapter 1 Introduction

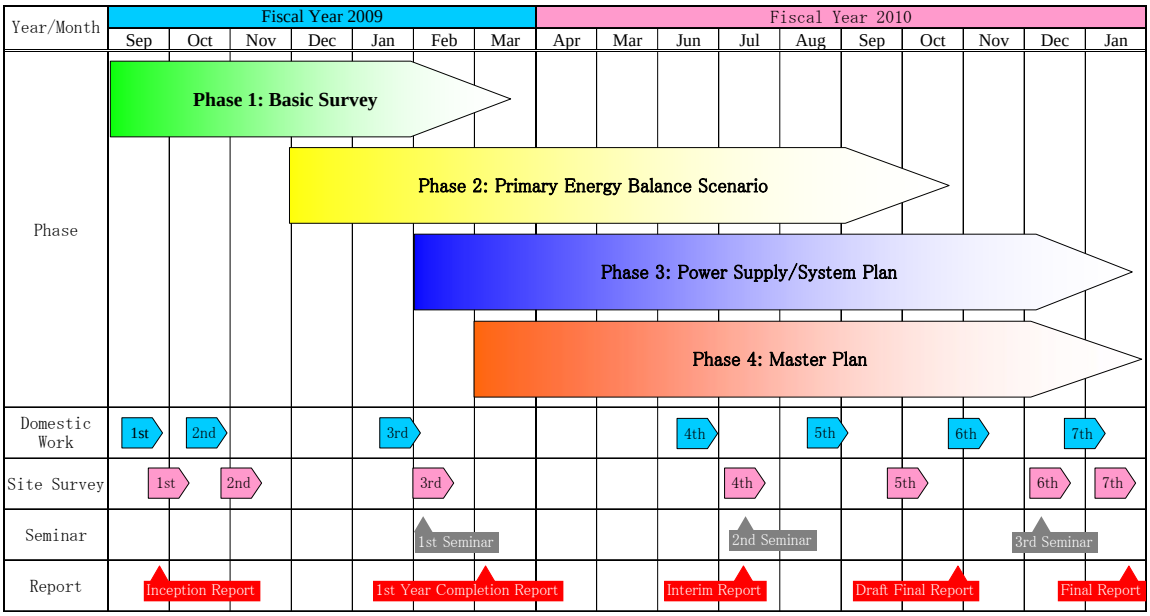
1.1 Objectives of the study

The main objective of this study is to formulate a Master Plan (MP) for the attainment of stable power supply in the People's Republic of Bangladesh up to year 2030 in consideration of the diversification of fuel resources, including an optimum power development plan, power system plan, and identification of the potential power plant sites based on the fuel diversification study. Therefore, this study includes a comprehensive power development master plan where the study of the fundamental conditions of the development (demand forecast, procurement of primary energy resources, optimum power development plan, future optimum power supply structure including the positioning of gas-fired power plants, and so on) are added. In addition, the necessary technology transfer to the Counter Part (C/P) in Bangladesh will be carried out during the study.

1.2 Terms of reference of the study

1.2.1 Schedule of the study

This study for the Master Plan will be carried out over approximately two years from September 2009 to January 2011, a total of 17 months, including seven site surveys. A draft work schedule and work process for each phase is shown in the following chart.

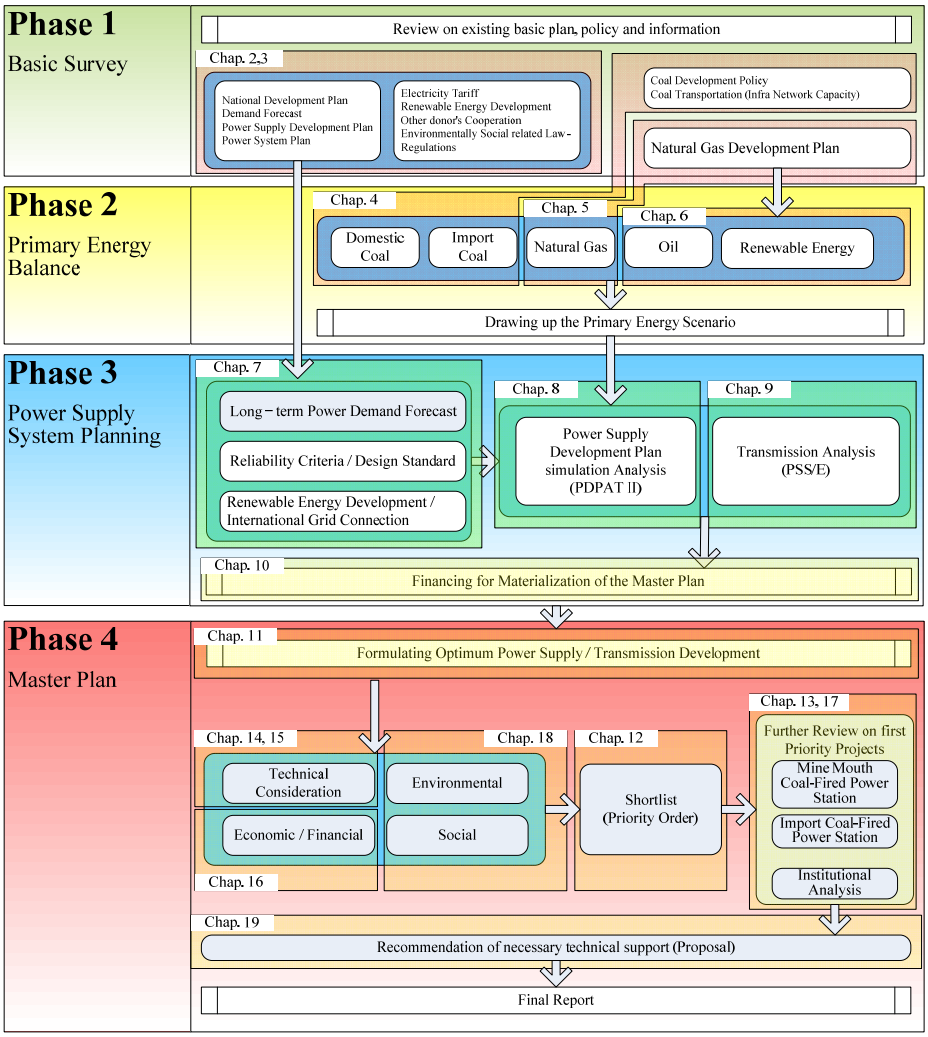


Source: PSMP Study Team

Fig. 1-1 Schedule

1.2.2 Basic work flow

As shown in the basic work flow in Fig. 1-2, the study has been categorized into four phases. The Study will be carried out in close cooperation with each work area to formulate the comprehensive Master Plan on power supply development. In addition, a dissemination workshop will be held at each study stage to reflect the opinions from relevant organizations.



Source: PSMP Study Team

Fig. 1-2 Basic Work Flow

1.2.3 Counterpart organization

- Ministry of Power, Energy and Mineral Resources (MPEMR)
  - ✓ Power Division
  - ✓ Energy and Mineral Resources Division (EMRD)
  - ✓ Power Cell
- Economic Relations Division, Ministry of Finance
- Bangladesh Power Development Board (BPDB)
- Barapukuria Coal Mine Company Ltd (BCMCL)
- Power Grid Company of Bangladesh (PGCB)
- Dhaka Power Distribution Company Limited (DPDC)
- Dhaka Electric Supply Company Limited (DESCO)
- Rural Electrification Board (REB)
- Bangladesh Oil, Gas Mineral Corporation (Petrobangla)
- Electricity Generation Company of Bangladesh (EGCB)
- Ashganj Power Station Company Limited (APSCL)
- North-West Power Generation Company Ltd (NWPGCL)
- Geological Survey of Bangladesh (GSB)
- Ministry of Environment and Forestry Affairs (MOE)

1.2.4 Experts and respective area of the study

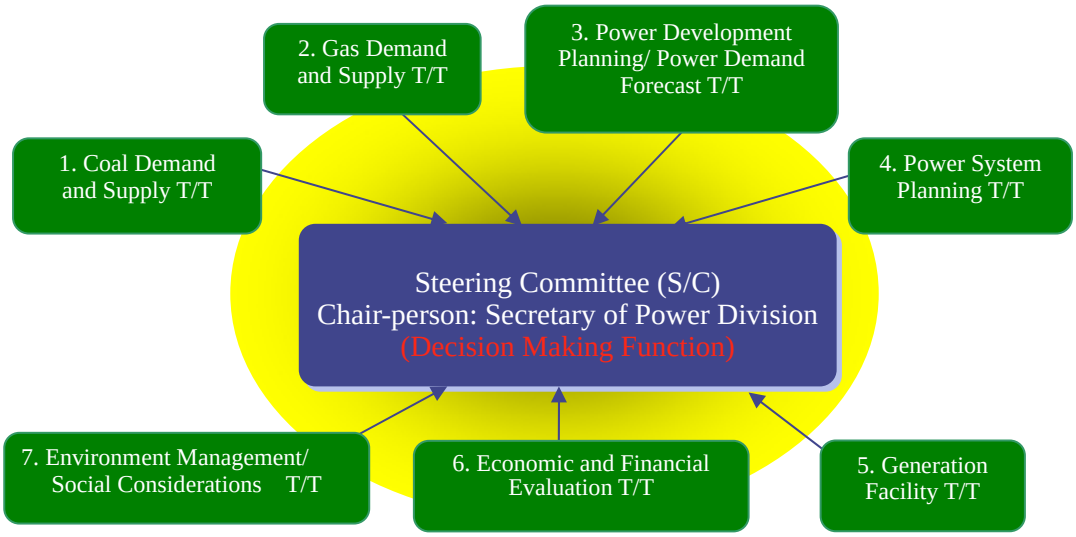
Expert list and its role of work are as follows:

(1) Expert list

Team Leader / Coal-fired Power Generation System	Nobuteru TAKEDA
Sub-Leader/ Power Development Planning / Demand forecast	Toshiyuki KOBAYASHI
Renewable Energy Development	Noboru SEKI
Coal Development/ Supply system A	Hajime ENDO
Coal Development/ Supply system B	Atsushi KAKIZAKI
Natural Gas Supply System A	Kiyoshi KATAOKA
Natural Gas Supply System B	Hideo MATSUSHITA
Natural Gas Supply System C	Chikanobu NAKAMURA
Civil/ Fuel Transportation	Genshiro KANO
Coal-fired Power Generation System/ O&M Management System	Yoichiro KUBOTA
Power Transmission Line and Substation Facilities/ Power System Planning A	Shinichi FUNABASHI
Power Transmission Line and Substation Facilities/ Power System Planning B	Masaki KUROIWA
Economic/ Financial Analysis/ Organization Structure A	Atsumasa SAKAI
Economic/ Financial Analysis/ Organization Structure B	Yasuhisa KURODA
Environmental Management	Takahisa ITO
Social Considerations	Junko FUJIWARA

(2) Steering Committee (SC) and Task Team (TT) Structure

Based on the discussion with C/P, Steering Committee (SC) as decision making board and seven Task Teams as discussion group at working level under SC are formed. The structure of SC and TT is shown in Fig. 1-3. SC is held properly in line with the progress of the Study. The items discussed within individual TTs are brought up at SC, shared amongst both parties, and made decision.



Source: PSMP Study Team

Fig. 1-3 Structure of Steering Committee and Task Teams

1.3 Information sharing and cooperation with Development Partners

Throughout the first to the 5th site survey, the PSMP Study Team has endeavored to share its information with the Development Partners (DP) and discussed the content of the study and the principle by holding individual and joint meetings and attending the forum and official meeting hosted by DP, including the following events.

- The first site survey: from Saturday, 3rd October to Friday, 9th October 2009, Explanation of Inception report, TOR, schedule, principle of the report
- The second survey: from Wednesday, 28th October to Friday, 13th November 2009, track record and progress of the power sector projects supported by DPs as a part of the study.
- The third survey: from Saturday, 30th January to Friday, 19th February, the first Seminar, the report and discussion on the site survey and its findings
- The fourth survey: from Saturday, 3rd July to Friday, 23rd July 2010, the second Seminar, the explanation and discussion of the Interim Report and its concrete context.
- The follow-up survey: from Friday, 3rd September to Tuesday, 7th September 2010, discussion on the comments from World Bank
- The fifth survey: from Saturday, 2nd October to Sunday, 17th October 2010, the joint discussion with DPs and governments regarding the official comments for Interim Report

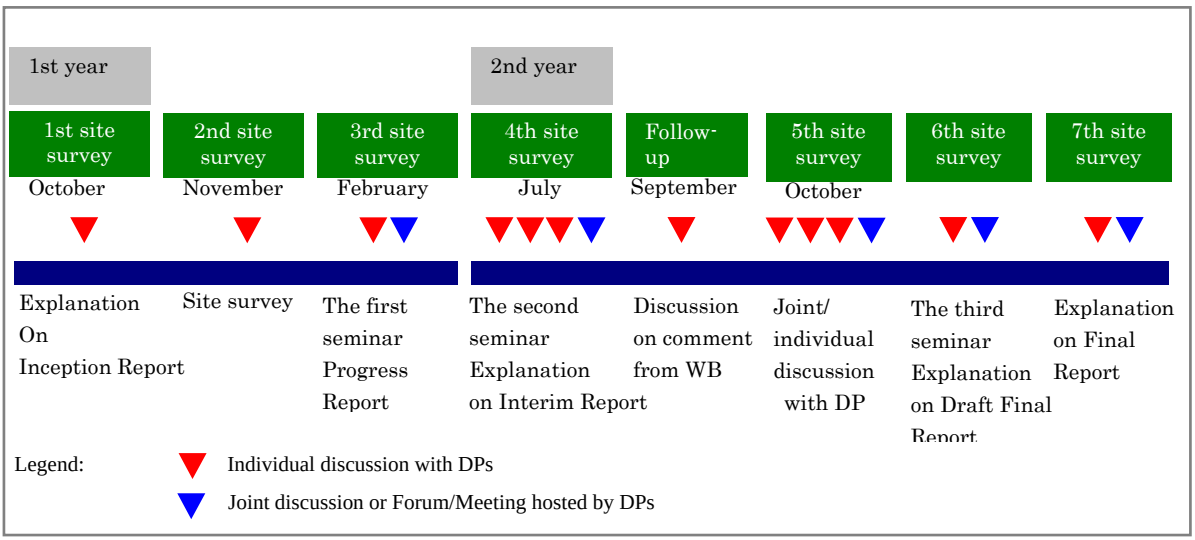


Fig. 1-4 The track record of the discussion with Development Partners

Individual Discussion (every survey)

Bangladesh Development Forum (2010.2)

DP meeting (2010.7)

Joint meeting (2010.10)

Source: PSMP Study Team

1.4 Seminars

1.4.1 The First Seminar

(1) Date: Wednesday 3rd February 2010, 10:00-16:00

(2) Venue: Lakeshore Hotel , conference room

(3) Outline:
The first seminar was held at the Lakeshore Hotel conference room on 3rd February, 2010. The seminar was composed of two parts; the first part was for those at the working level to discuss the context of the survey, and second part was for about 40 persons from the Additional Secretary of Power and Energy Division, DPs including ADB to explain the purpose, principal, schedule, technical transfer and progress of this study. PSMP Study Team and CPs from Bangladesh confirmed the direction of this study via a live discussion during the question and answer session at this Seminar.



Source: PSMP Study Team

1.4.2 The Second Seminar

(1) Date : Sunday 11th July 2010, 14:00-17:00

(2) Venue: BPDB conference room

(3) Outline:
The second seminar was held at the BPDB conference room on 11th July 2010. The main purpose of the seminar was to explain and discuss the Interim Report. The Honorable Adviser to the Prime Minister was attended as the representative of the Bangladesh Government and discussed the primary energy scenario, power demand forecast, the potential sites of the prioritized coal fired power station projects. Bangladesh CP and PSMP Study Team jointly confirmed the direction of the Study hereafter.



Source: PSMP Study Team

1.4.3 The Third Seminar

(1) Date : Monday 13th December 2010, 10:00-17:00

(2) Venue: Sheraton Hotel Ball Room

(3) Outline:
The third seminar was held at the Sheraton Hotel on 13th December 2010. The seminar was composed of two parts; the first session for the high level officials and the second session for the working level. The Honorable Adviser to the PM was attended as the representative of the Bangladesh Government, and the Ambassador of Japan was also attended in the first part, to discuss about outline of the Draft Final Report, and second part was for detail discussion about each expert at the working level. PSMP Study Team and CPs from Bangladesh confirmed the direction of this study via a live discussion during the question and answer session at this Seminar.



Source: PSMP Study Team

1.4.4 Final Report Consultation Meeting

(1) Date: Sunday 30th January 2011, 10:00-13:30 (Lunch session after 12:00)

(2) Venue: Dhaka Sheraton Hotel Ball Room

(3) Outline:
Final Report Consultation Meeting was held at the Dhaka Sheraton Hotel on 30th January 2011. Secretary Power Division and related persons attended this meeting and discuss about the treatment for comments of Draft Final Report, and the contents of Final Report was shared to finalize the report.



