INTERNATIONAL DEVELOPMENT ASSOCIATION

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED SCALE UP FACILITY CREDIT

IN THE AMOUNT OF EUR 55.7 MILLION
(US$59 MILLION EQUIVALENT)

TO THE

PEOPLE’S REPUBLIC OF BANGLADESH

FOR THE

POWER SYSTEM RELIABILITY AND EFFICIENCY IMPROVEMENT PROJECT

MARCH 30, 2017

Energy & Extractives Global Practice
South Asia Region

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CURRENCY EQUIVALENTS
(Exchange Rate Effective as of February 28, 2017)

Currency Unit = Bangladeshi Taka (BDT)
BDT 79.7 = US$1
US$ 1.0603 = EUR 1

FISCAL YEAR
July 1 - June 30

ABBREVIATIONS AND ACRONYMS

AGC Automatic Generator Control
APSCL Ashuganj Power Station Company Limited
BAFO Best and Final Offer
BERC Bangladesh Energy Regulatory Commission
BPDB Bangladesh Power Development Board
BREB Bangladesh Rural Electrification Board
CE Citizen Engagement
CPF Country Partnership Framework
DLR Dynamic Line Rating
ECoP Environmental Code of Practice
EMP Environmental Management Plan
EGCB Electricity Generation Company of Bangladesh
ESMF Environmental and Social Management Framework
ESMU Environmental and Social Management Unit
FGMO Free Governor Mode Operation
GDP Gross Domestic Product
GOB Government of Bangladesh
GHG Greenhouse Gas
GNI Gross National Income
GWh Giga watt hour
IDA International Development Association
IPP Independent Power Producer
MMCFD Million Cubic Feet Per Day
MPEMR Ministry of Power, Energy, and Mineral Resources
NLDC National Load Dispatch Centre
NPF New Procurement Framework
NWPGC North West Power Generation Company
OEM Original Equipment Manufacturer
PGCB Power Grid Company of Bangladesh
PPA Power Purchase Agreement
PPSD Project Procurement Strategy for Development
PMU Project Management Unit
PSMP Power System Master Plan
RAP Resettlement Action Plan
RPF Resettlement Policy Framework
RMS Regulating and Metering Station
SCADA Supervisory Control and Data Acquisition
SCD Systematic Country Diagnostic
SIA Social Impact Assessment
SMP Social Management Plan
SVC Static VAR Compensator
VFM Value For Money
WTP Willingness to Pay

Regional Vice President: Annette Dixon
Country Director: Qimiao Fan
Senior Global Practice Director: Riccardo Puliti
Practice Manager: Demetrios Papathanasiou
Task Team Leader(s): Md. Iqbal, Issa Diaw
BASIC INFORMATION

Is this a regionally tagged project?  
No

<table>
<thead>
<tr>
<th>Country(ies)</th>
<th>Lending Instrument</th>
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<td></td>
<td>Investment Project Financing</td>
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[ ] Situations of Urgent Need of Assistance or Capacity Constraints
[ ] Financial Intermediaries
[ ] Series of Projects

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<th>Approval Date</th>
<th>Closing Date</th>
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<td>26-Apr-2017</td>
<td>31-Dec-2021</td>
<td>B - Partial Assessment</td>
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Bank/IFC Collaboration
No

Proposed Development Objective(s)

Improve the reliability and efficiency of the power system in Bangladesh through optimization of dispatch operation.

Components

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<th>Component Name</th>
<th>Cost (US$, millions)</th>
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<td>Technical Assistance</td>
<td>8.00</td>
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<tr>
<td>Operational Enhancements</td>
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<tr>
<td>Removal of Transmission Bottlenecks and Improvement of Voltage Quality</td>
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<td>Total</td>
<td>77.00</td>
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Organizations

Borrower:  
Peoples Republic of Bangladesh

Implementing Agency:  
Power Grid Company of Bangladesh (PGCB) Ltd.
### Counterpart Funding

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<th>Financing Source</th>
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<td>IDA-60100</td>
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<td><strong>Total</strong></td>
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### Expected Disbursements (in US$, millions)

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<td>15.00</td>
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<td>Cumulative</td>
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### INSTITUTIONAL DATA

**Practice Area (Lead)**
Energy & Extractives
**Contributing Practice Areas**

**Climate Change and Disaster Screening**

This operation has been screened for short and long-term climate change and disaster risks

**Gender Tag**

Does the project plan to undertake any of the following?

a. Analysis to identify Project-relevant gaps between males and females, especially in light of country gaps identified through SCD and CPF
   
   Yes

b. Specific action(s) to address the gender gaps identified in (a) and/or to improve women or men's empowerment
   
   Yes

c. Include Indicators in results framework to monitor outcomes from actions identified in (b)
   
   Yes

**SYSTEMATIC OPERATIONS RISK-RATING TOOL (SORT)**

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<th>Risk Category</th>
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<td>2. Macroeconomic</td>
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<td>3. Sector Strategies and Policies</td>
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<tr>
<td>4. Technical Design of Project or Program</td>
<td>Moderate</td>
</tr>
<tr>
<td>5. Institutional Capacity for Implementation and Sustainability</td>
<td>Substantial</td>
</tr>
<tr>
<td>6. Fiduciary</td>
<td>Substantial</td>
</tr>
<tr>
<td>7. Environment and Social</td>
<td>Low</td>
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<td>8. Stakeholders</td>
<td>Substantial</td>
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<td>9. Other</td>
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<td>10. Overall</td>
<td>Substantial</td>
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</table>
## COMPLIANCE

### Policy

Does the project depart from the CPF in content or in other significant respects?

[ ] Yes  [✓] No

Does the project require any waivers of Bank policies?

[ ] Yes  [✓] No

### Safeguard Policies Triggered by the Project

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<td>Environmental Assessment OP/BP 4.01</td>
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<td>Physical Cultural Resources OP/BP 4.11</td>
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<td>Indigenous Peoples OP/BP 4.10</td>
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<td>Projects on International Waterways OP/BP 7.50</td>
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<td>Projects in Disputed Areas OP/BP 7.60</td>
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### Legal Covenants

#### Sections and Description

**Financing Agreement (FA), Schedule 2, Section I.A. PGCB Subsidiary Agreement.** Recurrent: Yes. Due Date: Effectiveness.

Description: To facilitate the carrying out of the Project, the Recipient shall make the proceeds of the Credit available to PGCB under a subsidiary loan agreement (“PGCB Subsidiary Loan Agreement”) between the Recipient and PGCB under terms and conditions acceptable to the Association.

**Sections and Description**

**FA Schedule 2, Section I.B. Safeguards.** Recurrent: Yes. Due Date: N/A
Description: The Recipient shall, and shall cause PGCB to, ensure that the activities under the Project are carried out in accordance with the provisions of the ESMF and RPF, the objectives, policies and procedures thereof, and the social and environmental mitigation measures and monitoring requirements provided therein including any and all plans, acceptable to the Association, developed thereunder.