Source: PSMP Study Team

1.5 Technical transfer

1.5.1 Technical transfer through Task Team meetings

During Task Team meetings, the technical transfer was proceeded by working analysis and investigation together.



Source: PSMP Study Team

1.5.2 Group training

(1) Power development simulation software (PDPAT) training

The group training for power development simulation software (PDPAT) was held by lecture style.

(1) Date: Saturday, July 10, 2010

(2) Venue: BPDB conference room


Source: PSMP Study Team

(2) Power system planning software (PSS/E) training

The group training for power system planning software (PSS/E) was held by lecture style.

(1) Date: Thursday, July 8, 2010 (Part 1), Monday, January 31, 2011 (Part 2)

(2) Venue: PGCB conference room



Source: PSMP Study Team

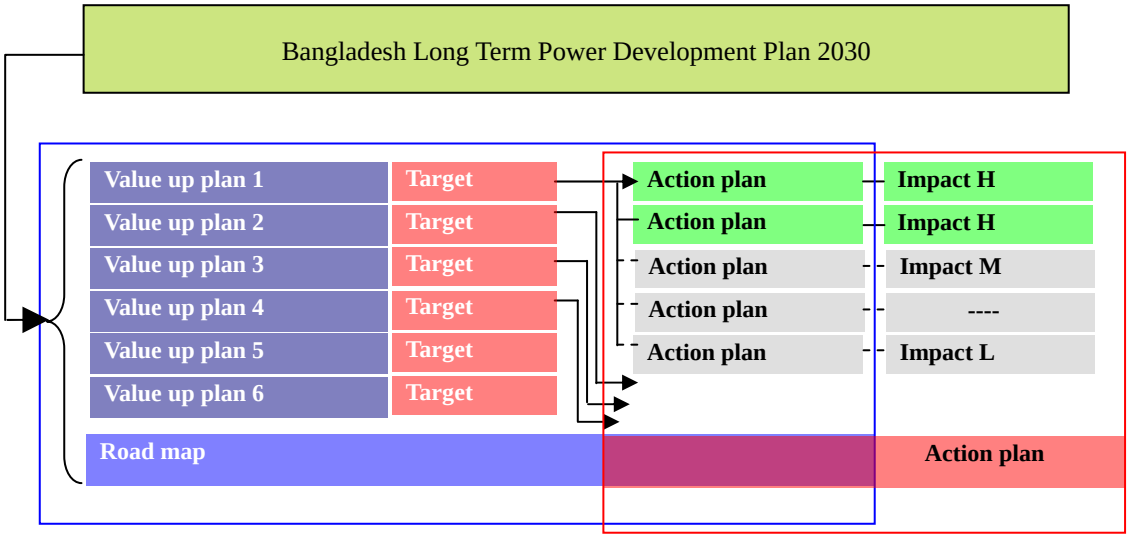
Chapter 2 Viewpoints and Objectives of the Master Plan

2.1 Viewpoints and objectives of the Master Plan

When reviewing the Power System Master Plan (MP), the fundamental objective is to formulate the Master Plan for the attainment of stable power supply by achieving the 3Es; Economic Growth, Energy Security and Environmental Protection simultaneously. The government of Bangladesh set the maximum target to reduce poverty in a period as swift as possible by achieving high economic growth. Planning electrification via the stabilization and efficiency of the electric power supply system can be expected to reduce poverty. This Master Plan will aim to promote development that will provide a self-reinforcing cycle of poverty reduction and 3E simultaneous achievement. In addition, this Master Plan will propose the vision in line with Government energy policy, and stipulate 6 value-up plans to achieve the vision.

2.2 Structure of the Vision, Road map, Action plan and Target

The structure of the Vision, Roadmap, Action Plan and Target is shown in the following figure. The Vision is proposed as Bangladesh's long term strategic power development vision 2030. To achieve this Vision, 6 value-up plans have been stipulated, where each value-up plans have their own targets to achieve the plans. There are Action Plans to achieve the Targets, where each Action Plan indicates the action agents and potential impact. The Roadmap shown in this chapter extracts the Action Plans that will result in high potential impact, and describes the details.



Source: PSMP Study Team

Fig. 2-1 Bangladesh Long Term Power Development Plan 2030

2.3 Conclusion of the Master Plan

So far, Government of Bangladesh (hereinafter GoB) has fallen into vicious circle where the power shortage has lasted for long time due to a multiple factor of lack of primary energy resources like domestic natural gas, decrepit power stations, imperfect maintenance and lack of funding. To solve these issues, the GoB focuses on more short-term measurements rather than long-term one. For example, it seems that the national plans such as development plan for domestic primary energy like coal and natural gas, development plan for power and infrastructure plan for fuel transportation are independently formulated by each government division, in which there is no efficient coordination among such plans. Therefore, expected effect for this Master Plan will be to indicate direction for the coordination amongst energy sector, power sector and infrastructure sector based on the certain logic.

It is also expected for the Master Plan to show the direction of comprehensive power development plan in long-term basis.

Under considering such situation, the final conclusion of this Master Plan is integrated as follows;

The final conclusion of this Master Plan
To show the direction of power development plan with comprehensive proposals of “Vision”, “Roadmap” and “Action Plan” comprehensively from short, mid and long term points of view.

2.4 Vision Paper

The Vision Paper and associated value-up plans are shown as follows;

Bangladesh

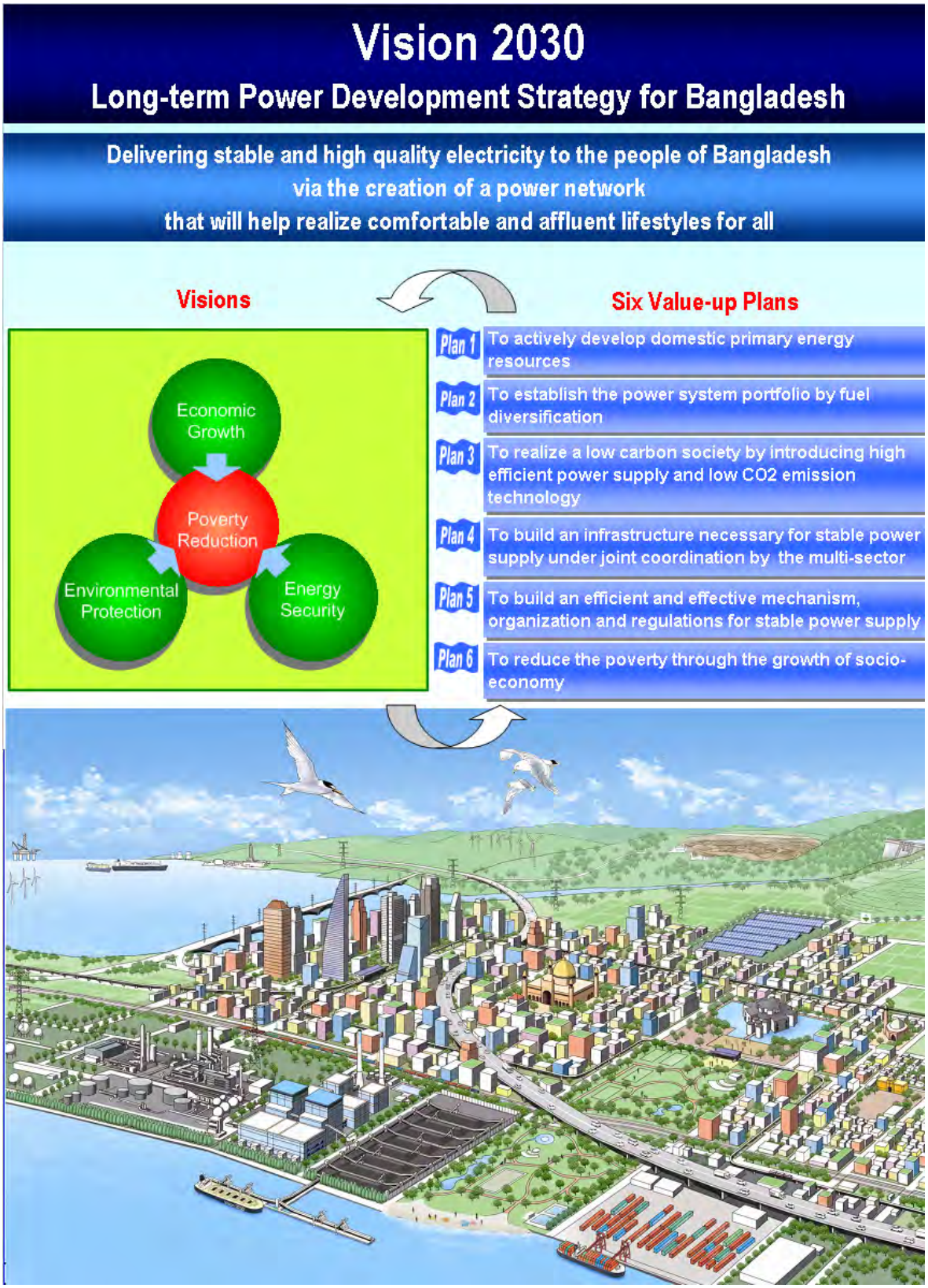
2030

Long-term power development strategy

Vision

Source: PSMP Study Team

Vision



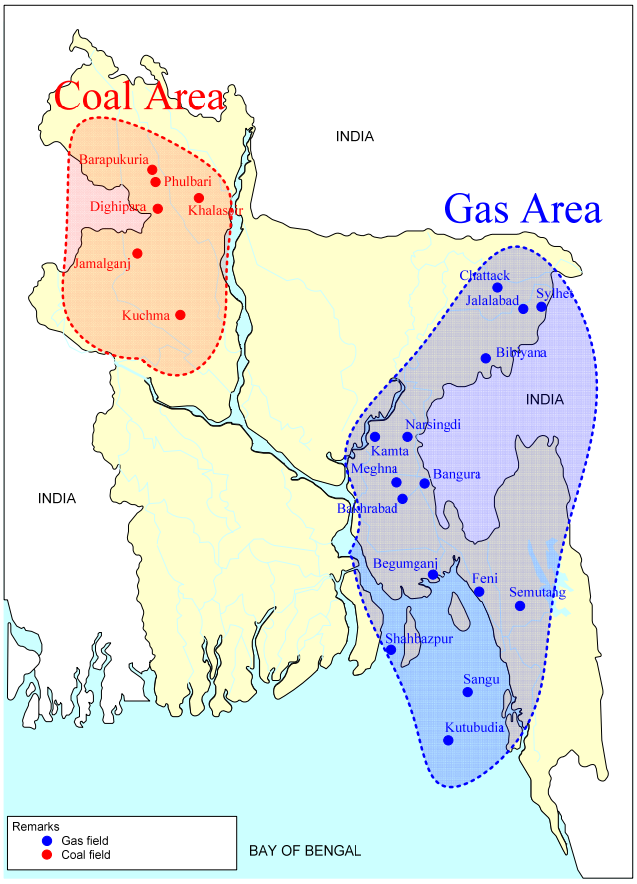
Source: PSMP Study Team

Plan 1 **To actively develop domestic primary energy resources**

Target **To maintain domestic primary energy supply over 50%**

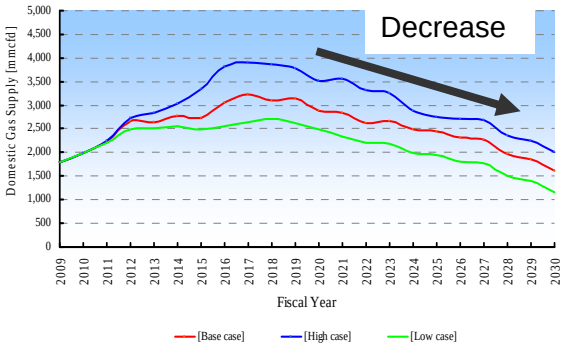
To deal with Bangladesh's rapid economic growth and the accompanying increase of electric power, there is an urgent need to secure a source of energy that is essential to the economy and stability. The active development of domestic primary energy resources is the best and realistic way to supply energy resources.

The main domestic primary energy resources are domestic natural gas and domestic coal. As shown in Fig. 2-2, domestic coal has been unevenly distributed in the Western part of Bangladesh, while natural gas is located in the Eastern area. As shown in Fig. 2-3 and Fig. 2-4, domestic gas supply will be expected to decrease in the near future, while domestic coal supply will increase. In the event that fuel diversification advances during the later years, the Master Plan aims to acquire a 25% share of domestic coal and a 20 percent share of domestic natural gas, and a 5% share of national hydropower and renewable energy, thus ensuring the self-sufficiency of the primary energy resource to be over 50 percent by Year 2030.



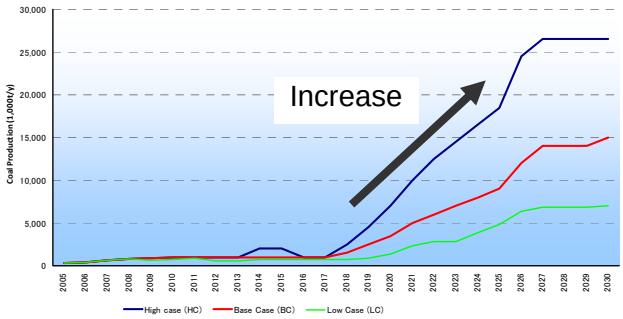
Source: PSMP Study Team

Fig. 2-2 Domestic coal and natural gas production area



Source: PSMP Study Team

Fig. 2-3 Domestic gas supply scenario



Source: PSMP Study Team

Fig. 2-4 Domestic coal supply scenario

(1) Domestic natural gas development

Action plans for domestic natural gas development are as follows;

- Re-evaluation of domestic natural gas reserve: to periodically re-evaluate domestic natural gas reserve in order to forecast future gas supply and justify the development and work over planning.
- Demand forecast for natural gas: to forecast the demand for natural gas on a rolling basis in order to match natural gas production planning.
- Exploration and development of domestic natural gas: to explore and develop domestic natural gas in order to enhance domestic natural gas production from new gas fields.
- Workover of existing natural gas field: to implement the work-over of the existing natural gas field in order to enhance natural gas production from existing gas fields.

(2) Domestic coal development

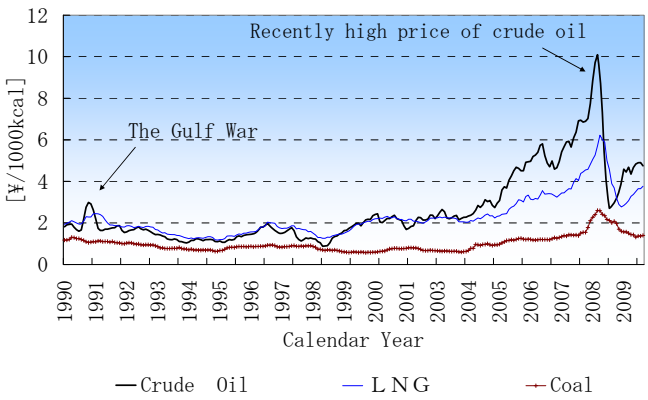
Action plans for domestic coal development are as follows;

- Finalization of Coal Policy: to finalize the current draft Coal Policy and to formulate the laws and/or regulations with regards to domestic coal development or coal mine development.
- Implementation and evaluation of the pilot mining: to implement and evaluate the pilot mine in order to judge the open cast mine feasibility, including the underground water treatment, coal production rate, and social impact.
- Demand forecast for domestic coal: to forecast the demand for coal on a rolling basis in order to match coal production planning.
- Building for the mine engineer training system: to build the mine engineer training system in order to stand upon a self-reinforcing mine operation without dependence on foreign country's support.
- Considering the CBM and/or UCG technology: to consider the CBM (Coal Bed Methane) and/or UCG (Underground Coal Gasification) technology in order to promote the utilization of un-used or un-developed domestic coal.

Plan 2 **To establish the power system portfolio by fuel diversification**

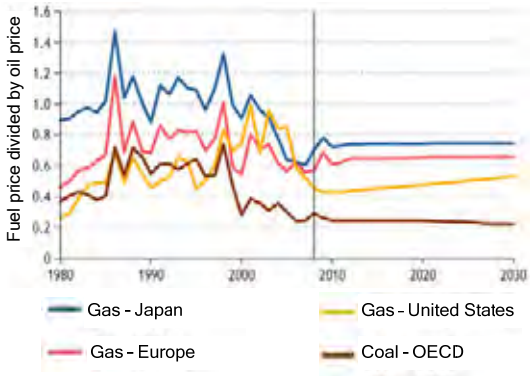
Target **Fuel composition ratio as of 2030: coal 50%, natural gas 25%, others 25%**

As shown in plan 1, the Master Plan prioritizes the use of domestic primary energy sources. However, in the case domestic energy supplies are not enough to fulfill the rapid demand growth for electricity and natural gas, it will be necessary to tap into other power sources from outside the Bangladesh.
To achieve the best mix of energy supply including imported resources, it would be required to use economical and stable power source in consideration of environmental protection. Especially coal will be an important resource as the primary energy supply in Bangladesh hereafter, due to i) its price stability and lower volatility compared with oil and natural gas, ii) longer reserve to production ratio compared with oil and natural gas, and iii) its wide spread availability throughout the world and is expected to be supplied stably, as shown in the following figures.



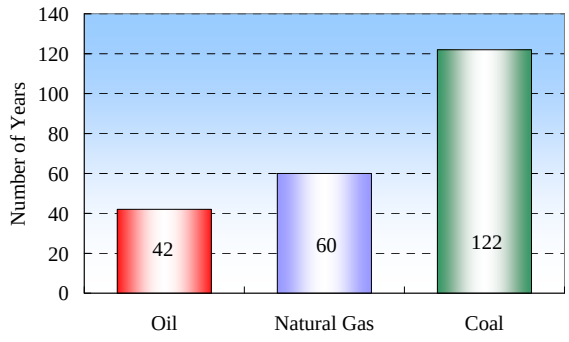
Source: The Institute of Energy Economics, Japan , 2010.4

Fig. 2-5 Fuel price trend



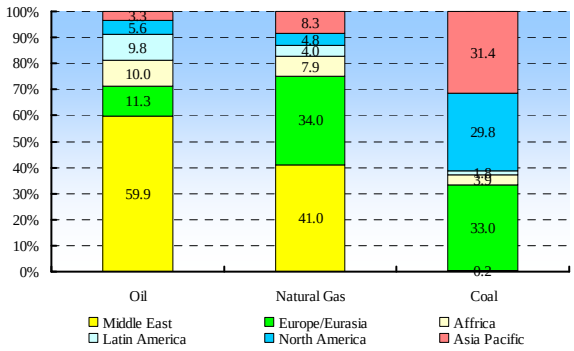
Source： IEA World Energy Outlook 2009

Fig. 2-6 Compare with fuel price divided by oil price



Source：BP Statistical Review 2009

Fig. 2-7 Production reserve ratio of each fuel



Source：BP Statistical Review 2009

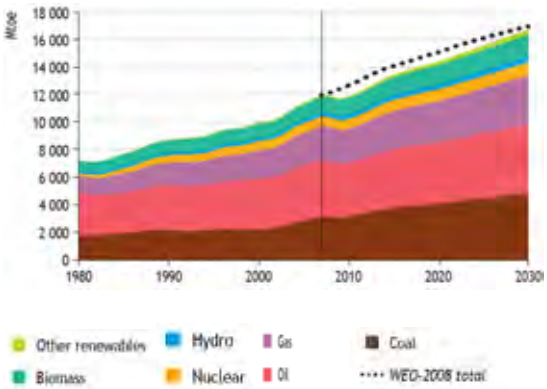
Fig. 2-8 Resource reserve of each area

Reviewed by the International Energy Agency (IEA), while coal consumption in the world was 3,200 billion tons of oil equivalent (Mtoe) in 2007 (26% of primary energy), it will be 4,900 Mtoe in 2030, more than a 50% increase (26% of primary energy). About 90% of increased 1,700 Mtoe can be attributed to increased Asian consumption. The coal consumption share of Asia was about 60% in 2007, and about 70% in 2035. Asia will be center of coal consumption. OECD shares will decrease from 36% in 2007 to 27% in 2035. On the other hand, shares of LDC will increase from 64% in 2007

to 73% in 2035. It is projected that coal will play a major role among primary energy sources in the next decade or so. [1]

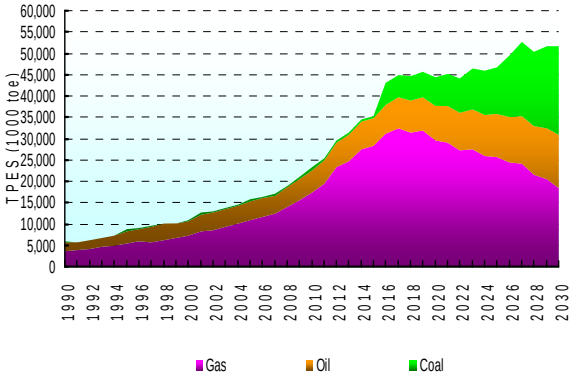
When reviewing world power generation, coal use shares will not change significantly.[2] It indicates that coal currently plays a major role in global power generation and this central role will still remain for some time.

The major primary energy supply forecast in Bangladesh is shown in the figure below, where natural gas supply will decrease after 2017 while coal supply will increase as an alternative source of natural gas. In this Master Plan, the target composition of power supply as of 2030 is set at 50% for domestic and imported coal, 25% for domestic and imported (in the form of LNG) natural gas and 25% for other sources such as oil, nuclear power and renewable energy.



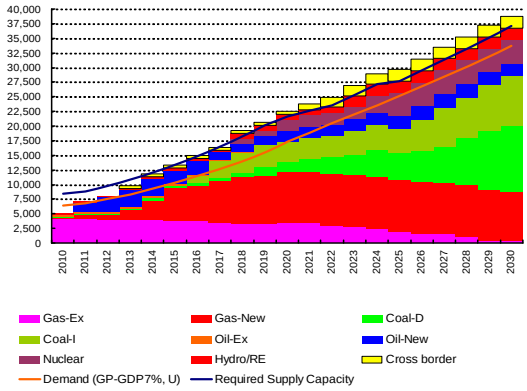
Source: IEA World Energy Outlook 2009

Fig. 2-9 World primary energy balance



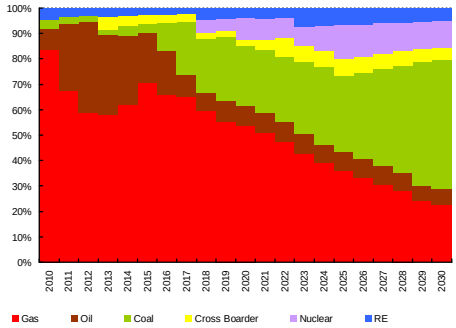
Source: PSMP Study Team

Fig. 2-10 Bangladesh primary energy balance



Source: PSMP Study Team

Fig. 2-11 Power development plan up to 2030 (MW)



Source: PSMP Study Team

Fig. 2-12 Power development plan up to 2030 (%)

(1) Construction of imported coal power station

- FS for imported coal power station: to carry out the FS for imported coal power stations
- DD for imported coal power station: to implement the detailed design reflecting the result of the FS

[1] The Institute of Energy Economics, Japan 2010.04

[2] IEA World Energy Outlook, 2009

- Procurement for imported coal: to examine the method on how to procure imported coal as this is the first time for Bangladesh to import coal by sea
- Establishment of the imported coal chain: to establish the imported coal chain, which provides a seamless coal delivery system from the mine mouth in the exporting country to the banker at the power station in Bangladesh
- Construction of a high efficient USC power station: to construct a high efficient power station by utilizing USC technology in order to prevent global warming.

(2) Introduction of LNG facilities

- FS of the offshore LNG terminal: to implement a feasibility study for the offshore LNG terminal.
- Procurement of LNG: to establish the LNG chain from the gas fields in exporting countries to re-gasification.
- Construction of the offshore LNG terminal: to construct an offshore LNG terminal, if the results of the FS are feasible.
- Consideration of the onshore LNG terminal: to consider the construction of the onshore LNG terminal in order to establish a long term LNG supply chain

(3) Construction of the oil fired power station

- Establishment of an oil-fired power station (Rental Power) as an emergency measure: to establish the oil-fired power station or Rental Power as an emergency measure for the short term solution and to use them during peak demand periods for the long term

(4) Import the electricity generated by hydro power from the neighboring countries or joint development

- There are huge potential of hydro power sources in the neighboring countries such as India, Nepal and Bhutan so they can be utilized in the context of the South Asia Regional Initiative (SARI) for joint development with Bangladesh and the countries of the region.

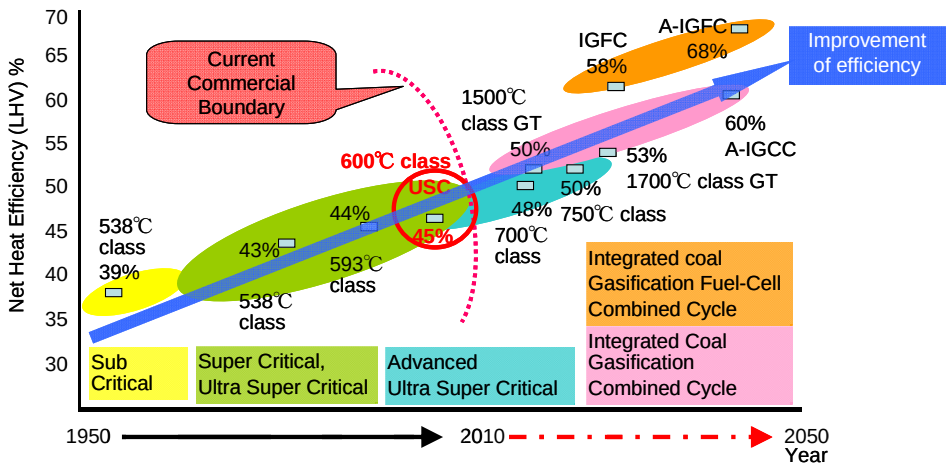
(5) Development of domestic renewable energy (wind and solar power)

- To develop wind and solar power as a domestic power supply source.

Plan 3 **To realize a low carbon society by introducing a high efficient power supply and low CO2 emission technology**

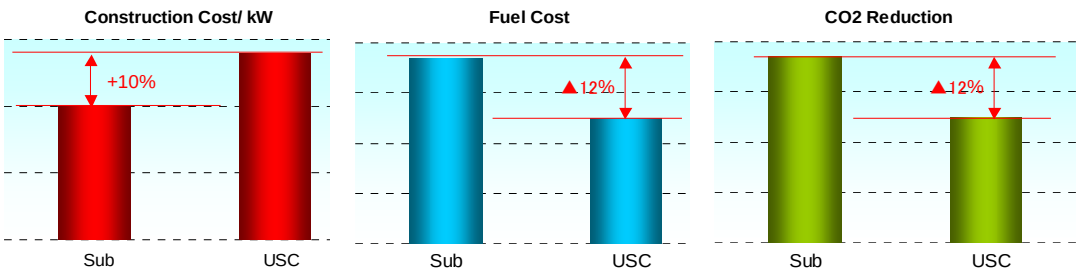
Target **To improve 10 points thermal efficiency on average**

In order to lessen the coal power station's environmental impact, it is essential to improve thermal efficiency by utilizing the proven Clean Coal Technology that has been established in Japan. According to recent coal-fired power station operations, the world class thermal efficiency (45%, LHV basis) was achieved by using Ultra Super Critical (USC) technology as a part of the Clean Coal Technology. By utilizing such technology in Bangladesh, great improvements of thermal efficiency and contributions to reduce green house gas could be achieved, if compared with the situation by using the sub critical technology (40%, LHV basis) widely used in other Asia regions.
In addition, there are environmental measures other than global warming, such as the reduction of NOx, SOx, and particulate matter. With regards to the comprehensive technology transfer regarding the environmental protection and the promotion of the technology, it makes it possible to achieve 3E, especially simultaneous environmental protection and economic growth, even through utilizing coal.



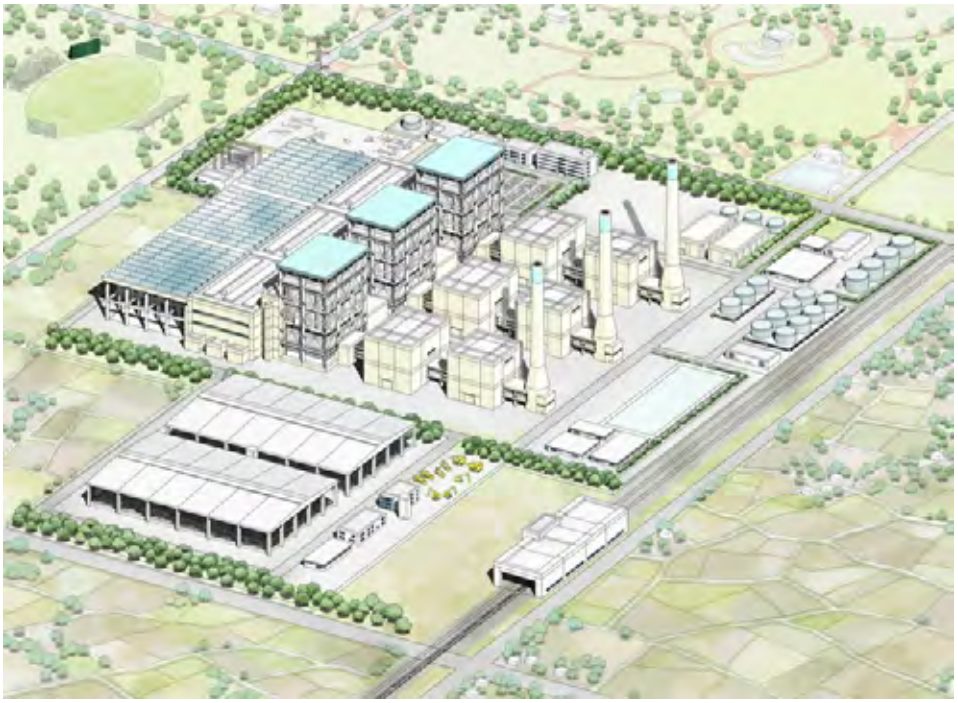
Source: Cool Earth 50 Energy Technical Innovation Program

Fig. 2-13 Efficiency improvement of coal fired power plant



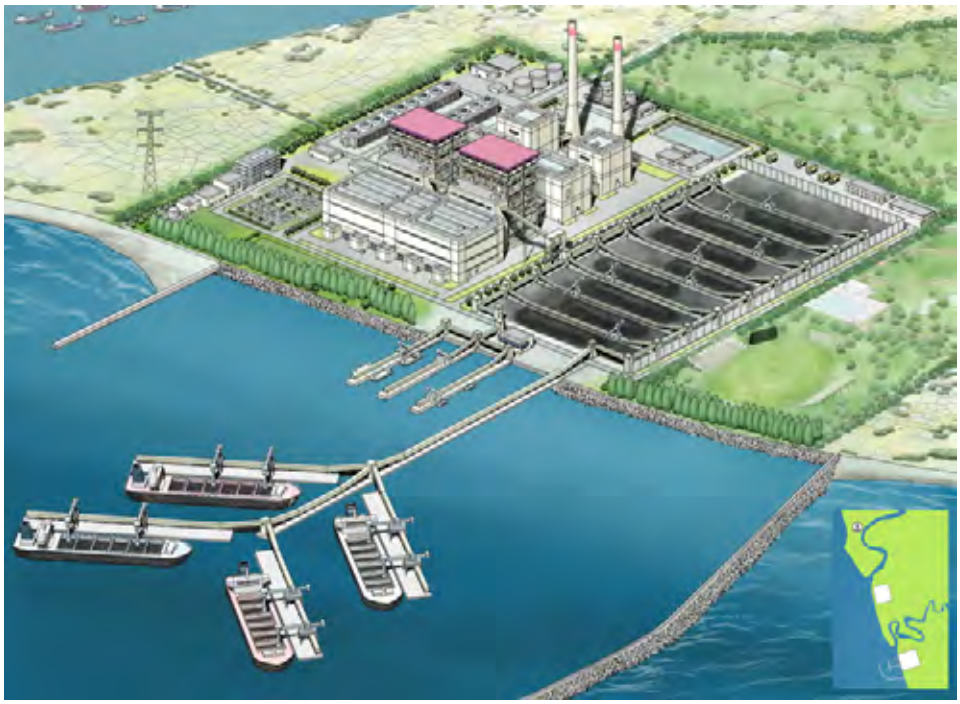
Source: PSMP Study Team

Fig. 2-14 Subcritical vs. USC (image)



Source: PSMP Study Team

Fig. 2-15 Domestic coal fired power station bird's eye view (B-K-D-P site)



Source: PSMP Study Team

Fig. 2-16 Imported coal fired power station bird's eye view (Cittagong South site)

In line with the apparent curtailment of natural gas production, the improvement of gas utilization efficiency has become an urgent matter. To prioritize gas supply for higher efficiency power plants is practically necessary in order to improve the effectiveness of gas utilization in the whole power sector. Therefore, during the construction of a new power station, including the demolishment of the old power station, power expansion planning and system operation planning will be implemented in

comprehensive consideration of the stability, environment, economics and operation, in line with the introduction of the world's class efficient combined cycle power station, and high efficiency and low carbon emission thermal power technology.