Sections and Description

FA Schedule 2, Section I. D. Expenditures to be financed with counterpart funds. Recurrent: Yes. Due Date: N/A

Description: 1) The Recipient shall cause PGCB, at all times, to remain the entity duly authorized and responsible for land acquisition and resettlement, compensation and rehabilitation or other assistance during Project implementation.

2) The Recipient shall, and shall cause PGCB to: (a) ensure that the following expenditures are financed exclusively out of its own resources or other resources of the Recipient and/or PGCB and not out of the proceeds of the Credit; and (b) provide, promptly as needed, the resources needed for this purpose: (i) all land required for the purposes of the Project; (ii) all resettlement and rehabilitation compensation and other assistance to Affected Persons in accordance with the RAPs; (iii) recurrent expenditures such as workshop allowances, sitting allowances, cash per diems, honoraria and fuel; (iv) vehicles; and (v) import and supplementary duties and value-added taxes at import stage.

Sections and Description

Project Agreement (PA) Sec. I.A.2. Project Management Unit. Recurrent: Yes. Due Date: One month after Effective Date.

Description: (a) By no later than one (1) month after the Effective Date, PGCB shall establish, and thereafter maintain throughout the period of implementation of the Project, a project management unit headed by a project director and comprise of competent staff, all with experience and qualification, in numbers and under terms of reference acceptable to the Association including, inter alia, two (2) procurement specialists, two (2) financial management specialists, and one (1) monitoring and evaluation specialist.

(b) PGCB shall maintain throughout the period of implementation of the Project its existing dedicated environmental and social sub-unit comprise of one (1) environmental specialist and one (1) social specialist, both with experience and qualifications acceptable to the Association.

Sections and Description

PA Section I.A.3. Audit Committee. Recurrent: Yes. Due Date: One month after Effective Date.

Description: By no later than one (1) month after the Effective Date, PGCB shall establish, and thereafter maintain throughout the period of implementation of the Project, an audit committee: (a) comprise of staff, with experience and qualification, in numbers and under terms of reference acceptable to the Association; and (b) responsible for overseeing and settling any audit issues during the implementation of the Project.
Sections and Description
PA Section I.A.4. Bid/Proposal Evaluation Committee; Probity Assurance Provider. Recurrent: Yes. Due Date: N/A

Description: (a) PGCB shall ensure, throughout the period of implementation of the Project, that the final composition(s) of its bid/proposal evaluation committee(s) are agreed with the Association. (b) At any stage of the procurement processes of contracts defined as high value in the Procurement Plan and following a request from the Association, PGCB shall hire an independent third party under terms of reference satisfactory to the Association for providing probity assurance over those high value contracts.

Sections and Description
PA Section I.A.5. Memorandum of Understanding. Recurrent: Yes. Due Date: Two months after Effective Date.

Description: By no later than two (2) months after the Effective Date, PGCB shall enter into, and thereafter maintain throughout the period of implementation of the Project, a memorandum of understanding with BPDB and the selected power generator plants to be supported under the Project, under terms and conditions satisfactory to the Recipient and the Association, to allow an agile implementation of, and close coordinating during, the carrying out of the frequency control activities to be carried out under the Project.

Sections and Description
PA Section I.D. Safeguards. Recurrent: Yes. Due Date: N/A

Description: 1. PGCB shall carry out the Project in accordance with the provisions of the ESMF and RPF and the relevant Safeguards Assessments and Plans.

2. Whenever an additional or revised Safeguard Assessment and Plan shall be required for any proposed Project activity in accordance with the provisions of the EMF and/or the RPF, as the case may be, PGCB shall: (a) prior to the commencement of such activity, proceed to have such Safeguard Assessment and Plan: (i) prepared and publicly consulted on in accordance with the provisions of the EMF and/or the RPF, as the case may be; (ii) furnished to the Association for review and approval; and (iii) thereafter adopted and disclosed as approved by the Association, in a manner acceptable to the Association; (b) thereafter take such measures as shall be necessary or appropriate to ensure compliance with the requirements of such Safeguard Assessment and Plan and not amend, suspend or abrogate any provisions of the Safeguards Assessment and Plan without the prior written agreement of the Association; and (c) in the case of any land acquisition or resettlement activity under the Project involving Affected Persons, ensure that no displacement shall occur before necessary resettlement measures consistent with the RAP applicable to such activity have been executed, including, in the case of displacement, full payment to Affected Persons of compensation and of other assistance required for relocation, prior to displacement.

3. PGCB shall: (a) ensure that any technical assistance to be supported under the Project is carried out under
terms of reference satisfactory to the Association following its review thereof and, to that end, said studies shall
duly incorporate the requirements of Association’s Safeguard Policies and be publicly disclosed and consulted
upon in accordance with the Association’s Safeguard Policies; and (b) ensure that any capacity building activities
under the Project are consistent with, and pay due attention to, the Association’s Safeguard Policies.

### Conditions

<table>
<thead>
<tr>
<th>Type</th>
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<tbody>
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<td>Effectiveness</td>
<td>The PGCB Subsidiary Loan Agreement has been duly authorized or ratified by the Recipient and PGCB and is legally binding upon the Recipient and PGCB in accordance with its terms.</td>
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</table>

<table>
<thead>
<tr>
<th>Type</th>
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<tbody>
<tr>
<td>Effectiveness</td>
<td>The Additional Condition of Effectiveness consists of the following:</td>
</tr>
<tr>
<td></td>
<td>The PGCB Subsidiary Loan Agreement has been executed on behalf of the Recipient and PGCB and all conditions precedent to its effectiveness or to the right of the Recipient to make withdrawals under it (other than the effectiveness of this Agreement) have been fulfilled.</td>
</tr>
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</table>

### PROJECT TEAM

<table>
<thead>
<tr>
<th>Bank Staff</th>
<th>Role</th>
<th>Specialization</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Md. Iqbal</td>
<td>Team Leader(ADM Responsible)</td>
<td>Power Engineering</td>
<td>GEE06</td>
</tr>
<tr>
<td>Issa Diaw</td>
<td>Team Leader</td>
<td>Power Systems</td>
<td>GEE06</td>
</tr>
<tr>
<td>Tanvir Hossain</td>
<td>Procurement Specialist(ADM Responsible)</td>
<td>Procurement</td>
<td>GGO06</td>
</tr>
<tr>
<td>Mohammed Atikuzzaman</td>
<td>Financial Management Specialist</td>
<td>Financial Management</td>
<td>GGO24</td>
</tr>
<tr>
<td>Debabrata Chattopadhyay</td>
<td>Team Member</td>
<td>Power Systems</td>
<td>GEESO</td>
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<tr>
<td>Gunjan Gautam</td>
<td>Team Member</td>
<td>Operations</td>
<td>GEE06</td>
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<tr>
<td>Iqbal Ahmed</td>
<td>Team Member</td>
<td>Environment Safeguards</td>
<td>GEN06</td>
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<tr>
<td>Liliana Elisabeta Benitez</td>
<td>Team Member</td>
<td>Economic and Financial Analysis</td>
<td>GEE05</td>
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<tr>
<td>Md. Bazlul Kadir</td>
<td>Team Member</td>
<td>Procurement</td>
<td>GEE06</td>
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<tr>
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<tr>
<td>Md. Tafazzal Hossain</td>
<td>Team Member</td>
<td>Program Assistant</td>
<td>SACBD</td>
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<td>Mohammad Sayeed</td>
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<tr>
<td>Nadia Sharmin</td>
<td>Safeguards Specialist</td>
<td>Environment Safeguards</td>
<td>GEN06</td>
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<tr>
<td>Sabah Moyeen</td>
<td>Safeguards Specialist</td>
<td>Social Safeguards</td>
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<td>Shaukat Javed</td>
<td>Team Member</td>
<td>Program Assistant</td>
<td>GEE06</td>
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<tr>
<td>Sheoli Pargal</td>
<td>Team Member</td>
<td>Economics</td>
<td>GEEES</td>
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<tr>
<td>Zubair K.M. Sadeque</td>
<td>Team Member</td>
<td>Financial Analysis</td>
<td>GEE08</td>
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Extended Team
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I. STRATEGIC CONTEXT