(1) Higher efficient gas power station

- Higher efficiency of the existing gas power station: to achieve higher efficiency via the re-powering of the existing power station.
- Construction of the combined cycle gas power station: to construct a higher efficient gas combined power station, and to improve the total efficiency via the allocation of gas to a higher efficient power station.

(2) Development of domestic coal power station

- FS for domestic coal power station: to implement the FS for domestic coal power station by using Clean Coal Technology
- DD for domestic coal power station: to implement a detailed design reflecting the result of the FS
- Construction of high efficient USC power station: to construct a high efficient power station by using USC technology in order to prevent global warming.
- Consideration of large scale coal power station: while the initial capacity is 600MW, however, the construction of the large scale power station (1000MW class) will be studied after 2020.

(3) Reviewing O&M scheme

- To reviewing current O&M scheme, in order to reduce the number of unplanned starts and stops, and to improve the load factor.
- To establish the USC O&M scheme.
- To establish the environment and safety scheme

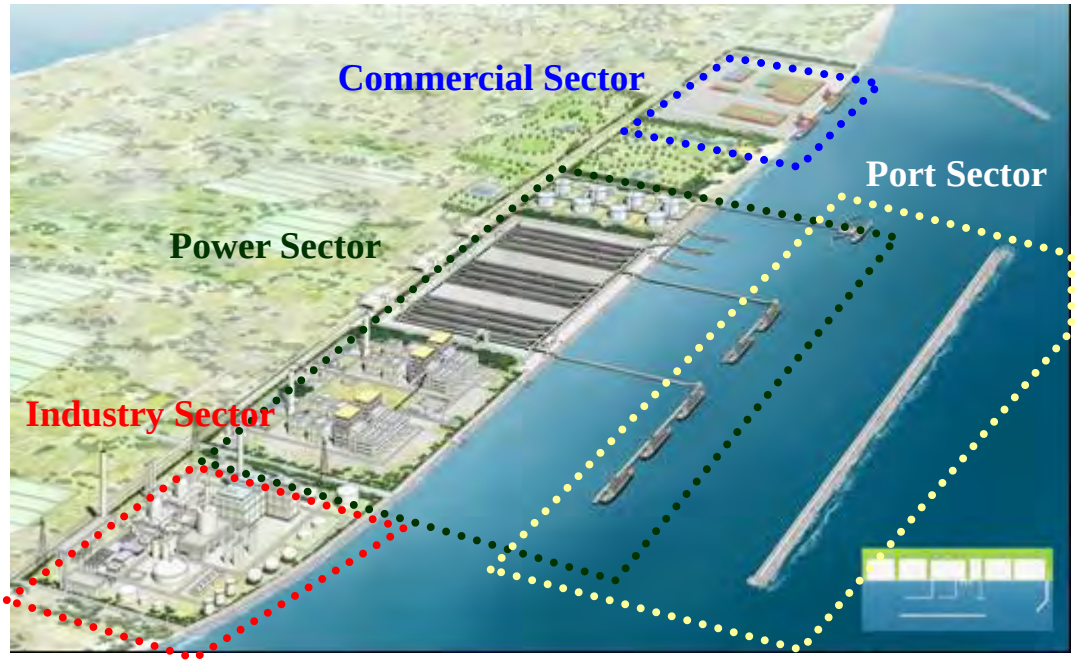
(4) Energy conservation, Demand side management

- To rationalize the load dispatch by prioritization of gas allocation to higher efficient power station in order to reduce CO2 emission.
- To rationalize the customer side by energy conservation and demand side management in order to reduce CO2 emissions.

Plan 4 **To build an infrastructure necessary for stable power supply under joint coordination by the multi-sector**

Target **To jointly build a deep sea port facility by power, industry and commercial sector**

It is clear that the enhancement of power supply will be necessary in line with future power demand growth. As a power supply related infrastructure, it is also necessary to develop a gas transmission line, a fuel center, a deep sea port, a domestic waterway, a railway and so on. Vast amount of investment is required to build these infrastructures. It is impossible for the power sector to bear such huge investment alone. Hence, cooperation with other sectors such as industry and commercial enterprises will be needed to achieve cost reduction and a synergy effect.



Source: PSMP Study Team

Fig. 2-17 Example of deep sea port development

(1) Construction of deep sea port

- As of today, the power sector, commercial sector and industry sector are individually planning to develop the port. However, the multi-sector will harmoniously develop a deep sea port where huge costs are required.

(2) Improvement of the power transmission system

- To improve the power transmission system in line with power supply amount growth
- To develop cross border power trading.

(3) Enhancement of gas transmission line

- To enhance the gas transmission line in line with domestic gas demand growth

(4) Construction of fuel center

- To enhance the gas transmission line in line with domestic gas demand growth
- To implement a coal center FS.

- To construct a coal center.
- To jointly develop a fuel center (receiving facility for imported coal, LNG and oil) via multi sector cooperation.

(5) Strengthening the domestic waterway

- To strengthen the domestic waterway via periodical dredging for internal ships from the coal center to the power station.

(6) Strengthening the railway system

- To strengthen the domestic railway system in order to transport coal from the coal center to the power station.

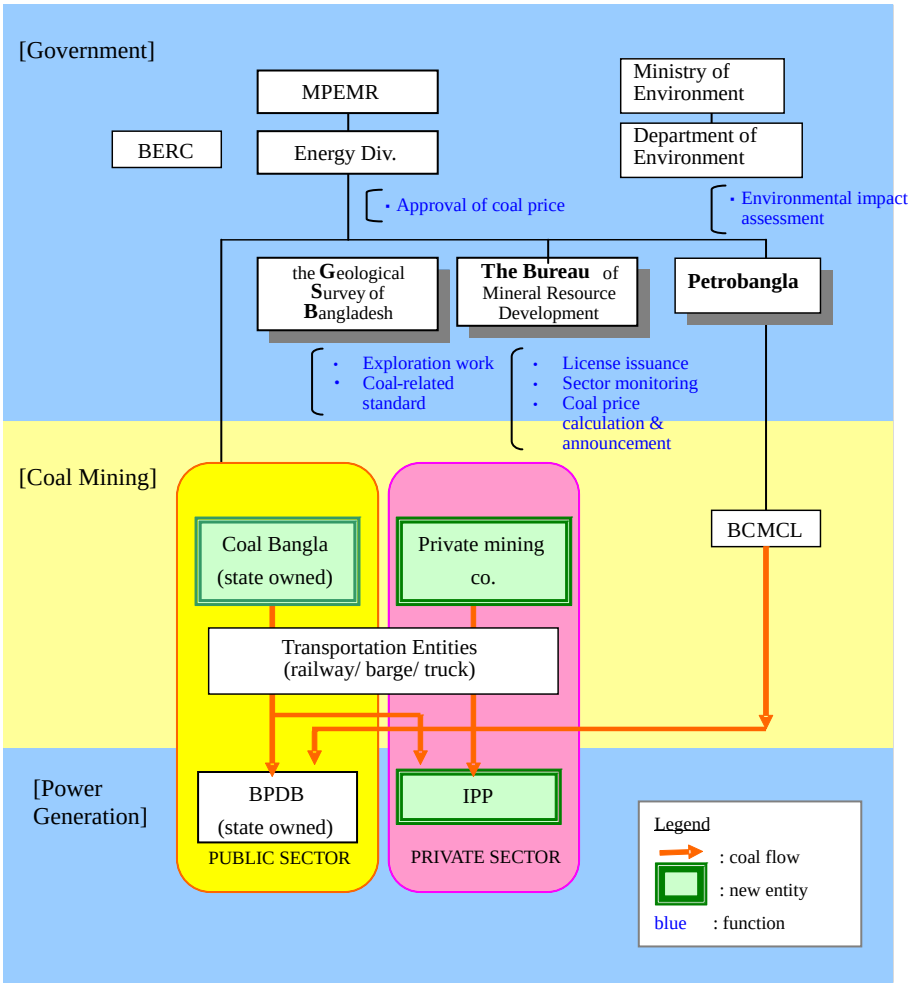
Plan 5 **To build an efficient and effective mechanism, organization and regulations for stable power supply**

As Bangladesh has less experience in dealing with coal power station development, the Master Plan recommend to set up an organization for coal procurement, to strengthen the regulations leading to the sure implementation of regular inspections, to prepare a lucrative investment environment by the private sector, to impose levies for the plant and equipment investments, to create an investment environment for the private sector and to establish an effective and efficient power market.

Target **To establish an organization for long-term stable fuel supply security**

(1) Organization for coal procurement

As Bangladesh has less experience in dealing with coal power station development, the Master Plan recommended to set up a new organization for coal procurement to smooth the way towards its realization. The following figure is an organizational example of domestic coal procurement.



Source: PSMP Study Team

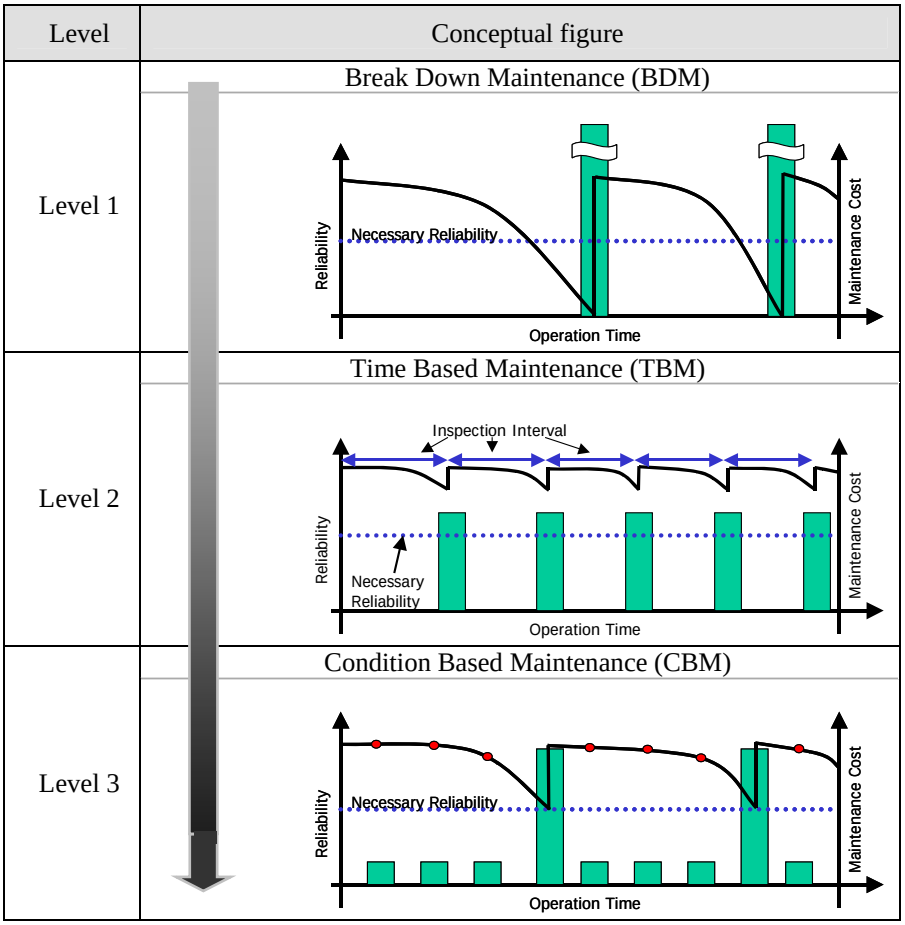
Fig. 2-18 Example of the fuel procurement implementation system of coal fired power plant

Target **To formulate regulations for compulsory regular inspection of power stations by leadership of government.**

(1) Formulation of regulations for compulsory periodic inspection and repair of power stations.

So far there is no law or regulation for regular inspections, so that each generator independently carries out its own inspection based on its own judgment. In reality, it is difficult to shut down the plant due to a tight supply-demand situation for electricity and/or lack of inspection funds. This creates a situation of non-stop operations until the equipment breaks down, which has a tendency to lead to more severe damage and longer repair periods; a classic case of "break-down maintenance."

In order to ensure the implementation of regular inspections, the Master Plan recommends the revision of existing rules and regulations, which enables the maintenance scheme to shift over from break-down maintenance to time-based or condition-based maintenance to maintain the plant at effective level.



Source: PSMP Study Team

Fig. 2-19 Conceptual figure of maintenance management (level-wise)

Target **To revise the tariff structure to recover maintenance costs and future investment for plant and equipment**

(1) Introduction of Power Development Surcharge into the power tariff

The current tariff is politically constrained so that it does not envisage funding for neither appropriate maintenance nor future system expansion. While the prevailing tariff policy adheres to the cost reflection. The Master Plan recommends that the tariff be revised to realize the cost for necessary maintenance to maintain the plant condition at an appropriate level. It is also recommended that the introduction of the power development surcharge into the power tariff be conducted for the purpose of funding the development of the power system and/or energy saving projects.

(2) Promotion of private investment to realize the Master Plan

So far public funding has played a major role in establishing power system development, it is recommendable to promote private investment and develop an environment that allows private funding.

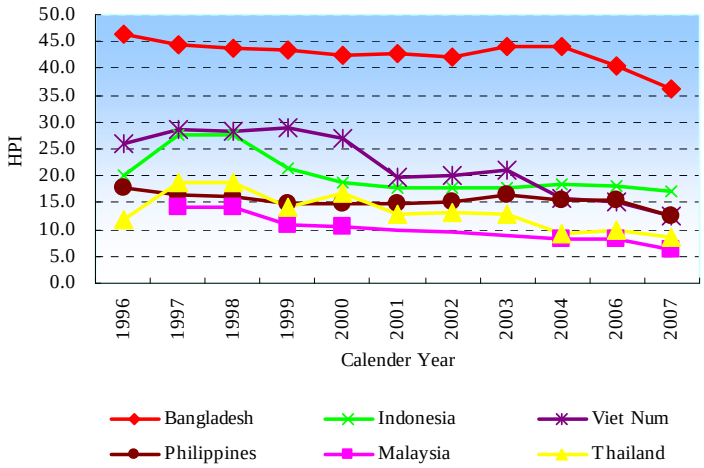
(3) To create an effective and efficient power market

In order to make the power sector more effective and efficient, the Master Plan recommends the introduction of a competitive market where the customer can select power providers.

Plan 6 **To reduce the poverty through the growth of socio-economy.**

Target **To promote the local community and mutual collaboration**

According to the Human Poverty Index (HPI-I) by UNDP, the 36.1% index value, Bangladesh ranks 112th among 135 countries in 2007, and is the third worst in the entire Asian region after Afghanistan and Timor-East. However, when looking at the HPI trend, the HPI-I for Bangladesh improved quickly over the last recent years. The present poverty index of Bangladesh is slightly higher than that of Indonesia and the Philippines 10 years ago. However, it is possible that Bangladesh could rank within the middle range of countries on the HPI within several years, if the present economic growth continues.



Source: United Nations Development Programme [Human Development Report 1998] – [Human Development report 2009]

Fig. 2-20 Human poverty index trend

(1) To spread stable and sustainable power supply

Stable and sustainable power supply will be essential for Bangladesh to continue economic growth and switch the industry structure over to export processing. Power expansion planning and transmission planning shown in the Master Plan should surely be implemented.

(2) To promote remote area electrification

Through power system expansion and power transmission development, the power system all over Bangladesh will be enhanced, as a result, local electrification will also be promoted.

(3) To promote the local industry, associated employment opportunities and income increases

An ample amount of stable power supply makes it possible to expand into local industries such as garments, developing industrial zones and free trade zones, which lead to massive long term employment opportunities for people in the region. In the operation of power stations, 250 to 300 operators and engineers are required per power station. In addition, 1,000 personnel per day are needed for the construction, 1500 to 2000 contractors per day for the regular overhaul and other outsourcing resources for regular services are also required. When the construction of the power station is implemented according to this Master Plan, 6,500 to 8,000 regular employees and 80,000 to 150,000 of non regular manpower will be required as a whole for the generation industry. These people will be preferentially employed from within the local community. This momentum

contributes to economic growth with macro-economic improvements which ultimately enhances social and economic inclusion, integration of marginalized people and the reduction of poverty.

(4) To promote mutual collaboration between the power station and the local community

For the construction and operation of the power station, the understanding and cooperation of the local community is essential. For security reasons, power stations are normally isolated by a fence so that land providers and local residents are not able to enter the power station's property. In a recent case in Japan, however, the green belt park, playground and swimming pool adjacent to the power station are opened to local community to promote mutual collaboration and exchange between the local people and power station personnel.

When introducing the coal fired power station, it is necessary to reduce environmental impact from environmental equipment. In addition, it may be required to disclose measured data from pollution, noise, vibration, land subsidence etc. to gain the understanding of the local community. It is also recommended to employ local people and promote mutual collaboration between the power station and the local community by using the power station's facilities.