A. Country Context

1. Bangladesh’s economy has performed well over the past decade. Its Gross Domestic Product (GDP) growth has risen by one percentage point per decade, from an average of 3.7 percent per annum in the 1980s to over 6 percent since 2010. This sustained growth was achieved despite the adverse impacts of the global recession, oil price rise, unrest in the Middle East (an important source of healthy remittance inflow) and natural disasters. Bangladesh has moved up to lower-middle income status in Fiscal Year (FY) 14 from low income group. The country has not only maintained the minimum requirement of the per capita income in the past consecutive three years, but also achieved a phenomenal rise in the Gross National Income (GNI) in the just concluded fiscal year. Its per capita income soared to US$1,314 at the end of FY15 which was US$1,190 in FY14 and US$1,154 in FY13. This economic growth has largely been dependent on a reliable and affordable supply of electricity. Moreover, the national poverty rate fell from 44.2 percent in 1991-92 to 18.5 percent in 2010, and to 14.4 percent in 2016. However, challenges to poverty reduction and shared prosperity remain as the recent sustained growth has widened infrastructure deficits in electricity, transport and telecommunication. In particular, Bangladesh’s economy could have performed much better if the energy infrastructure had developed in line with the economic demands.

2. The supply of power has not been able to keep pace with the rapid growth of electricity demand, resulting in frequent outages and load shedding. This has major effects on the economy as a majority of manufacturing and service firms in Bangladesh identify that absence of reliable electricity supply is the most important constraint to smooth operation and expansion of their businesses. The 2013-World Bank Enterprise survey report showed that businesses suffered power outages for 840 hours per year on an average, resulting in an output loss equivalent to 3 percent of GDP. In the same vein, Bangladesh was ranked the lowest out of 189 economies on the ‘Getting Electricity’ indicator in the 2016-'Doing Business Report’ prepared by the World Bank.

3. Finally, the constraint identified above in terms of access and quality of service is also affecting households and translates into a 407 kWh/year electricity consumption per capita, one of the lowest in the world and lower than most of the South Asian countries. About 78 percent of the population has access to electricity with almost full coverage in urban areas but only 70 percent of households have access in rural areas.

B. Sectoral and Institutional Context

4. Bangladesh has implemented an ambitious power sector reform program over the last 20 years to improve sector performance and create an enabling environment to attract private and public investment.

---

Footnotes:

1 As per ‘Bangladesh Development Update’, The World Bank, October 2016. The first two poverty rates are based on survey data and the third one on “projected actuals”.

2 Bangladesh is ranked 107th out of 140 countries on Global Competitiveness Index and 120th on quality of electricity supply. The Global Competitiveness Survey identified inadequate supply of infrastructure as the most problematic factor for doing business along with corruption.

3 Capacity shortfall of 1,000MW on average culminating with a nationwide black-out in November 2014.
The country made substantial progress but still needs to tackle major challenges linked to (i) finalization of the institutional reforms to ensure technical and financial sustainability of the sector (ii) timely financing and implementation of the investment needed to match the demand for electricity and reach universal access and, (iii) improvement of the operational performance and the quality of service.

**Power sector reform and current institutional set up**

5. The Ministry of Power, Energy, and Mineral Resources (MPEMR) is responsible for the power sector. Its Power Division is overseeing the electricity generation, transmission and distribution activities as well as the development of renewable energy. Power Cell was established in 1996 as an analytical and advisory body of the Ministry, to assist Power Division to design, facilitate, and monitor reform measures in power sector.

6. The Bangladesh Power Development Board (BPDB) was created in 1972 to handle the sector as a vertically integrated entity. However, the sector went through successive restructurings starting with the creation of the Bangladesh Rural Electrification Board (BREB) in 1977 to build and operate rural electricity distribution networks using a cooperative model. In 1994, the country approved the Power Sector Reform Program which paved the way for further unbundling. As a result, three (3) generation, one (1) transmission and three (3) distribution entities as well as a regulatory body (Bangladesh Energy Regulatory Commission- BERC) were formed. However, BPDB retained a large portion of public generation and a part of distribution, and it has been acting as a single buyer. Figure 1 illustrates the current institutional structure of the sector.

**Figure 1: Institutional Structure of Bangladesh Power Sector**

Government and Regulatory Institutions

- Bangladesh Energy Regulatory Commission (BERC)
- Ministry of Power, Energy and Mineral Resources (MPEMR)
- Power Cell
- Office of Energy Audit and Chief Electrical Inspector

Power Sector Companies and State Owned Enterprises

- Generation
  - BPDB (35%)
  - APSCL (10%)
  - NWPGC (3.5%)
  - EGCB (5%)
  - IPPs (42%)
  - Small IPPs (42% includes Small IPPs; missing 4.5% represents power import)

- Transmission
  - Power Grid Company Bangladesh (PGCB)

- Distribution
  - BPDB (24%)
  - DPDC (18%)
  - DESCO (10%)
  - WZPDCL (6%)
  - BREB (42%)
7. On the generation segment, the Ashuganj Power Station Company (APSCL), Electricity Generation Company (EGCB) and Northwest Power Generation Company (NWPGC) have been created as part of the unbundling process. Several Independent Power Producers (IPPs)\(^4\) are operating as well as the Rural Power Company Ltd (RPCL).

8. As part of the unbundling of the power sector along functional lines, the Power Grid Company of Bangladesh (PGCB) was established in 1996 to own, operate and expand the country’s power transmission assets. It took over the transmission assets and associated staffing from BPDB in 2002. It generates revenue from a wheeling charge determined by the regulator.

9. On the distribution side, there are two corporatized distribution companies that supply power to Dhaka, the capital city. These are Dhaka Electric Supply Company (DESCO) and Dhaka Power Distribution Company (DPDC). Additional power distribution companies were to be created as part of the power sector reform, namely, South Zone Power Distribution Company (SZPDC), Central Zone Power Distribution Company (CZPDC), West Zone Power Distribution Company (WZPDC) and North West Power Distribution Company (NWPDC). These are yet to be fully corporatized. Finally, BREB manages 79 Rural Electric Cooperatives which are also operating at the distribution level.