2.5 Road map and Action plan

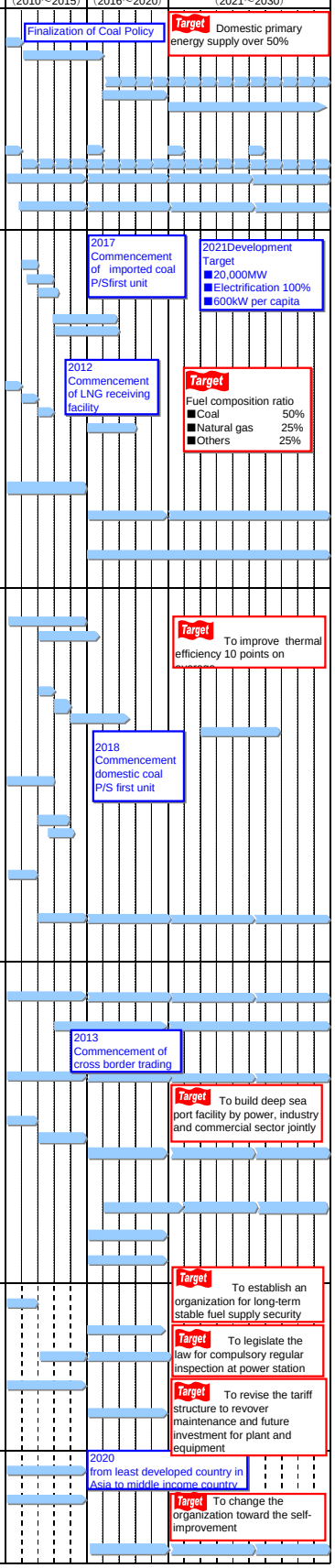
A roadmap for the Master Plan regarding sound implementation guidance has been created based on the discussion with counterparts and the PSMP Study Team. The roadmap indicates implementation timing on short, mid and long term basis for each item and also indicates targets to be achieved, so that the GoB is easily identify what and when the minimum requirements should be implemented by whom. A certain implementation of activities in line with the designated roadmap by the designated time frame is highly recommended.

For reference, an action plan with activities corresponding to this Master Plan is proposed in order to achieve further good practice. Among activities on the action plan, which are described on the roadmap, are highlighted with ID numbering. On the action plan, concrete implementation measures in line with the corresponding references are expected for utilization for the GoB.

Road Map

Road map toward 2030

Value-up Plan	Action Plan	ID No.
Plan 1 To actively develop domestic primary energy resources	■Domestic coal development	
	・Finalization of Coal Policy	DR-1
	・Implementation and evaluation of the pilot mining: to implement	DR-3
	・Demand forecast for domestic	DR-6
	・Building for the mine engineer training system	DR-8
	・Considering the CBM and/or UGC technology	DR-4,5
	■Domestic natural gas development	
	・Re-evaluation of domestic natural gas reserve	DR-10
	・Demand forecast for natural gas	DR-11
	・Exploration and development of the domestic natural gas	DR-14
	・Workover of existing natural gas field	DR-14
Plan 2 To establish the power system portfolio by fuel diversification	■Construction of imported coal power station	
	・FS for imported coal power station	ERD-19
	・DD for imported coal power station	ERD-14
	・Procurement for imported coal	ERD-15
	・Establishment of imported coal chain	ERD-16
	・Construction of high efficiency USC power station	ERD-20
	■Introduction of LNG facilities	
	・Procurement for LNG	ERD-4
	・FS of offshore LNG terminal	ERD-17
	・Construction of offshore LNG terminal	ERD-17
	・Consideration of the onshore LNG terminal	ERD-17
	■Construction of the oil fired power station	
	・Establishment of the oil fired power station (Rental Power) as emergency measure	ERD-8
	■Import the electricity generated by hydro power from the neighboring countries or joint development	ERD-9
	■Development of domestic renewable energy (wind and solar poewr)	ERD-9
Plan 3 To realize a low carbon society by introducing high efficient power supply and low CO2 emission technology	■Higher efficient gas power station	
	・Higher efficiency of existing gas power station	EEU-7
	・Construction of combined cycle gas power station	EEU-8
	■Development of domestic coal power station	
	・FS for domestic coal power station	ERD-18
	・DD for domestic coal power station	ERD-20
	・Construction of high efficient USC power station	ERD-20
	・Consideration of large scale coal power station	ERD-21
	■Reviewing O&M scheme	
	・To reviewing current O&M scheme, in order to reduce the number of unplanned start and stop, and to improve the load factor	EEU-4
	・To establish the USC O&M scheme	EEU-5
	・To establish the environment and safety scheme	EEU-6
	■Energy conservation, Demand side management	
	・To rationalize the load dispatch by prioritization of gas allocation to higher efficient power station in order to reduce CO2 emission	EEU-7
	・To rationalize at customer side by energy conservation and demand side management in order to reduce CO2 emission	EEU-11
Plan 4 To build an infrastructure necessary for stable power supply under joint coordination by the multi sector	■Improvement of the power transmission system	
	・To improve power transmission system in line with the power supply amount growth	I-7
	・To develop cross border power trading	I-7
	■Enhancement of gas transmission line	I-1
	■Construction of fuel center	
	・To implement coal center FS	I-5
	・To construct coal center	I-5
	・To jointly develop fuel center (receiving facility for imported coal, LNG and oil) by multi sector cooperation	I-5
	■Construction of deep sea port	I-4
	■Strengthening the domestic waterway	I-6
	■Strengthening the railway system	I-8
Plan 5 To build an efficient and effective mechanism, organization and law for stable power supply	■Legislation of the law for compulsory periodic inspection and repair at power station	PN-1
	■Organization for coal procurement	PN-2
	■Introduction of Power Development Surcharge into the power tariff	PN-3
	■Promotion of private investment to realize the Master Plan	PN-4
	■To create effective and efficient power market	PN-5
Plan 6 To reduce the poverty through the growth of socio-economy	■To spread stable and sustainable power supply	TFE-1
	■To promote remote area electrification	TFE-2
	■To promote the local industry and associated employment opportunity and income increase	TFE-3



Source: PSMP Study Team

Action Plan

Plan 1 To actively develop domestic primary energy resources

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
DR-1	O			4.1	Finalization of Coal Policy	High	GoB
DR-2	O			4.2	Disision of mining method for 2nd slice	Midium	GoB, Petrobangla
DR-3	O			4.2	Implementation of Pilot mining	High	Petorbangla
DR-4			O	4.2	Considering the CBM project	High	Petorbangla
DR-5			O	4.2	Considering the UGC project	High	Petorbangla
DR-6	O	O	O	4.2	Formulation of domestic coal scenario	High	Petorbangla
DR-7	O	O	O	4.5	Formulation of domestic coal price scenario	Midium	Petorbangla
DR-8		O		4.2.2	Building for the mine engineer training system	High	Petorbangla
DR-9	O			5.1	Formulate gas sector development	Midium	GoB
DR-10	O	O	O	5.2	Re-evaluation of domestic natural gas reserve	High	GoB, HCU
DR-11	O	O	O	5.3	Demand forecast for natural gas	High	Petorbangla, GTCL
DR-12	O	O	O	5.4, 5.5	Formulation of domestic gas supply plan	Midium	Petrobangla
DR-13	O	O	O	5.6	Formulation of imported gas supply plan	Midium	Petrobangla
DR-14	O	O	O	5.7	Mid-long term gas evaculation plan	High	Petrobangla
DR-15	O	O	O	5.9	Forecast for natural gas price	Midium	Petrobangla
DR-16	O	O	O	5.9	Formulation of gas development plan	Midium	Petorbangla
DR-17	O	O	O	14.3	Site sellection for domestic coal P/S	High	BPDB
DR-18		O		14.3	Implementation domestic P/S FS	High	BPDB
DR-19		O		14.2	Decision of domestic coal P/S spec	High	BPDB

Plan 2 To establish the power system portfolio by fuel diversification

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
ERD-1	O	O	O	4.3, 4.4	Forecast for imported coal	Midium	Petrobangla/BPDB
ERD-2	O			4.5	Forecast for imported coal price	Midium	Petrobangla/BPDB
ERD-3	O			4.6	Forecast for domestic/import coal supply	Midium	GoB
ERD-4	O			5.1	Formulate of LNG introduction plan	High	GoB
ERD-5	O	O	O	6.1	Formulation of imported oil plan	Midium	BPC
ERD-6	O	O	O	6.1	Formulation of oil supply plan	Midium	GoB
ERD-7	O	O	O	6.1	Formulation of oil price scenario	Midium	BPC
ERD-8	O	O	O	8.4	Formulation of oil P/S plan	High	BPC/BPDB
ERD-9	O	O	O	8.7	Formulation of renewable energy scenario	High	GoB
ERD-10	O	O	O	6.2	Risk analysis of renewable energy	Midium	GoB
ERD-11	O			14.3	Sellection of desing coal	Midium	BPDB
ERD-12	O			14.3	Decision of imported coal transportation	Midium	BPDB
ERD-13		O		14.4	Decision of coal import by large vessel	Midium	BPDB
ERD-14	O			4.4, 17.3	DD for imported coal power station	High	BPDB
ERD-15	O			14.3	Procurement for imported coal	High	BPDB
ERD-16	O			13.3	Establishment of imported coal chain	High	GoB
ERD-17	O			5.7	Decision of LNG facility spec	High	Petrobangla/BPDB
ERD-18	O	O	O	14.3, 14.4	Implementation of domestic coal P/S FS	Midium	BPDB
ERD-19	O	O	O	14.3	Implementation of imported coal P/S FS	High	BPDB
ERD-20	O	O	O	15.1	Planning for construction schedule	High	BPDB
ERD-21			O	14.3	Considering large scale power plant	High	BPDB
ERD-22	O	O	O	15.2	Estimation for P/S construction cost	Midium	BPDB

Plan 3 To realize the low carbon society by introducing high efficient power supply and low CO2 emission technology

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
EEU-1	O	O	O	11.3	Introduction of USC technology	high	BPDB
EEU-2	O	O	O	12.1, 12.2, 12.3,	Formulation of optimum power supply	high	BPDB
EEU-3	O	O	O	14.2, 14.3	Decision of P/S major equipment/layout	high	BPDB
EEU-4	O			17.1	Establish P/S maintenance scheme	high	BPDB
EEU-5	O			17.1	Establish the USC O&M scheme	high	BPDB
EEU-6	O			17.2	Establish the environment and safety scheme	high	BPDB
EEU-7	O			8.3	Considering conversion to higher efficient gas P/S	high	BPDB
EEU-8	O			8.4	Considering construction of combined cycle gas P/S	high	BPDB
EEU-9		O	O	6.2	Development of domestic renewable energy	high	BPDB
EEU-10		O	O	6.2, 19.6	Joint Development of hydor with neighbour countries	high	BPDB
EEU-11	O	O	O	7.5	Energy conservation, Demand side management	high	BPDB

Plan 4 To build infrastructure necessary for power stable supply coordinated by multi sector jointly

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
I-1	O	O	O	5.10	Enhancement of gas transmission line	High	Petrobangla, GTCL
I-2	O	O	O	6.1	Construction of oil receiving facility	High	BPC
I-3	O	O	O	11.1	Formulation of infrastructure construction road map	High	GoB
I-4	O	O	O	11.2	Construction of deep sea port	High	GoB
I-5	O	O	O	13.1	Construction of fuel center	High	BPDB、BPC、Petrobangla
I-6			O	13.3	Strengthening the domestic waterway	High	GoB
I-7	O	O	O	9.2	Improvement of the power transmission system	High	PGCB
I-8	O	O	O	14.3	Strengthening the railway system	High	GoB

Plan 5 To build the efficient and effective mechanism, organization and law for stable power supply

ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
PN-1	O			17.1	Legislation of the law for compulsory periodic inspection and repair at power station	High	PGCL
PN-2		O		17.3	Establishment of mine management section	High	GoB
PN-3	O	O		10.5	Introduction of Power Development Surcharge into the power tariff	High	GoB
PN-4		O		10.1	Promotion of private investment to realize the Master Plan	High	GoB
PN-5		O	O	10.1	To create effective and efficient power market	High	GoB

Plan 6 To reduce the poverty through the growth of socio-economy

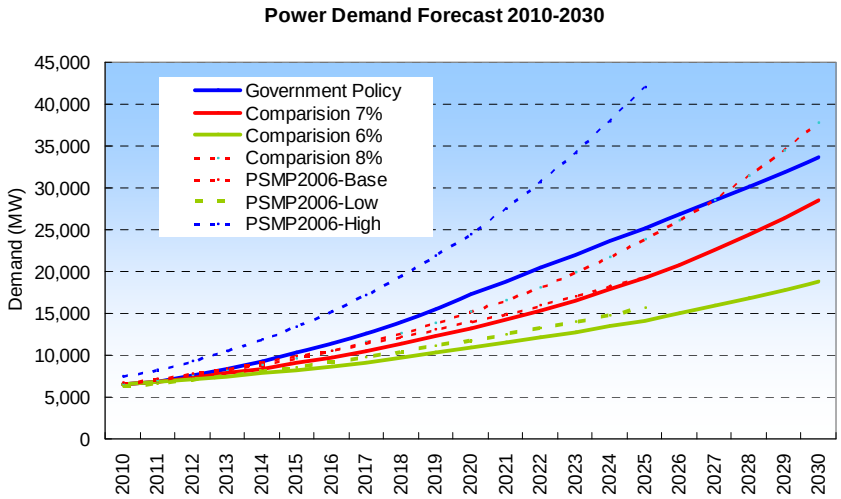
ID	Phase S	Phase M	Phase L	Corresponding	Action Plan	Potential Impact	Action Agents
TFE-1	O			8.8	To spread stable and sustainable power supply	High	GoB
TFE-2	O			2.3	To promote remote area electrification	High	GoB
TFE-3		O	O	2.3	To promote the local industry and associated employment opportunity and income increase	High	GoB

Source: PSMP Study Team

Chapter 3 Power Demand Forecasts and Power Development Plan

3.1 Power demand forecasts

The adoption scenarios of the power demand forecast in this MP are as shown in the figure below. The figure indicates three scenarios; (i) GDP 7% scenario and (ii) GDP 6% scenario, based on energy intensity method, and (iii) government policy scenario.



Source: PSMP Study Team

Fig. 3-1 Three scenarios for power demand forecast

Table 3-1 Result of demand forecast (3 scenario)

FY	Government Policy Scenario		Comparison GDP7% Scenario		Comparison GDP6% Scenario	
	Peak Demand [MW]	Generation [GWH]	Peak Demand [MW]	Generation [GWH]	Peak Demand [MW]	Generation [GWH]
2010	6,454	33,922	6,454	33,922	6,454	33,922
2011	6,765	35,557	6,869	36,103	6,756	35,510
2012	7,518	39,515	7,329	38,521	7,083	37,228
2013	8,349	43,882	7,837	41,191	7,436	39,084
2014	9,268	48,713	8,398	44,140	7,819	41,097
2015	10,283	54,047	9,019	47,404	8,232	43,267
2016	11,405	59,945	9,705	51,009	8,680	45,622
2017	12,644	66,457	10,463	54,994	9,165	48,171
2018	14,014	73,658	11,300	59,393	9,689	50,925
2019	15,527	81,610	12,224	64,249	10,255	53,900
2020	17,304	90,950	13,244	69,610	10,868	57,122
2021	18,838	99,838	14,249	75,517	11,442	60,640
2022	20,443	109,239	15,344	81,992	12,056	64,422
2023	21,993	118,485	16,539	89,102	12,713	68,490
2024	23,581	128,073	17,840	96,893	13,416	72,865
2025	25,199	137,965	19,257	105,432	14,167	77,564
2026	26,838	148,114	20,814	114,868	14,979	82,666
2027	28,487	158,462	22,509	125,209	15,848	88,156
2028	30,134	168,943	24,353	136,533	16,776	94,053
2029	31,873	180,089	26,358	148,928	17,768	100,393
2030	33,708	191,933	28,537	162,490	18,828	107,207

Source: PSMP Study Team

3.2 Detailed study for realizing long-term target

3.2.1 Setting scenario of power development plan

The following scenarios are examined in consideration of uncertain events in regards to the power development plan.