10. The technical and economic regulation of the energy sector is under the purview of BERC. It was established as an independent body to introduce a transparent and effective management of the energy sector by (i) issuing licenses to service providers, (ii) setting and enforcing uniform operational and quality standards for all players, and (iii) rationalizing costs and setting cost reflective tariffs and introducing performance and incentive-based regulations. Even if the tariffs are not still fully cost reflective, Figures 2.a. and 2.b. below illustrate reasonable efforts to reach that goal and reduce losses. BERC has been issuing regulations as well as tariff orders on electricity and natural gas. However, the Government of Bangladesh (GOB) continues to set tariffs on petroleum products.

\[\text{Figure 2.a: Cost of Supply versus Tariff}\]
\[\text{Figure 2.b: Reduction in System Losses and Account Receivables}\]
\[\text{Sources: PGCB/WBG}\]

11. Despite major progress in the unbundling process and the setting of the regulatory framework, there are strong resistances from the labor unions which have prevented further reforms and unbundling for the last six years. BPDB still retains 35 percent of the generation and part of distribution assets (24%)

\(^4\) IPPs occupy 42 percent of total capacity.
under its balance sheet without clear agenda to fully corporatize them. BPDP, with GOB endorsement, is rather setting up Strategic Business Units (SBUs) under the BPDB corporate umbrella. SBUs are expected to operate quasi-independently, with their own boards and management structure as well as separate accounting. While the SBU model can be considered as a step forward to improve the governance, the dominant and/or conflicting role of BPDB remains a major regulatory challenge for ensuring transparency of the electricity market.

**Addressing the infrastructure gap to ensure a sustainable supply-demand balance**

12. The power sector in Bangladesh has grown rapidly over the last decade as shown in Figure 3. The peak demand increased from 4,530 mega-Watt (MW) in 2010 to more than 9,036 MW in 2016 (not taking account of significant suppressed demand). At the same time, the installed generation capacity doubled over 5 years to reach 11.8 giga-Watt (GW) in 2016. However, only 8.5-9 GW is available at the maximum and a 1,000 MW of load shedding on average is observed, in particular during the summer.

![Figure 3: Supply-demand Balance 1997-2016](image)

*Source: BPDB System Planning*

13. Electricity demand is projected to grow by more than 10 percent per annum over the medium term. To address the gap, the Government’s plan is to double the 2016 installed capacity by 2021 and reach 50 GW by 2041 using private and public funding. The Government is also working on the optimal energy mix (including imports from India, Bhutan and Nepal) taking into account the depleting natural gas reserves. In the meantime, the World Bank Group (WBG) is currently engaged, through IDA, International Finance Corporation (IFC) and Multilateral Investment Guarantee Agency (MIGA), to support a green-field project at Siddhirganj (US$504 million IDA support) and two repowering projects at Ghorashal (US$217 by IDA for Unit-4 and a MIGA guarantee to back US$260 million investment in Unit-3).

14. Expansion of the transmission network is also needed to accommodate increase of power flows and ensure a reliable supply. The development of a strong 400 kV backbone network is required. The Bank is already funding a Rural Electricity Transmission and Distribution Project for US$600 million. A specific operation to strengthen the eastern transmission network is also under preparation for FY18 delivery.

15. In addition to WBG support, the country is mobilizing financial resources to invest in transmission...
lines and substation expansion from the Government of China, the Asian Development Bank (ADB), the Japan International Cooperation Agency (JICA), the German KfW, the Korea Economic Cooperation Development Fund (ECDF) and Islamic Development Bank (IDB).

**Improving system operation to ensure quality and reliability of supply**

16. The rapid increase of the power system size amplifies the challenge to ensure the quality and reliability of the electricity supply with the operational tools and rules used currently. Three major issues should be addressed as soon as possible to enable PGCB keep its capacity to operate and expand the system with efficiency as per its mandate. They are related to (i) frequency control, (ii) voltage fluctuation and (iii) merit order dispatch.

17. A proper frequency control is key to delivering quality supply and enabling integration of large planned power plants and renewable energy. The country is planning to double its generation capacity in the next five years and as the system increases in size it will also become increasingly susceptible to cascading outages, for instance, following initial failure of a large generator or loss of a feeder, resulting in significant economic losses. However, the primary frequency control is currently absent in Bangladesh. In addition, SCADA/EMS exist at both NLDC and the plant level but are not integrated or used for dispatch. This lack of system automation and integration implies the system operator faces considerable delays and uncertainty in balancing the demand and supply. As a result, (i) stand-by oil and diesel fired plants are often run pre-emptively to avoid a situation of demand-supply imbalance in the absence of spinning reserve, leading the system to use unnecessarily large amounts of expensive liquid fuels and (ii) the distribution feeders trip automatically in case of under-frequency.

18. Voltage stability is a second element characterizing the quality of supply which need attention in Bangladesh. It is the indicator most readily apparent to consumers whose lights dim/brighten or fans slow down/speed up as voltage declines and increases. Industry must incur additional costs and make special efforts to stabilize voltage so that equipment is not damaged and manufacturing processes can continue unharmed when voltage fluctuates. Reactive power is required to compensate instantaneously for voltage drops and maintain the quality of supply. It helps also to address network congestion. Installation of capacitor banks or, if needed, the more expensive Static VAR Compensator (SVC) at the sub-station/load end is generally the solution to fix voltage problems.

19. Finally, the dispatch of power by the NLDC is currently not fully consistent with the merit order (i.e., the concept that power plants are dispatched in increasing order of cost). Here also the lack of automation and proper dispatch optimization tools constitutes one of the major reasons. In some instances, transmission bottlenecks and/or gas (fuel) shortages can result in more expensive oil fired plants being called into service in advance of cheaper gas fired ones.

20. The details of the technical and institutional challenges and solutions for achieving frequency control and merit order dispatch, and for mitigating voltage fluctuation are presented in Annex 1. As part of the preparation of the proposed operation, an analysis of the system operation was undertaken. It confirms the diagnostic above. Frequency control trials were conducted to confirm that the frequency band can be narrowed down to a range of 49.6 to 50.5 Hertz (Hz) from 49-51 Hz and identify how to implement that

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5 SCADA: Supervisory Control and Data Acquisition / EMS: Energy Management System
in a sustainable manner. The proposed project will support the progressive implementation of primary/secondary frequency controls as well as the needed investments on participating generators and transmission bottleneck removals and the institutionalization of merit order dispatch.

C. Higher Level Objectives to which the Project Contributes

21. The proposed project is in line with the World Bank’s twin goals of ending extreme poverty and boosting shared prosperity. It is also consistent with the World Bank’s Energy Sector Direction Paper, which is designed to help client countries secure affordable, reliable, and sustainable energy supply. The Paper states that “adequate, reliable, and competitively priced modern energy is essential for business development, job creation, income generation, and international competitiveness”. Moreover, the Bangladesh 2015 Systematic Country Diagnostic highlighted that availability and reliability of power is a key concern for businesses. Surveyed on 15 factors that comprise the business environment, Bangladeshi firms rated electricity as the second highest constraint to their operations (after political instability and ahead of finance and corruption).