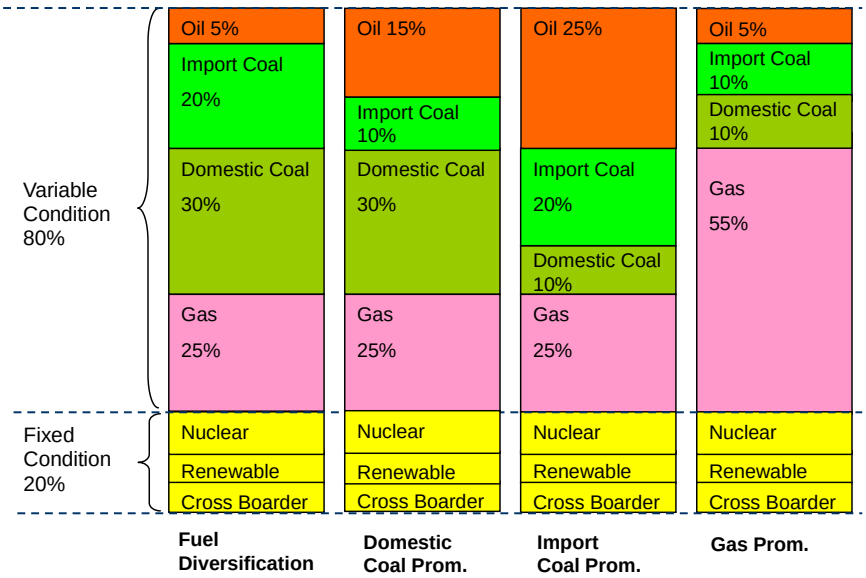
Table 3-2 Power development scenario

Scenario	Concept
Fuel Diversified Scenario (Base case)	Optimum power sources development plan, securing fuel supply via multiple sources based on coal development (developing new domestic mining, increasing existing mining capacity, securing imported coal) ; natural gases, fossil fuels (heavy and light oil), renewable energy.
Domestic Coal Promotion Scenario	For the Base Scenario, fuel supply mainly via a large-scale increase in production at domestic mining including strip mining is considered.
Import Coal Promotion Scenario	For the Base Scenario, fuel supply comes mainly from imported coal due to considerations regarding the impossibility or a long period to develop domestic mining.
Gas Promotion Scenario	For the Base Scenario, fuel supply mainly comes from new domestic gas development, and gas procurement secured from a long-term perspective.

Source: PSMP Study Team

3.2.2 Determination of power development scenario, being closely-interlinked with primary energy supply

The power development plan is closely-interlinked with prime energy supply. The government plan for renewable, cross boarder, and the nuclear power generation plan is provided in light of the power development plan. As detailed in chapter 5, the gas supply scenario will decrease gradually from its peak in 2017. In considering factors such as the construction lead time for gas-fired power stations, the government plan for the gas fired power station should be given in regards to the power development plan in the same manner. Therefore, the power development scenario is to be determined in combination with coal and oil as a variable condition.



Source: PSMP Study Team

Fig. 3-2 Fuel-wise composition for each scenario

3.2.3 Quantitative Evaluation of 3E (Economy, Environment, Energy security)

The fuel diversification scenario has been selected as the most optimum scenario, maximizing 3E value.

Table 3-3 3E Quantitative evaluation result

Scenario	Economy	Environment	Energy Security	Total Point	Priority
	0.7	0.1	0.2		
Fuel Diversification	4	2	5	4.064	1
Import Coal Lack	3	3	4	3.245	2
Domestic Coal Lack	2	3	1	1.845	4
Gas Promotion	2	4	2	2.180	3

Source: PSMP Study Team

3.2.4 Power development plan based on the Fuel Diversification scenario

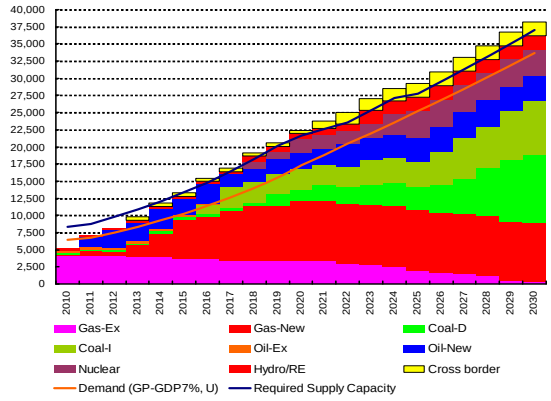
The detailed plan of power development by fuel diversification scenario is as follows,

Table 3-4 Unit additions and system reliability indices (Fuel Diversification scenario)

FY		Unit Additions, Number of Unit								Cross Border [MW]	Installed Capacity [MW]	System Reliability Indices		
	Peak Load [MW]	Domestic Coal 600MW	Domestic Coal 1,000MW	Import Coal 600MW	Gas CC 750MW	Gas CC 450MW	FO Engine 100MW	Nuclear 1,000MW	Hydro 100MW			LOLP [%]	ENS. GWH	Reserve Margin [%]
2016	11,405			2		1			1	250	14,943	0.001%	0	20.57
2017	12,644			3	1	1					16,399	0.000%	0	23.38
2018	14,014			1	1			1		500	19,249	0.000%	0	31.16
2019	15,527	2					2				20,649	0.000%	0	26.26
2020	17,304	1			1		2	1			22,509	0.000%	0	26.71
2021	18,838						1			500	23,809	0.006%	0	18.39
2022	20,443	1					1			750	24,961	0.017%	0	14.96
2023	21,993	1		1			1			1,000	26,954	0.006%	0	16.57
2024	23,581	2						1			28,966	0.011%	0	15.72
2025	25,199						1	1			29,717	0.079%	0	12.19
2026	26,838	1		2			2				31,388	0.114%	0	11.37
2027	28,487		1	2			1				33,513	0.126%	0	11.20
2028	30,134		2				1				35,253	0.277%	0	9.11
2029	31,873		2	2			2				37,263	0.110%	0	11.94
2030	33,708		1	1							38,685	0.321%	0	9.14
Total		8	6	14	3	2	14	4	1					
TotalMW		4,800	6,000	8,400	2,250	900	1,400	4,000	100	3,000	30,600			

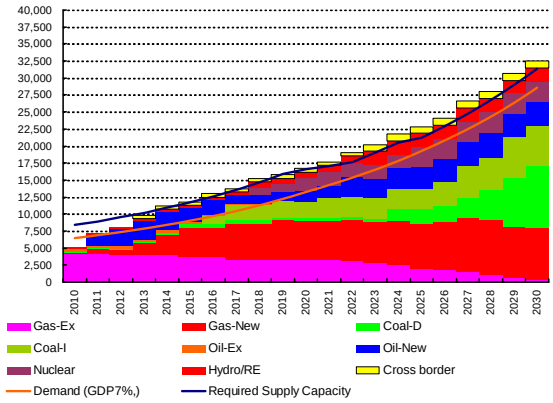
Source: PSMP Study Team

Power development plans are formed by fuel type based on diversification scenario for each demand forecast up to 2030.



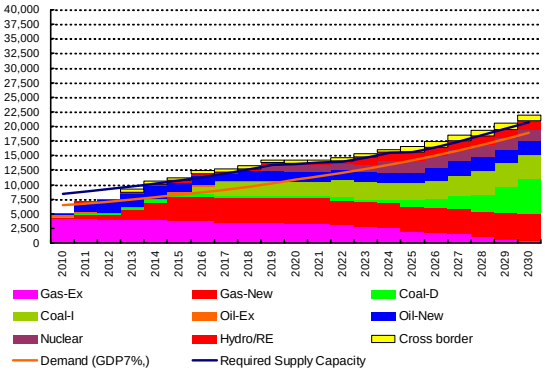
Source: PSMP Study Team

Fig. 3-3 Power development plan by 2030 (Demand: Government policy)



Source: PSMP Study Team

Fig. 3-4 Power development plan by 2030 (Demand: Comparison 7%)



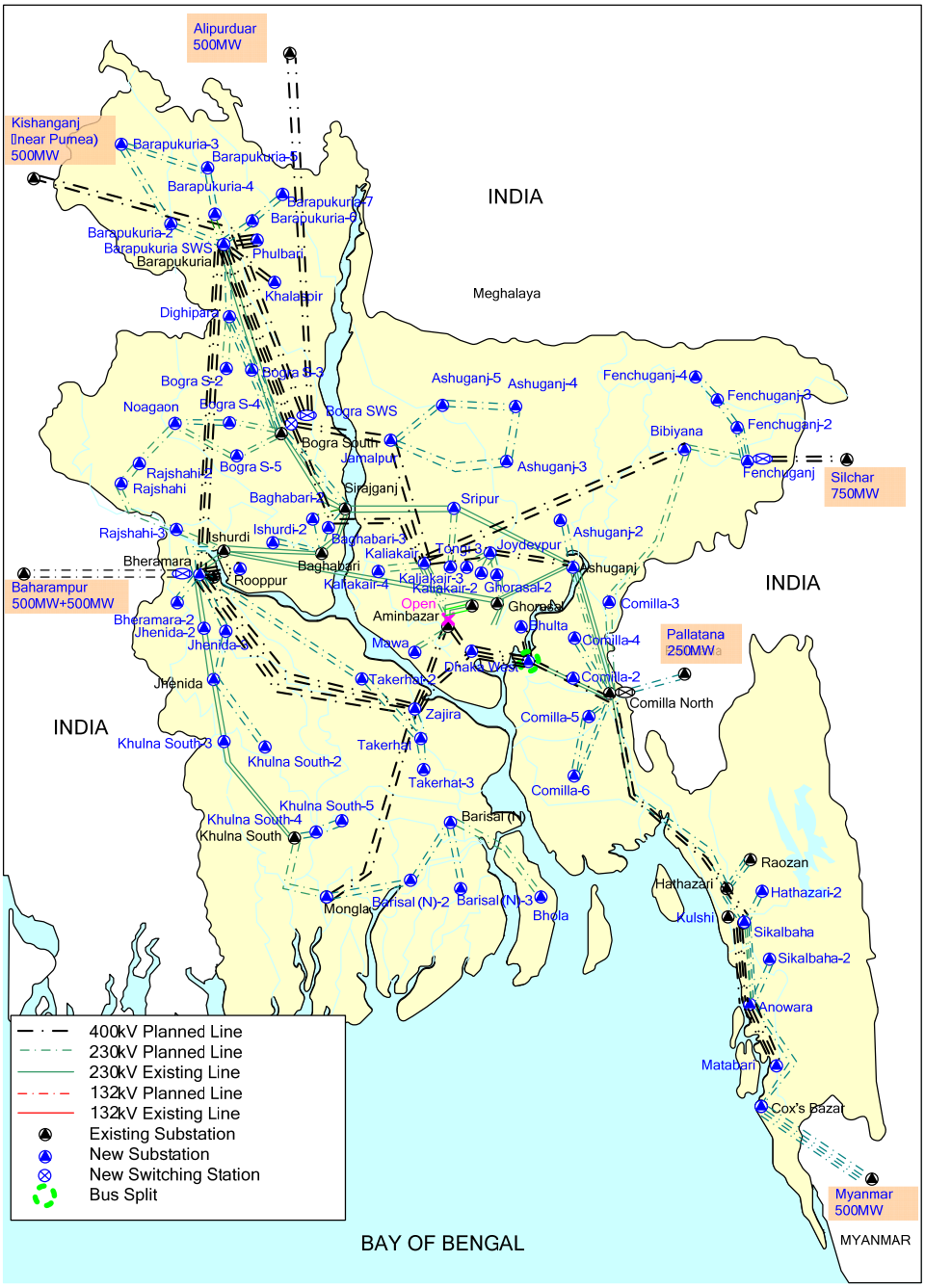
Source: PSMP Study Team

Fig. 3-5 Power development plan by 2030 (Demand: Comparison 6%)

3.2.5 2030 power system expansion plan

The 2030 power system expansion plan, which satisfies the Fuel Diversification scenario is shown in Fig. 3-6.

System Configuration (2030) (Grid Demand: 33GW)



Source: PSMP Study Team

Fig. 3-6 Power system expansion plan at 2030 (overall system)

Chapter 4 Financing for Materialization of the Master Plan

4.1 Total investment required and funding sources

4.1.1 Aggregated amount of investment

The aggregated amount of investment for the development of the generation, transmissions and the related facilities to implement this Master Plan are estimated to be as follows;

Table 4-1 Aggregated amount of investment

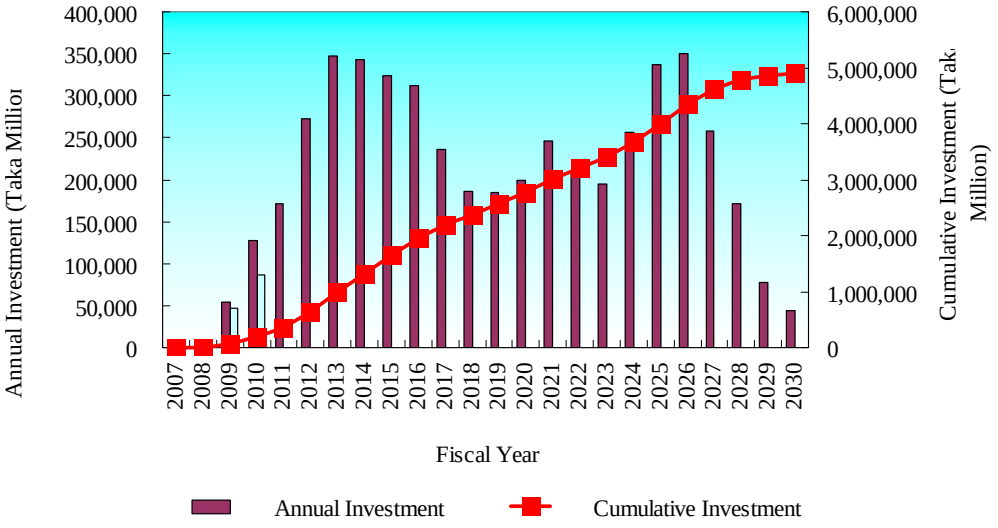
Executing Agency	Generation Capacity	Total Investment (Taka Billion)	Annual Averega of Investment (Taka billion)	ditto (US$ million)
Generation & Transmission				
Public Sector	5,787 MW	947	47.4	681
Private Sector	9,436 MW	710	35.5	510
Pub/Priv Unclassified	17,600 MW	1,776	88.8	1,276
Renewable Energy[1] & Intl Connection	3,611 MW	25	1.3	19
Sub-total	36,434 MW	3,456	172.8	2,483
Related Facilities		1,449	72.5	1,042
Total	36,434 MW	4,905	245.3	3,525

Source: PSMP Study Team

The aggregated investments for the development of the generation, transmission and related facilities are found to be at Taka 4.9 trillion (US$ 70.5 billion). The annual average of the investment amounts to Tk 245 billion (US$ 3.5 billion). The peak of the investment will be reached in FY 2013 for the amount of Tk 347 billion (US$ 5.0 billion) while the bottom will be found during the final couple of years. The amount will be Tk 78 billion (US$ 1.1 billion). The year wise investment and its cumulative total appear in the figure below.

The graph presents the twin peaks of annual investments, the first one of which is during the fiscal years of 2012 and 2017, while the second one is during FY 2024 and FY 2027. The first peak is formed by a concentration of investments that are intended to cope with the prevailing power shortage while the second one is formed by the concentration caused by the retirements of plants with shorter life spans that have been constructed during the first peak period. The issue of financing is critically important for meeting the financial needs during the first peak period, in particular. The underlying reason is found in the fact that the entire first peak of investments is the new investments that need to be identified with financing sources from scratch. The second peak, on the other hand, should be less difficult in terms of financing as the expiring plants accompany the accumulated depreciation that can be re-invested for the replacing of investments.

[1] Hydro power is excluded from renewable energy, included in “Generation & Transmission, Public Sector”.



Source: PSMP Study Team

Fig. 4-1 The aggregated investment under the Master Plan (FY 2010 constant price)

4.1.2 Source of funds

The source of funds can be summarized in the following table;

Table 4-2 Funding source and fund volume for the Master Plan

(Taka Billion)

	Present Level of Fund Volume	Fund Volume Expected in 2-3 Years[1]	Annual Average Investment under Master Plan
National Budget (incl. ODA assistance by donors)	50	78.4	
Government Schemes for PPP Promotion	2.3	25.1	
Donors' Assistance to IPPs	-	18.6	
Rental Power	18	0	
Total	70.3	122.1	245.3

Source: PSMP Study Team

The volume of funds currently available from the identified sources of funds stands at Tk 70 billion (US$ 1.0 billion) annually. In the 2-3 years to come, the PPP funds in the national budget and commitments by donors are expected to increase. In addition to those mentioned and for the sake of analysis, the PSMP Study Team assumes that WB and ADB extend their assistance of direct loan and partial risk guarantees to one IPP plant for each three year period. Given these assumptions, the annual allocation to the power sector will increase by Tk 27 billion (US$ 0.3 billion) which will then be added by the leverage effect of Tk 27 billion (US$ 0.4 billion). The total volume that can be financed in consideration of those effects will amount to Tk 122 billion (US$ 1.7 billion). The Master Plan as a whole requires an annual allocation of Tk 245 billion and the amount calculated for future availability covers only 50% of the total requirement, while the remaining 50% has yet to be identified in its funding source. It is imperative that the funding source needs to be expanded and efforts should be made to increase the funding volume from each of the funding sources to fill the gap.