22. The Country Partnership Framework for FY 2016-2020 (CPF) identifies the following priorities for the energy sector, ‘increasing supply of electricity and gas, diversifying sources of power supply, retiring polluting and expensive emergency diesel generators, and reducing energy subsidies.’ The CPF is anchored in Bangladesh’s 7th Five Year Plan and recognizes the need for additions to generation capacity while squeezing inefficiencies out of the entire value chain. Ensuring merit order dispatch, enhancing transmission capacity to limit congestion and ensure efficient evacuation of power, and improving grid operation are key priorities for Bank support. These priorities are also consistent with the Government’s power sector strategy, which seeks to ameliorate the country’s severe shortages of power while increasing the efficiency of use of scarce domestic gas. Furthermore, an improved efficiency of the system operation will lead to reduction of fuel used and impact positively on the climate with greenhouse gas (GHG) reduction.

23. Finally, the use of IDA Scale Up Facility (SUF) to finance the current project is convincing given the fact that it is an economically viable operation which will generate quickly significant savings in operating expenditures (mainly fuels) as well as additional revenues with the reduction of unserved energy.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

24. The Project Development Objective (PDO) is to improve the reliability and efficiency of the power system in Bangladesh through optimization of dispatch operation.

25. The project interventions (TA, operational enhancements, and transmission decongestion) envisage

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6 Toward a Sustainable Energy Future for All: Directions for the World Bank Group’s Energy Sector, July 2013.
7 More specifically, 28 percent of firms surveyed identify electricity as their top obstacle and 52 percent identify it as a major constraint to doing business
upgrading the power system to enable an automated and integrated operation with optimization of dispatch. The upgrades will enable the system to reduce outages due to under-frequency, save fuels in power generation and finally run it on an optimal mode thereby achieving the reliability and efficiency of the system. Details on the technical and institutional problems and solutions proposed through this project are presented in Annex 1.

B. Project Beneficiaries

26. Government of Bangladesh will benefit from the fiscal savings expected from the reduction in fuel use. The use of fuel by rental powers and IPPs results in the increase of the average cost of power supply which create a fiscal burden to GOB as it is not fully passed on the consumers.

27. The project does not have specific direct beneficiaries among the electricity consumers. However, all grid connected consumers will be less exposed to interruptions and voltage fluctuations through project interventions on the transmission system. With a more stable frequency, they will benefit from improved reliability. Households will experience less appliances destructions. Businesses and industrial enterprises will use less back-up generators. Power distribution entities will improve their performance because the reduction of frequency fluctuations will lead to reduction of outages. Generators also will benefit from a more reliable and stable system operation (fewer start-ups, less spikes coming back from the network, and overall smooth operations).

28. In addition to the benefit to the overall economy, the use of less oil fired generation will reduce the GHG emission to the atmosphere and therefore generate health benefits due to reduced air pollution.

C. PDO-Level Results Indicators

29. Progress toward achieving the PDO will be measured by the following indicators:
   - Unserved energy due to under-frequency led outages (Giga-Watt hours)
   - Projected fuel saving (Giga-Joules)

30. The intermediate outcome indicators will be: (a) Minimum/maximum frequency (Hertz), (b) Number of staff trained, (c) Number of generation units with governors and excitation system upgraded/replaced, (d) Number of Dynamic Line Ratings (DLRs) installed, (e) Transmission lines constructed or rehabilitated under the project (kilometers), (f) Cumulative duration of power outages per year due to under-frequency (hours), (g) Number of power outages per year due to under-frequency, (h) Percentage of female staff trained from total staff trained, and (i) Number of citizen engagement event on power supply quality.

III. PROJECT DESCRIPTION

A. Project Components

31. From the analysis and trials undertaken with PGCB, BPDB and other stakeholders, it appears that the retrofitting to an automated, modernized dispatch function with associated investment in transmission upgrading would ultimately (i) improve system security and reliability (minimizing outages and preventing wider blackouts or a sudden disturbance in network); and, (ii) increase the efficiency or cost effectiveness of system operation by ensuring that it follows merit-order dispatch.
32. The project is conceived as the first stage of a process of modernization of power system dispatch in Bangladesh, recognizing that this is a long process that can best be implemented in phases as described as follows (see details in Table A.1.1 of Annex 1):

(i) Phase 0: It consists of limited duration Free Governor Mode Operation (FGMO)\(^8\) trials to test the feasibility of reducing the frequency bandwidth and willingness of participating plants to cooperate. This was implemented successfully with 15 generators in 2016 under a Grid Stability Committee established by GOB.

(ii) Phase 1: It will be covered by the proposed project and will ensure a continuous FGMO operation with full participation of at least 15 generators with technical assistance (TA) from international experts. It will allow to put in place the needed technical and commercials agreements between stakeholders, provide operating and modelling tools and physical investments required and amend the grid Code accordingly.

(iii) Phase 2: It should achieve a full modernization/automatization of the System Dispatch including a full modernization of the NLDC and a functioning compensation system to enable payments for ancillary services\(^9\) provided to support the network.

33. The project will support implementation of primary frequency control and finance the software and hardware investments needed to integrate generators with NLDC while upgrading its SCADA/EMS. It will address critical transmission bottlenecks. An in-depth institutional and policy review will be undertaken to identify barriers that have led to dispatch not following a merit-order and the observed lack of cooperation with NLDC by generators. The review will recommend actions to address various constraints and pave the way to system-wide improvement under Phase 2 including Automatic Generation Control (AGC), modernization of the SCADA/EMS and full merit-order dispatch (taking account of Power Purchase Agreements (PPAs) and existing constraints that might need to be managed more actively). Associated capacity building for NLDC, PGCB, BPDB and the Power Division of MPEMR would also be included in the project.

34. The project has three major components covering technical assistance and capacity building; investment in immediate operational enhancements; and, investment in transmission upgrades to address bottlenecks in specific high priority lines. The investments to improve operation will target the performance of NLDC in system management (key elements being automation, integration of generators into the system, and moving to merit-order dispatch). Following are the proposed components:

**Component 1: Technical Assistance (US$8 million funded by IDA)**

35. This component will fund two sub-activities:

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\(^8\) FGMO refers to using the ability of generators to respond automatically to frequency variation by adjusting fuel injection (i.e. output). The generators’ governing systems can sense the frequency change and automatically load or unload (generally in the range of +/-5%) to support balancing of the system and bring back frequency within the limit.

\(^9\) Ancillary services refer to functions that support the transmission of electricity from generation plants to customers. In addition to the frequency response, it may include the provision of additional generation when needed (spinning reserve) and reactive power to support the voltage plan.
(i) Sub-component 1.1: Primary frequency control trials and training for PGCB/NLDC engineers/operators on modern, state-of-the-art frequency control and dispatch protocols (US$4 million by IDA). The frequency control trials are pre-requisite to and will be followed by implementation of primary frequency control in at least 15 power generation plants. Experienced power system control specialists will be engaged to perform the following tasks before the trial starts: visit all participating power stations (i.e., the plants which will provide frequency control services) to check the status of their controls, assess the condition of governors and tune them wherever needed (as most are currently not set to provide frequency response), check the SCADA system, and, undertake detailed modeling studies using PSSE software or similar modeling tools to simulate the operation of the system. The inspection will also identify the hardware that will need to be procured to ensure effective implementation of primary and secondary frequency controls. The power system control specialists will also help NLDC to prioritize the plants for frequency control purposes and set up a dispatch order for these plants. They will assist NLDC/PGCB staff during the trial process to ensure the trial proceeds smoothly; and they will record frequency response, recalibrate parameters, and prepare a final report on the outcome of the trials. The process will take place over a period of six months and will require a team of experts including offsite power system modelers; and

(ii) Sub-component 1.2: Capacity building and institutional review (US$4 million by IDA) to (i) acquaint NLDC staff with modern control theory, practical aspects of regulating frequency in real-time through governor response as well as secondary control, and (ii) build power system dynamic modeling capability using PSSE. It will also include an in-depth review of the institutional and policy barriers that have, both, limited NLDC control over generators and that have resulted in lack of merit order in dispatch. The study is expected to identify the critical path for implementing merit order dispatch and make recommendations for transitioning to AGC and a fully modernized dispatch system over time, which the Bank could potentially support through a follow-up operation. Finally, it will build awareness and capacity on the basics of system dispatch through training to be provided to stakeholders beyond PGCB/NLDC, i.e., BPDB, the Power Division of MPEMR and, if possible, the regulator, BERC.

Component 2: Operational Enhancements (US$47 million of which US$34 million plus US$5m contingency funded by IDA).

36. The NLDC in Dhaka is currently not integrated with the control system of the power generation plants and is therefore unable to send/receive signals for changing outputs. It does not receive also real time demand forecasts from the distribution companies. The lack of cooperation between generators (to give NLDC control of their governors) and the demand side (to provide more reliable inputs for demand forecast) means that NLDC has little choice but to balance the system using guesswork and through instructions to generators over the phone. This component will fund three sub-activities:

(i) Sub-component 2.1: Integration of generators to the NLDC’s SCADA/EMS system (US$16 million by IDA). As part of the TA component above, power system experts will assess the hardware and software required to be procured for integration. This component will finance the procurement of the hardware identified above that will eventually be needed for the plants to be fully effective in

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10 PSSE: Power System Simulation for Engineers
providing both primary and secondary control. It will include Remote Terminal Units, enhancement of the plant SCADA system, replacement of generator controls, Automatic Voltage Regulators, power system stabilizers, etc.;

(ii) **Sub-component 2.2:** Upgrading/modernization of the NLDC SCADA/EMS software (US$6 million by IDA). It will cover procurement of software for real-time economic dispatch control, operator load flow, AGC and modeling power system dynamics, including licenses for five years so that NLDC staff are able to fully utilize the SCADA/EMS system. The software will enable the monitoring of generators for frequency control and dispatch; and

(iii) **Sub-component 2.3:** Optimization software for dispatch (US$12 million by IDA). The dispatch optimization software will include week-ahead, day-ahead and hourly simulation capabilities to run fuel and transmission constrained dispatch optimization in an off-line mode and online (integrated with the SCADA/EMS) system. This sub-component will include a minimum of one license for five years with at least three user-keys, preparation of a dataset and analysis, and training on the dispatch system.

**Component 3: Removal of Transmission Bottlenecks and Improvement of Voltage Quality (US$22 million of which US$10 million plus US$2m contingency funded by IDA).**

37. The component will cover the needed network reinforcement\(^{11}\) including:

(i) **Sub-component 3.1:** The upgrade (by re-conductoring with higher capacity conductors) of selected congested 132 kV and 230 kV lines (US$4 million by IDA) to address existing bottlenecks and enhance system transfer capability; and

(ii) **Sub-component 3.2:** Dynamic Line Rating (DLR)\(^{12}\) to improve utilization of limited transmission capacity on 400 km of six critical transmission lines identified by PGCB (US$6 million by IDA);

38. The DLR investments will be prioritized for highest impact during the project, and additional system-wide investments may be rolled out in the future, beyond phase 1. In particular, SVCs were considered during the project but PGCB requires further studies to firm up its decision. It is also anticipated that this project will provide the foundation for follow-on investments in transmission that will permit the system-wide application of AGC and improved voltage control. Towards the end of the project, an impact assessment will be carried out to highlight the sustainability of the results of the project and justify the next phase.

**B. Project Cost and Financing**

39. The estimated cost of the project is about US$77 million of which IDA financing is proposed to cover US$59 million. Counterpart funding of US$18 million will cover PMU costs (US$ 6 million), and tax and VAT associated with imports (US$ 12 million). The PMU cost will include staff salary, other operating and recurring expenditures\(^{13}\), costs for procuring vehicles as well as import and supplementary duties and value added taxes at import stage. The project costs funded by IDA includes provisions for a contingency

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\(^{11}\) See Annex 1 for the details

\(^{12}\) DLR allow the utilization of an existing transmission line capacity based on real conditions under which it operates.

\(^{13}\) Such as workshop allowances, sitting allowances, cash per diems, honoraria and fuel.
for US$7 million to cover both price and physical contingency and another US$7 million to cover domestic taxes and VAT on contracts but excludes supplementary duties and VAT at the import stage. The Table 1 below provides an overall cost breakdown.

<table>
<thead>
<tr>
<th>Project Components</th>
<th>Project cost</th>
<th>IDA Financing</th>
<th>Counterpart Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Assistance</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Operational Enhancements</td>
<td>47</td>
<td>39</td>
<td>8</td>
</tr>
<tr>
<td>Removal of Transmission Bottlenecks and Improvement of Voltage Quality</td>
<td>22</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total Financing Required</strong></td>
<td><strong>77</strong></td>
<td><strong>59</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

40. The project is proposed as an Investment Project Financing (IPF) to the GOB on IDA SUF terms. The GOB has agreed to access this facility given high returns anticipated for this investment. Funds will be made available to PGCB under a Subsidiary Loan Agreement with the Ministry of Finance.

C. Lessons Learned and Reflected in the Project Design

41. The design and development of this project has benefited from lessons learned from on-going projects in Bangladesh and other Bank-financed operations in South Asia and beyond.

42. A dedicated Project Management Unit (PMU) within PGCB with clear coordination mechanisms with external stakeholders is essential for successful implementation. The complexity of the project requires a strong PMU but also a structured involvement of players in the generation and transmission segments. A Project Director has already been appointed, PGCB has assigned other officials, and the remaining required staff are expected to be on board by approval of the Development Project Proposal (DPP). Fiduciary aspects are covered as well as monitoring and evaluation (M&E) requirements. Furthermore, a Memorandum of Understanding (MOU) will be signed with all the key stakeholders to allow a quick implementation of the frequency control measures (critical aspect of system operation) identified by the Grid Stability Committee, and facilitate the preparation of the next phases of the grid stability improvement program.