[1] Includes leverage effects

In the meantime, although the realization of the Master Plan requires painstaking efforts to secure the sufficient amount of funds required, it is needed to be considerate before hastily concluding that the prevailing conditions constitutes an insurmountable barriers which could endanger the implementation of the Master Plan. In general, the funds float in search of better investment opportunities while scrutinizing the risks and returns involved. The fact that power sector was not able to receive sufficient funds for development buttresses the underlying fact that the projects have not yet been formulated which is sufficiently attractive for risk-taking and investment. What is important is to carefully prepare the projects, while developing an environment conducive to investments including the assurance of a sufficient return which is matched against the risks to be taken on the investment, diversify the funding source, pursuing the expansion of funding through which the Master Plan grows as the plan assuring a high probability of funding support.

4.1.3 Promotion of private sector investment

At around 2000, the private sector development in the power sector used to be in a full swing but has lost its momentum since then. Since 2003, there has been no large scale development of IPPs. The development has been on stall for a considerable time period. The following underlying reasons behind the stagnant development are frequently referred to;

- Unfavorable business environment for investments owing to the global financial crisis and economic slump,
- Low and inadequate levels of electricity tariffs and gas tariffs,
- Vulnerable financial standing of the single power purchasing entity, BPDB,
- Unstable supply of gas for long term supply and commitment by contracts,
- Constraints of implementation capability of government institutions,
- Lack of transparency in the government processes, lack of timely decision-making and enforcement of government commitment, and
- The spreading of a skepticism among private sector investors against the government handling of private investment.

The government, on the other hand, launched a series of promotion policies and proceeded in their implementation. The following are some of the policy measures launched by the government;

- Exemption and alleviation of income taxes, import duties and value added taxes by virtue of the Private Power Generation Policy,
- The purchasing of electricity generated by captive generation plants by virtue of the Captive Power Generation Policy
- Establishment of PPP Guideline and special fund allocation for PPP within the national budget,
- Introduction of rental power generation and quick rental power generation as the emergency measures to cope with the power shortage.

The policy measures adopted by the government directly address the improvement of investment returns and the alleviation of the shortage of funds over a shorter time span. On the other hand, the long term and fundamental elements such as protection from country risks, improvement of fundamental risk/return correlations, improvement of the financial strength of the single power purchasing entity, revision of electricity tariffs, long term assurance of fuel supply, capacity building of government institutions engaged in the power sector development, etc. have yet to be addressed and remain insufficient.

The new political regime, having assumed the power in early 2009, has started tackling the problems in the power sector by introducing and promoting a rental power generation system while launching a road-show to induce the private sector to invest in power sector development. These events are demonstrating the government attitude changes and their willingness to

confront power sector issues. Such changes of the government attitude are acknowledged to have drawn positive responses from private investors. The new government has taken over from the previous government large IPPs that the previous government made repeated but abortive attempts for competitive bidding over several years in the past but has successfully approved the bidding results lately. It is imperative to capture the momentum being created and to make such changes and momentum a solid path for development. The PSMP Study Team is of the opinion that each of the aforementioned constraints needs to be addressed and measures need to be implemented for improvement, revision, alleviation and strengthening. For an individual investor facing the risk of long term investment, any one of the issues mentioned poses to be a vital factor for making his/her investment decision. The government is urged to address and resolve the following hurdles and solidify an environment conducive to investment by any means;

(1) To develop an environment which is conducive and allows for a sufficient return amount matched against the risks of long term investment,
(2) To alleviate the risks involved for the recovery of investment (strengthening of the financial health of BPDB, assurance of the government for bill collection, arrangement by the government for protection from the country risk),
(3) To revise the electricity tariffs and gas tariffs,
(4) To strengthen the financial strength of the power purchasing entity, BPDB,
(5) To promote the development of fuel and to enable a stable long term supply of fuel under a long term supply contract, and
(6) To establish a transparent process in the government handling of private investment, to proceed with a timely decision-making and its enforcement, and the due delivery of commitments.

4.2 Master Plan and the electricity tariff

4.2.1 Pursuit for the electricity tariff in due reflection of the generation cost

The levelized costs during the Master Plan period turns out to be; Tk 6.91/kWh for new plant generation ; Tk 8.17/kWh from existing plants; and Tk 7.84/kWh for purchased power from third parties. The overall cost integrating all of the three is identified as Tk 7.83/kWh which is the value expressed in the FY 2010 constant price without including the inflation and levelization[1] for the whole term of the Master Plan.

The preceding sub-sections reviewed the generation cost of the generation plants and related plants together with the overall cost of generation including the purchasing costs of electricity. The cost derived indicates the total cost to be incurred to the power system of the country and the level of tariffs to be satisfied. The cost obtained stays at a high level and implies that the revision of the power tariff is required for a significant margin from the prevailing level. By all means, the tariff needs to be adjusted to a level that sufficiently covers the overall cost for the power. The prevalent bulk tariff adhered to by BPDB is Tk 2.37/kWh[2]. For the power tariff to reach the overall cost of power under the Master Plan at Tk 7.83/kWh, the bulk tariff needs to be raised to 3.3 times the prevailing level. Assuming that the gas price is adjusted to the international level in five years, the bulk tariff needs to be raised to 330%, equivalent to an annual increase of 27%. As indicated before, the overall power cost starts the Master Plan period at a high level from its very beginning and remains stagnant in the middle to latter part of the period. The start at the high level stems from the fuel cost adopting international prices, in particular, the gas price is set up at a level that is significantly higher than the prevailing price. According to the calculation, the overall cost records a peak of Tk 8.84/kWh in FY 2012. The overall cost tends to gradually decline from the year towards the final end of the Master Plan.

[1] The analysis here has adopted a discount rate of 12% in calculating the levelized cost.
[2] Based on the hearing at BPDB and BERC at the time of the revision of bulk tariff taken place in 2008.

Should it happen that the gas price is adjusted towards the international level, the storyline articulated above will become the reality in which, unless the tariff is drastically adjusted, the bulk selling business of power by BPDB will end up becoming a loss-making operation.

4.2.2 Recommendation for tariff revision

As of FY 2009, the structure of the power source of BPDB, the single buyer of the power in the country, consists of; 41% from its own generation; 19% from public generation entities (government/BPDB owned); 34% from IPP purchases; and 5% from rental power producers. The costs of electricity for each of the sources are Tk 2.53/kWh for its own generation; Tk 1.21/kWh for the publicly owned generation entities; Tk 2.70/kWh for IPPs; and Tk 5.20/kWh for rental power producers. The overall acquisition cost of BPDB for all the power sources stands at Tk 3.07/kWh for the year. The average billing rate of BPDB, on the other hand, stands at Tk 2.56/kWh including its retail selling to certain designated consumers[1]. The acquisition and selling prices leave BPDB with a negative margin of Tk 0.51/kWh[2]. Of particular mention is the increase of rental power which expanded its shares among the total acquisition of BPDB from 0.2% in FY 2008 to 5.2% in FY 2009, is creating significant losses in the single buyer operation.

The purchasing of power by BPDB from the rental power producers is conducted under government initiatives and is supposed to be supported by the government in its financial outcome. The remedy assistance provided by the government remains in the provision of funds in the form of loans with interest. BPDB, though it is helped by the funds for tiding over cash flow deficiencies but is of no help in terms of profit and loss accounting in ending up with the accumulation of losses in its profit and loss statement. For BPDB, there hardly exists a source of funds for repaying the funds provided through lending by the government. The financial standing of BPDB has been placed in very weak and vulnerable position for a long time with the accumulation of losses in its balance sheet and that fact has been one of the key elements that have constrained the development of IPP market. The situation is being further aggravated in line with the promotion of the rental power generation system. The weakness and fragility of BPDB's financial position has caused long lasting and fundamental problems such as the weak capacity for power development; lack of proper maintenance activities of existing plants; constraints in the purchasing of power generated by the private sector entities; anxieties spreading about the capability for contract performance; and constraints in new investment for the development of power both in the public and private sectors. The government is urged to take immediate steps for coping with the situations and resultant issues.

In concluding this Chapter, the PSMP Study Team stands resolved to face the issues needing rectifying and recommends that the government take the necessary steps in the following specific recommendations;

(1) Subsidy to cover the deficit Incurred by rental power

Rental power is a system that has been initiated and promoted by the government as an immediate measure to cope with the critical shortage of power. With the exception of several plants whose contracts runs for a relatively long term of 15 years, most of the contracts are short term ones of three to five years in which the per unit cost of power inevitably becomes expensive as the rental power producers try to absorb the depreciation of the plant within such limited short times. BPDB is obligated to purchase the rental power produced at such high cost and to sell the power at the regulated bulk tariff with no effective means to avoid the loss creation in the dealing operation. The negative margin incurred at BPDB needs to be recognized as the cost of the policy implementation initiated by the government and there

[1] BPDB, "Annual Report 2008-2009"
[2] ditto

exists a legitimate reason for the government to bear such cost. The present assistance of the government through the extension of loans to BPDB should be replaced by the grant for the purpose of alleviating the burden of loss creation at BPDB. Such actions of the government, if honored, are recommended to be made retroactive to the starting year of the rental power system (FY 2008), in theory.

(2) Revision of bulk selling tariff

The preceding subsection argued that the electricity tariff should be revised to reflect the overall power cost under the Master Plan. The fundamental policy of the government for setting the electricity tariff stipulates the achievement of the cost reflective tariff in Bangladesh. In actuality, the principle has not been duly met and the history of the tariff revision has been reputed as the ones of "too little, too late". The fundamental principle laid down appears to be becoming dormant. The prevailing insufficient tariff has caused the power sector of the country problems such as the delay in development; the delay in energy saving activities; while not meeting the growing demand which is ending in the acute and aggravating shortage of power. The revision of tariffs to reflect costs is vital to develop an environment conducive to private sector investment and to activate demand side management. The power shortage issue needs to be addressed from both sides of the demand and the supply. The establishment of a cost reflective tariff is one of the indispensable steps to be taken. It is unfortunate to know that, while arguments are occurring between the government agencies and officials concerned that the cost reflective tariff is a non-negotiable must, there is no clear initiative or indicative actions for the realization of such a tariff.

The government and BERC should take strong leadership in establishing and launching an action plan to materialize the cost reflective tariff. The power cost observed in the preceding sub-chapter has been based on the international fuel prices and its wide deviation from the current tariff prevailing in the country has been observed. The first phase of the action plan should focus on achieving the cost reflective tariff based on domestic fuel prices and in the second phase to proceed to adjust the fuel price and the electricity tariff to international levels. Should it happen that the fuel price be adjusted in the nearer future, it would be necessary to execute the two phases of actions simultaneously.

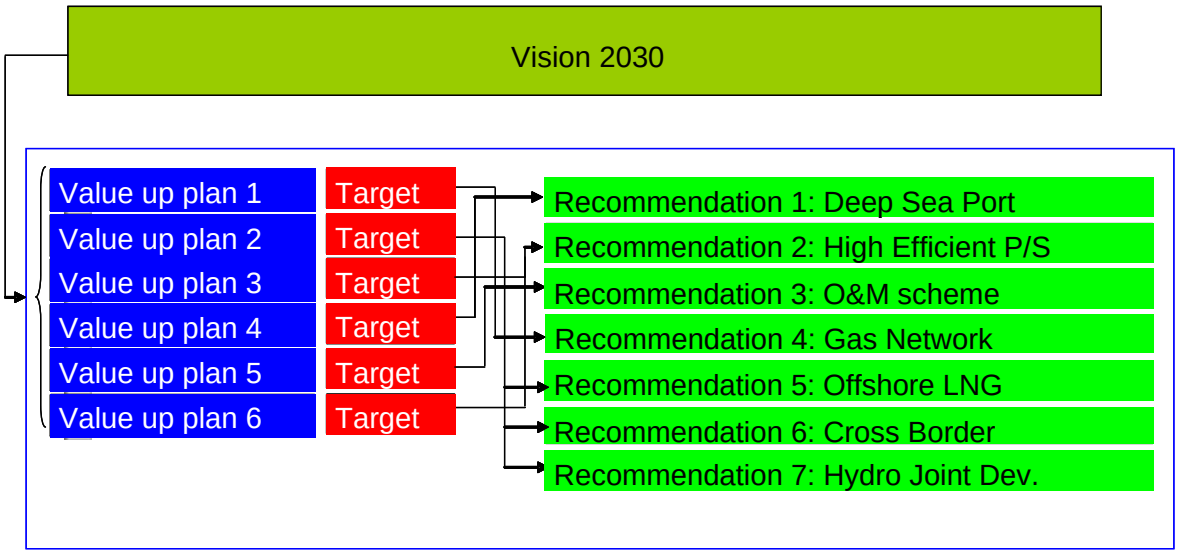
(3) Raising of funds through power development surcharge

In concluding the chapter, the PSMP Study Team recommends that the government introduce a "Power Development Surcharge" System for the purpose of raising the funds for power development and moving toward the self sustaining power system in the country. The fundamental principle for the electricity tariff is laid on the cost recovery which limits the power entities to collect electricity bills only to the extent that they recover the costs invested. There is no system where the power entities gain the funds for expansion through bill collection. The funding for expansion is virtually limited to relying on government and/pr donor funding only. The following recommends that the government establish a new channel for accumulating investment funds enabling the power sector to become financially self sustainable.

Chapter 5 Recommendations

In this chapter, the recommendations have been submitted based on knowledge acquired by investigation so far.

As mentioned in Chapter 2, this MP has developed the vision of the MP as the prioritized goal, and has set the value-up plans and targets in order to achieve the goal. The following describes the detailed recommendation to attain those targets. The following figure summarizes the target with the corresponding recommendations.

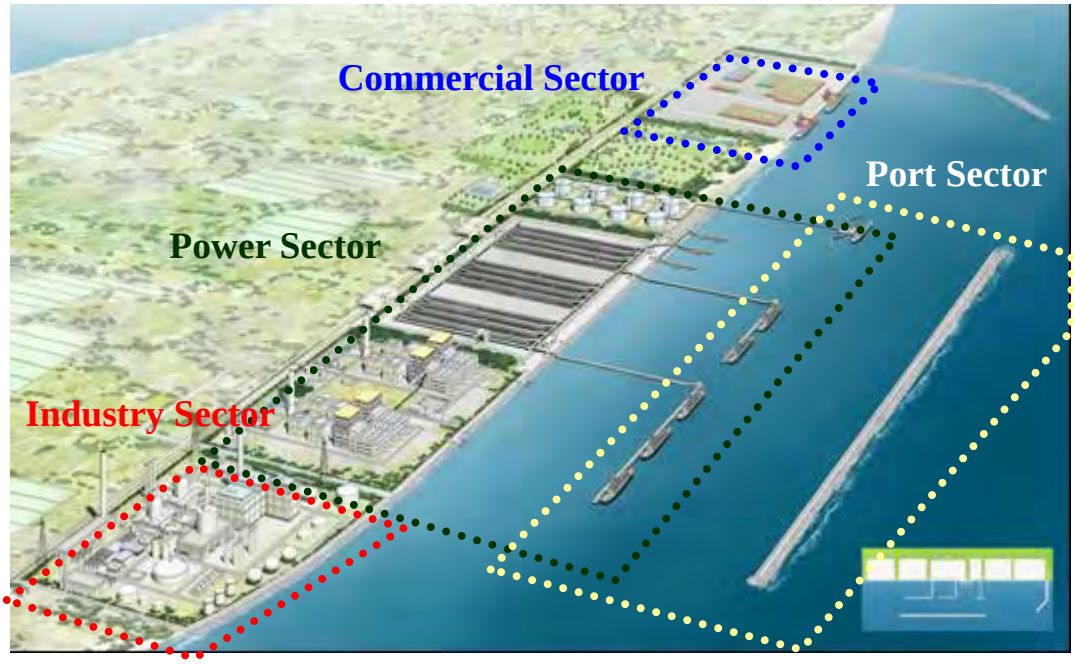


Source: PSMP Study Team

Fig. 5-1 Relationship between each target and recommendations

5.1 Study for basic design regarding deep sea port development (F/S, D/D)

In order to receive import coal ships, and for the industrial structural development of Bangladesh towards processed exportation and to export products, the necessity for a deep sea port continues to grow the economy. Because it needs a huge amount of investment for the development of deep seaports, it is difficult for the power sector to proceed alone. Hence, it should proceed with the coordination of other sectors such as commercial sector, industry sector and other financing from international organizations. The PSMP Study Team recommends a study for deep sea ports and the related conditions of import coal, oil, and gas.