43. Advance preparation of procurement packages is a must for fast-track implementation: It is generally agreed that such advance preparation up to draft bidding documents before project approval is good for project implementation but it is a must under this proposed project given the innovative and complex nature of the DLR and possible SVC equipment, which need to be introduced in PGCB network for the first time. To that effect, a consultant was hired to prepare specifications but also to undertake a market study to better design the packages. Discussion is on-going with PGCB under the Rural Electricity
Transmission and Distribution Project (P129920) to define standard specifications for major transmission equipment to be posted on PGCB web-site and adopted systematically in all future procurement packages.

44. Availability of state-of-the-art load dispatch center, coupled with advanced energy management system (EMS), is crucial for improving power system management and ensuring reliable electricity supply. No utility can manage the complexity of modern and large power systems such as in Bangladesh without deploying new protection and control technologies and relying on the use of state-of-the art dispatch center, coupled with advanced energy management systems. With the increased focus on integrating variable renewable energy and implementing operational measures such as demand-side management and control of emissions from power generation, the need for a state-of-the-art SCADA/EMS is even more pronounced and cannot be delayed without jeopardizing the integrity of the system.

45. Utility transformation is successful through a long term partnership, backed by a programmatic investment and capacity building program. This is a lesson learned from the long term engagement of the Bank with the India Central Transmission Utility, which underwent a substantial transformation to become one of the leading transmission companies in the world with state-of-the art tools and world-class practices [India Fourth Power System Development Project (PSDP) (P101657)]. Given the large volume of anticipated investments in the electricity transmission and distribution sector in Bangladesh, and the current level of IDA funding over the short to medium term (about US$ 1.0 billion), it makes sense to build a long term partnership with PGCB. The partnership will help shape PGCB’s transformation into not only a stronger project implementing agency but also a stronger utility corporation. This paves the way for further collaboration with GOB and PGCB through a multi-phase approach to provide both the knowledge and investment required to upgrade its system operations tools and practices.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

46. PGCB will be the implementing agency of the project, it has set up a dedicated Project Management Unit (PMU). PGCB has the experience of working with two World Bank-funded projects. It has completed the power evacuation component under Siddhirganj Power Project and has been working in Rural Electricity Transmission and Distribution Project. PGCB has demonstrated good performance in implementation of both the projects specially, in procurement, safeguards and construction management.

47. PGCB has already assigned a Project Director from NLDC. The PMU staffing will include:

- Dedicated Design & Supervision Engineers
- Procurement Experts. PGCB will establish and strengthen a Corporate Procurement Team. Two procurement consultants (one global and one local) already engaged in another project of the Bank may be available.
- Financial Management (FM) Experts. Strengthening is needed. Very recently the government has posted a civil servant as Director Finance of PGCB. PGCB has assigned a deputy director, accounts who will handle all FM matters of the project.
- Safeguard Experts: A dedicated Environment and Social Unit (ESU) is already established and permanent positions approved. It was agreed that one (1) Environmental, and one (1) Social Expert will be recruited no later than end of April 2017.
- PGCB has also assigned qualified staff in Design and Procurement.

48. GOB established a Grid Stability Committee in November 2015, to ensure quality of electricity in the national grid and stability of supply. It is composed of members from BPDB, NLDC, IPPs and Generation Companies. Its mandate, among others, is to maintain system frequency with FGMO of generators and conduct necessary primary frequency control trial runs. The committee has been holding frequent meetings, to plan and execute FGMO trial runs, and review results of the trials.

49. The complexity of the project will require a close cooperation between generators, BPDB, and PGCB/NLDC. All parties should understand own context and agree on respective level of engagements both for preparation and implementation. Ongoing cooperation between those parties around the trial exercise shows a commitment to work together. However, an MOU will be formalized between BPDB and other stakeholders to address relevant cost issues, among others. An implementation arrangement of the project has been provided in Figure A2.1 in Annex 2.

B. Results Monitoring and Evaluation

50. The PMU will be responsible for monitoring and evaluation (M&E) of the project. The PMU will submit quarterly progress reports which will include achievements in terms of intermediate indicators and provide an annual update of the PDO indicators. The monitoring of the project will be done in two phases: (i) in the first phase the focus will be on efficient, timely implementation of project components; and (ii) in the second phase it is through regular operational reporting by NLDC on the improved reliability and efficiency of the upgraded power supply system, through various indicators of the Results Framework and Monitoring table in Section VII.

51. GOB has been monitoring performance of the public sector entities through a set of KPIs and PGCB’s operational performances are already being monitored by the Ministry. The specific result indicators have been agreed with the implementing agency (PGCB) for this project and the progress according to the Results Framework and Monitoring table (Section VII) will be part of the monitoring process. The PGCB quarterly MIS and Progress Reports of the project will include updates of these results. The M&E capacity of PGCB will be strengthened during trial runs and periodic supervision by the Bank.

C. Sustainability

52. The strong engagement of all stakeholders during the trial runs showed a high level of ownership which will facilitate good design and implementation of activities. Training under the TA component as well as upgrading of the NLDC tools will also make it possible to establish a refined frequency control up to international standards.

53. The capacity building and institutional review under Component-1 will set up the right regulatory environment to provide required incentives to the participating generators.
54. Environmental and social sustainability will be ensured by a full implementation of the Safeguards instruments and the agreed Environmental and Social Management Plan which was derived from a due consultative process.

V. KEY RISKS

A. Risk Rating Summary Table

<table>
<thead>
<tr>
<th>Risk category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Political and Governance</td>
<td>Moderate</td>
</tr>
<tr>
<td>2. Macroeconomic</td>
<td>Moderate</td>
</tr>
<tr>
<td>3. Sector strategies and policies</td>
<td>Moderate</td>
</tr>
<tr>
<td>4. Technical design of project</td>
<td>Moderate</td>
</tr>
<tr>
<td>5. Institutional capacity for implementation and sustainability</td>
<td>Substantial</td>
</tr>
<tr>
<td>6. Fiduciary</td>
<td>Substantial</td>
</tr>
<tr>
<td>7. Environmental and Social</td>
<td>Low</td>
</tr>
<tr>
<td>8. Stakeholders</td>
<td>Substantial</td>
</tr>
<tr>
<td>Overall</td>
<td>Substantial</td>
</tr>
</tbody>
</table>

55. The overall risk of the project is Substantial. It reflects the key risks categories assessed below which will affect (i) the ability to ensure that an adequate number of generators participate in primary frequency control – critical for improved frequency management and, thus, system reliability; and (ii) NLDC’s capacity to adopt new software and approaches to managing grid dispatch and adhere to modern dispatch protocols, which, along with transmission de-bottlenecking, is key to enhancing system efficiency and lowering reliance on oil-fired generation. However, since the formation of the Grid Stability Committee, three primary frequency trial runs have been conducted that demonstrated a close cooperation and team work within the committee members. The last trial succeeded to narrow the band of frequency variation and reduce substantially 33 kV feeders outages by 90% percent in 20 days). This evidence downplays the risk at (i) above which can be mitigated further with the incentive scheme designed under sub-Component-1.2