Source: PSMP Study Team

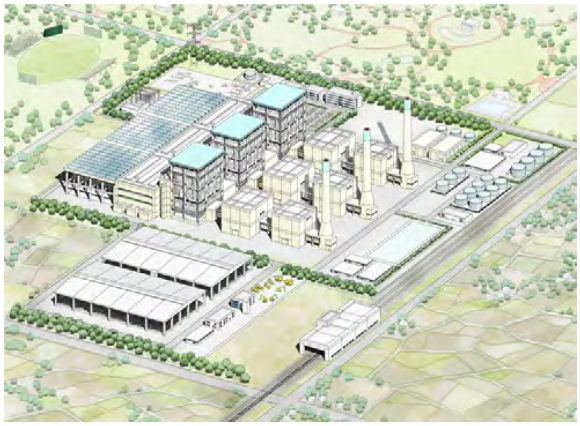
Fig. 5-2 Image of deep sea port development by multi-sector in Matarbari

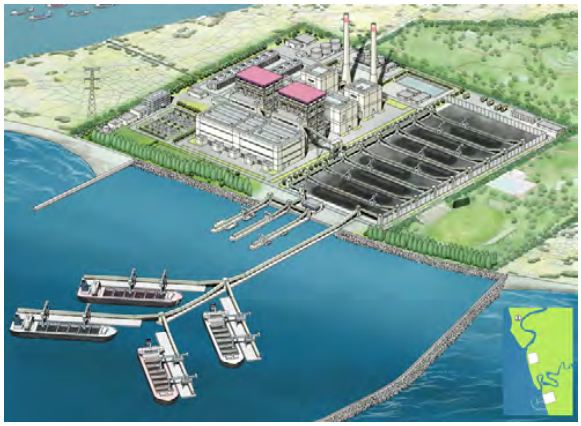
5.2 Study for the basic design of coal-fired power plant applied high efficiency generation technology (F/S, D/D)

In this study, from the optimum power generation plan and transmission network development plan which were formulated based on the results of the investigation in the 2nd year, after proceeding with the technical, economic, environmental and social analyses, to prioritize projects with high development possibility and create a short list with three sites and proceed to a rough technical study.

For the construction of a power station, based on the aforementioned technical study, the feasibility study (F/S), detailed design (D/D) reflecting the local characteristics is needed. The main study contents are; securing of ground, generation facilities, cooling water and fuel, transportation, capacity of fuel, treatment of coal ash, methods for the prevention of air pollution, methods of environmental conservation, the selection of the main equipment, water systems for the power station, coal handling facility, port infrastructure, ash treatment facility, heavy equipment and material during construction, packing for transportation, transportation restrictions, transportation methods for heavy equipment during maintenance etc.

Through application of the USC coal-fired power plant equipments, enhanced generation efficiency becomes possible and reduction of CO2 emission is also realized in order to contribute to adaptation of climate change problems. Further, although coal-fired power plants generally emit more NOx, SOx and dust than gas-fired ones, emissions can be reduced drastically by applying state-of-the-art denitrification, desulphurization and dust collection facilities or technology. This also means that the construction of environmental-friendly coal-fired power plants can also be attained. As the next step, the PSMP Study Team recommends conducting a feasibility study based on the needs of Bangladesh and the donor.





Source: PSMP Study Team

Fig. 5-3 Bird-view plan of power plants (L: Domestic coal: Import coal)

5.3 Support project for the enhancement of O&M organization and human education in thermal power generation (Technical support)

Based on the results of investigations of existing gas-fired power plants, it became clear that a majority of the plants are incapable of reaching designated performance levels of capacity and efficiency. The main reason is that these inspections are more restorative than preventive which means most repairs take place after something breaks down.

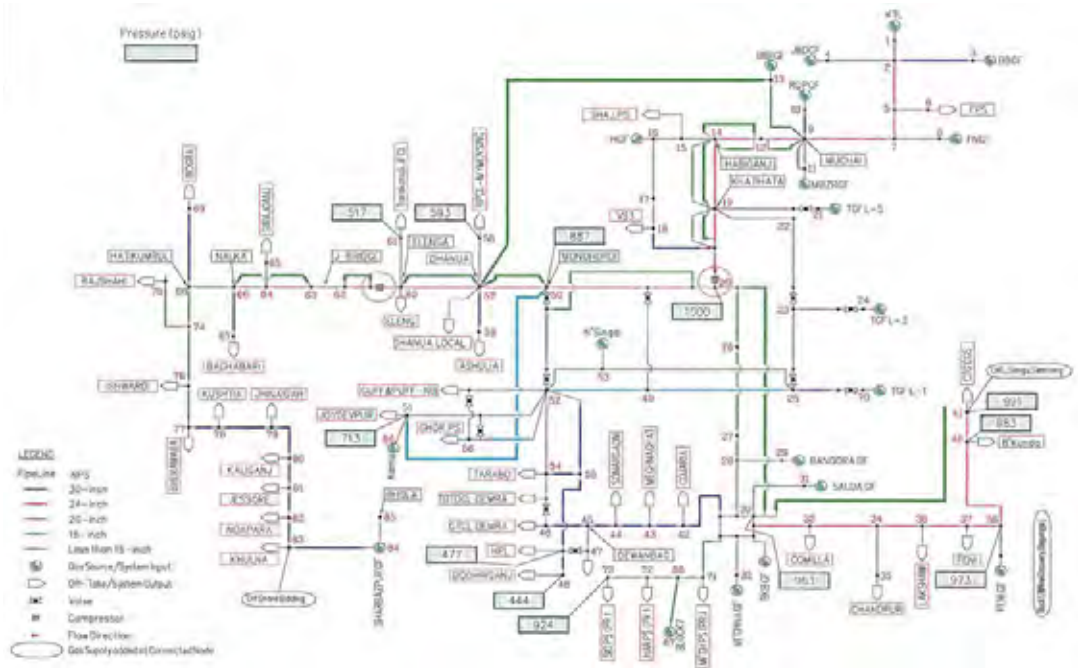
Since power demand will increase in the future, ensuring a stable power supply will require that generation facilities perform according to original specifications. In order to meet these requirements, it is important to change over to the concept of “take care before break down” instead of the current “repair after break down”. In other words, proceed with regular inspection regardless of whether something is broken or not such as (Time Based Maintenance (TBM))” or heeding to equipment predictors during monitoring (Condition Based Maintenance (CBM)”.

In order to taking root of TBM and CBM in Bangladesh, it is possible to teach by incorporating CP training into Japan to transfer maintenance know-how, etc. Moreover, one other effective means is to provide technical assistance in proceeding with the equipment diagnosis for individual plants which carries out aged deterioration together with the CP in order to judge the validity to proceed with rehabilitation.

5.4 Support project for enhancement of gas network (F/S, D/D)

The reason underlying the gas shortage in Bangladesh is the shortage of supply from the gas fields. In addition, the combined factor of the weakness of the existing gas pipeline does not make things better. On the other hand, in order to improve the gas network, a huge amount of investment is needed. It is difficult for Bangladesh given that support from international organizations like ADB is not sufficient.

One more purpose would be to make a promise to supply gas for Haripur P/S and Bheramara P/S for which Japan would provide financing, maintenance or upgrades for gas networks would be necessary in the future, the PSMP Study Team recommends in proceeding with the development study to secure gas supplies especially in the west side.



Source: PSMP Study Team

Fig. 5-4 Map of major gas network

5.5 Project for offshore re-gasification facilities (F/S)

Since natural gas demand is already larger than its supply, the introduction of LNG would be the practical option to fulfill this demand-supply gap. Establishing the LNG chain is essential for the introduction of LNG. The LNG receiving facilities must be constructed in Bangladesh. The constructions of proven onshore facilities require a great amount of cost and time. As the offshore gas receiving facility technique has developed and does not need so much cost and time, the offshore gas receiving facility has attracted attention. The PSMP Study Team recommends a study in order to stabilize the supply of LNG in the future.

Source: NIKKISO CO., LTD study data (2010)

Fig. 5-5 Type of mooring（Left: Jetty type, right: Buoy type）

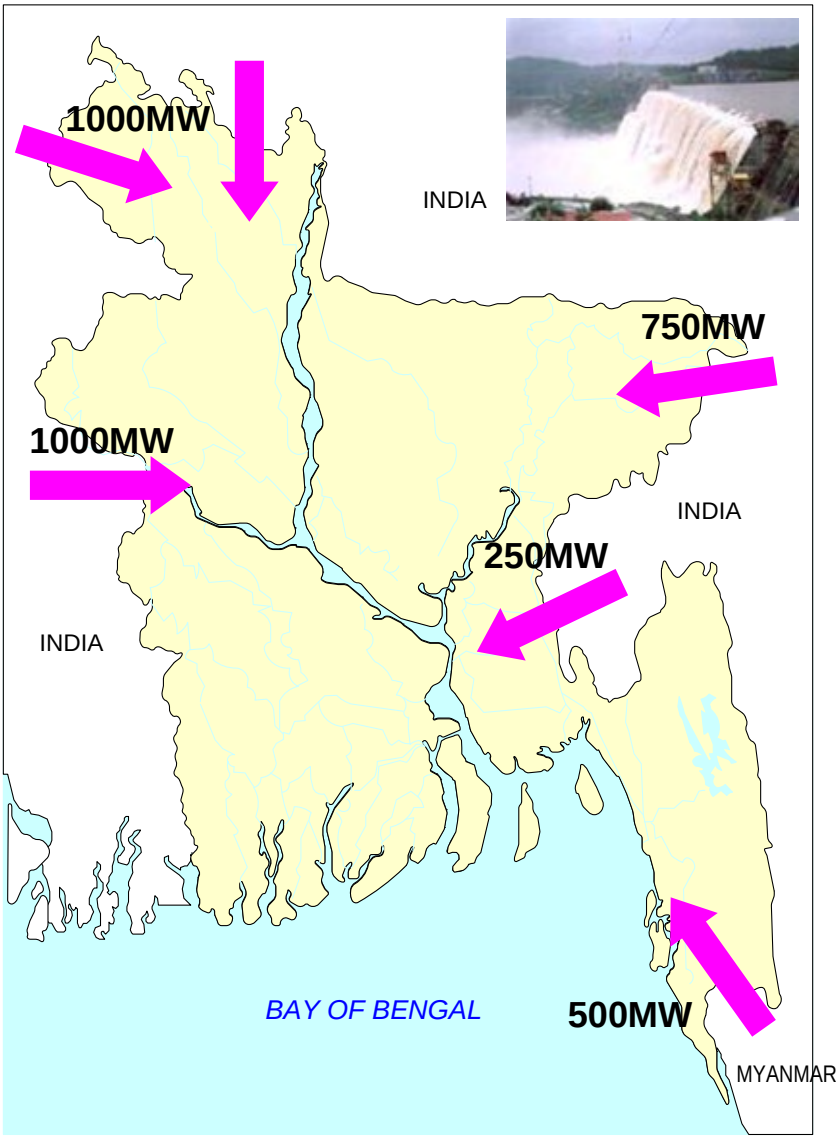
5.6 Technical support project towards the realization of cross border trading of electric power as a target (F/S)

The country surrounding Bangladesh, India, Nepal, and Bhutan possesses a vast potential of hydro power resource capability (assuming that potential hydro power is set in India at 148,700MW, Nepal at 44,000MW, and Bhutan at 30,000MW). It not only contributes to the development of these regions, but by using these abundant resources effectively within the countries in South Asia including Bangladesh, it also contributes to alleviating climate change via renewable energy conversion and large-scale CDM (Clean Development Mechanism) project development is also expected in the future. Moreover, hydro-power generation is excellent in load following capability since it is rich in frequency adjustment functions; there are various advantages for countries in South Asia to establish a firm electric power network in the future.

The South Asia broadband electric power network basic study is mainly implemented by USAID (SARI=South Asia Regional Initiative). Cross border trading has already been implemented between India and Bhutan and India and Nepal.

As for the possibility of cross border trading between India and Bangladesh, the cross border trading between the Bengal province in India and West Bangladesh is recommended by USAID in its basic study. In the short term, the power flow in Bangladesh is from east to west. Since power flow is mitigated by cross border trading, this cross border trading is efficient. But in the mid and long term, since power flow has changed from west to east, the cross border trading at East and North-east Bangladesh would became efficient. In addition, existing hydro-power resources are especially abundant in Bangladesh and in the border of the Eastern or North-east Indian area. Hence, for a certain period of time, this area will be targeted for development. The potential for cross boarder trading has been determined for the following reasons; a good supply-demand balance when surplus hydro power is off-peak during the rainy season is expected to be supplied to Bangladesh where there are power shortages. On the contrary, during the dry season, the electricity from Bangladesh to India and electric power accommodation is based on the time difference between both countries as well as holiday differences etcetera. Since the reinforcement of the power system in India is required, in order to proceed with electric power trading, it should be determined whether or not there is any

interest between the countries, in alignment with expectations that these activities will be conducted by an international organization. The PSMP Study Team recommnends to conduct a developmental study in order to search for an efficient potential electric power trading scheme from the perspective of the power development plan and power system plan.



Source: PSMP Study Team

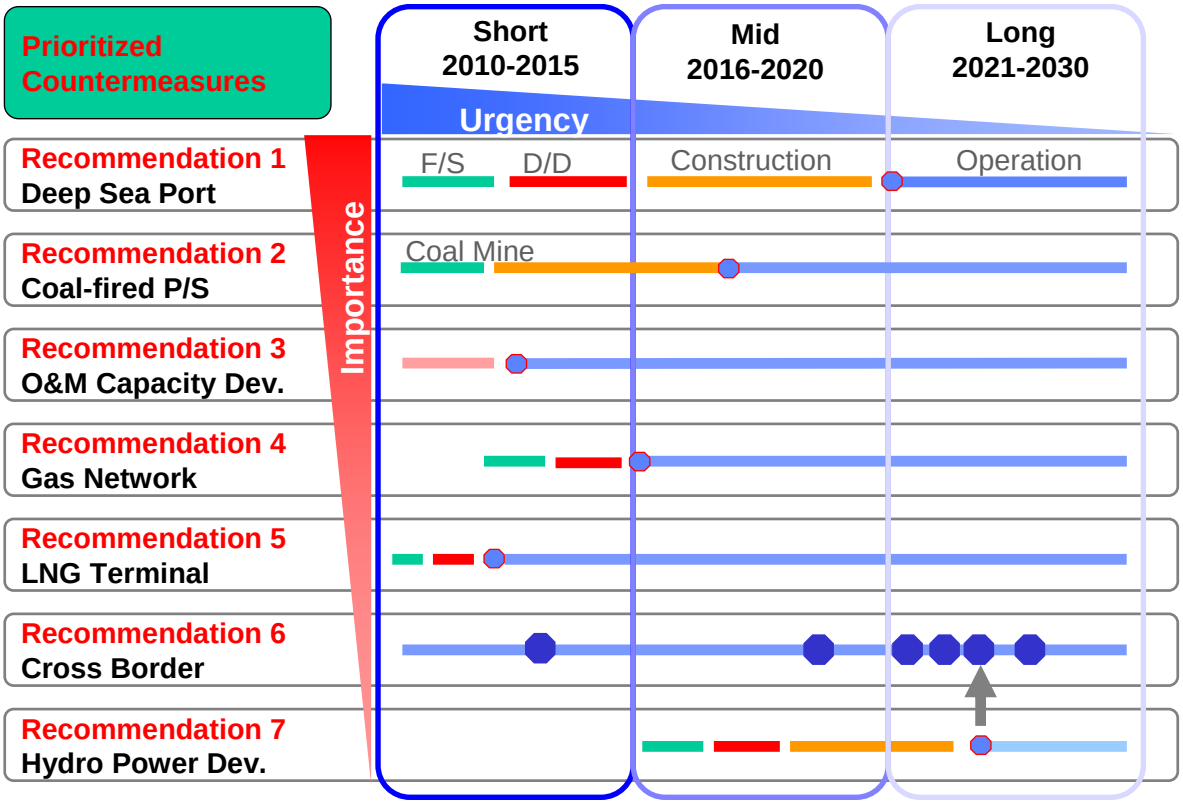
Fig. 5-6 Cross border trading of electric power plan

5.7 Support project for the joint development of a hydro power station with neighboring countries (F/S)

Although there is some possibility of an interconnected system between Bangladesh, Nepal or Bhutan, in order to realize such an interconnection that will have a network pass through India, there are some political difficulties that must be surmounted. It is clear that priority should be given to an interconnection system with India first. There is another possibility to develop not only an interconnection system but the joint development of the hydro power station in Assam State, Northeast India. On the stage of joint development, PSMP Study Team recommnends proceeding with an investigation of the concerned technical, environmental and social, economic issues.

5.8 Priority of recommendations

The following figure shows the importance and urgency of recommendations.



Source: PSMP Study Team

Fig. 5-7 Priority of recommendations

In order to implement the development of coal-fired power stations which are the core of this Master Plan smoothly, it is essential to secure fuel supply, prioritizing the development of port facilities for import coal and the development of domestic coal mines. The PSMP Study Team recommends the Bangladesh government to implement some measures to strengthen the O&M ability of power companies so that the increasing newly developed power stations would keep them full performance for long time.