56. Institutional capacity for implementation and sustainability risk is Substantial: While PGCB is considered a well-managed and well performing entity with a Board that includes a balance of public and private representatives as well as autonomous academic institutions, PGCB engineers and staff have not been trained in modern system operations. NLDC manages the grid in an outdated, manual, somewhat ad-hoc fashion, largely because it lacks connectivity with generators that would permit automation and familiarity with the modern technologies and software used for grid-management. The proposed project
includes capacity building to address the void in capacity -- immediate to short-term on-the-job training will be provided on modern system operations, primary control trials will be undertaken and efforts will be made to institutionalize adherence to optimal dispatch protocols. Ensuring cooperation among multiple agencies in installation, testing and using the new systems will be a challenge. To address this, day-to-day inter-agency issues are expected to be discussed and resolved by the Grid Stability Committee. A Project Steering Committee (PSC), chaired by the Power Secretary will also be formed. This will meet periodically to take stock of progress and resolve critical policy and implementation issues. A regulatory framework to govern the system application of secondary response will need to be developed. TA funds under the project will be directed toward identifying regulatory requirements and making recommendations in this regard.

57. Fiduciary risk is rated as Substantial. PGCB has few staff with adequate procurement knowledge for donor funded projects like World Bank, Asian Development Bank etc. But the number of such staff are not sufficient to manage significant number of donor funded projects ongoing in parallel. This has caused delay in decision-making in other Bank financed projects, although PGCB’s contract management has been good. Its financial management and internal audit functions also need to be strengthened and it needs to develop internal controls at both the entity and project levels. The Prime Minister’s Office and Power Secretary have been apprised of this and have agreed to take steps to build this capacity so that the risk of problems and delays is minimized. PGCB has agreed to recruit a qualified financial management specialist in the position of Director Finance as well as additional qualified accountants.

58. Stakeholder risk is Substantial, which stems from the absence of a formal requirement for generators to participate in primary frequency control. There is also a lack of authorization for NLDC to control the generators and therefore its inability to adjust system supply in response to a mismatch between demand and supply. The Grid Stability Committee will be assigning generators to participate in the primary frequency control trials and later in implementation. The risk of owners of rental plants and IPPs being reluctant to permit NLDC to control their plants is real and will need to be addressed at the policy level, including possibly adjustment of PPA terms. The IPPs will likely need to have their machines checked by the original equipment manufacturers to be assured they can participate in primary frequency control without negative impacts on machine life and/or performance. This will also need an agreement of the insurance agent. Recognizing this risk, BPDB will have to consider a provision for the system operator to remotely control the plants and adjust operation in new PPAs and tender documents for new plants. This is expected to build in the ability to implement AGC down the line. Other stakeholders are unlikely to pose a risk to the achievement of the PDO. An MOU between BPDB and PGCB will be executed to ensure continuity of cooperation between the parties. It is noted that out of seven participating generators in the third trial run, there are two IPPs that are extending continuous cooperation to the trial exercise.

VI. APPRAISAL SUMMARY

A. Economic Analysis

59. The economic analysis presented in Annex 4 demonstrates that the project benefits outweigh the costs. By providing frequency control, improving dispatch and reducing transmission bottlenecks, the electricity system will be avoiding costs of frequency variation, using lower cost power generators, saving heavy fuel oil (HFO) and diesel and reducing greenhouse gas emissions. Improvements in electric power service reliability will also result in benefits across end-use consumers and increase business confidence.
Operational enhancements will enable adding variable renewable energy sources (e.g. solar and wind) in the future.

60. The benefits of frequency control are well known. This includes reduction in the risk of partial/full grid failure, avoided damages to generator/customer equipment, avoided expensive generation needed to support frequency, ability to expand and integrate with other electricity networks and capability to integrate variable renewable energy resources. Frequency control can avoid catastrophic events such as the November 2014 blackout, which costed about US$50 million.

61. A cost benefit analysis on the impacts of frequency control measures was performed. This included fuel savings and reductions in unserved energy. Considering a discount rate of 12% and assuming 8 Taka/MWh for the marginal costs of HFO power generation (only fuel), the project’s Net Present Value (NPV) is US$ 41.1 million and the EIRR 46%.\textsuperscript{14} GHG emissions reductions due to avoided HFO consumption during the period 2018-2024 sum up 0.75 million tons/carbon dioxide equivalent (CO\textsubscript{2}e). A sensitivity analysis was performed on the HFO fuel price and adjusted energy savings is reported in Annex 4.

62. The benefits of improved dispatch can be conceptualized with an economic optimization model, although the methodology and data still pose very significant challenges. The analysis envisions an idealized optimal (“merit order”) dispatch and compares it with the actual dispatch. The difference in costs between the two scenarios are the (maximum) benefits associated with the improvement in dispatch. The World Bank carried such assessment of dispatch efficiency in collaboration with NLDC, using a standard dispatch optimization approach and data for 2014. This analysis demonstrates that the benefits of improving dispatch efficiency can be potentially very high. To realize such benefits, operational improvements discussed above as well as sufficient availability of gas are needed. Figure A4.1 on Annex 4 summarizes the results of the optimization model under different gas availability scenarios.

63. The project leads to net reductions of GHGs by switching from carbon intense sources (HFO and diesel) to natural gas, which has lower GHG intensity. GHG emissions reductions were estimated using the Intergovernmental Panel on Climate Change (IPCC) emissions factors and average heat rates for the power plants as provided by BPDB. GHG emission reductions are 0.75 million tons of CO\textsubscript{2}e over the 2018 – 2024 period in the core scenario evaluated. Operational enhancements will enable adding variable renewable energy sources (e.g. solar and wind) in the future, leading to additional GHG reductions.

64. The potential benefits of improvements in transmission line capacity were estimated by an International consultant firm in 2016 using an optimal Power Flow Model. Currently, existing transmission bottlenecks require the grid operator to dispatch localized oil-fired generation to augment supply that overturns the merit order. The report identified key transmission lines requiring upgrades in order to reduce transmission bottlenecks and system congestion. The study shows that nine lines have overloading in the base power flow (i.e. without any contingency) and more than forty lines were seriously overloaded under contingencies. Removing such bottlenecks can result in hourly savings close to Taka 18 million, leading to annual savings of Taka 39.5 billion or close to half a billion US Dollars.

\textsuperscript{14} The cost-benefit analysis conservatively considers benefits stream attributable to the project between years 2017 and 2021. There will still be benefits from the project for the remaining lifetime of the assets. However, the improvement of the system after 2021 will be mainly due to a much broader ongoing/planned investments in generation and transmission. The NPV estimate is therefore likely to be the lower boundary.
65. It is reasonable to assume that due to constraints outside of project boundaries (gas supply constraints, existing contracts with generators, transmission constraints), an optimal dispatch schedule may not occur. Furthermore, fuel prices are volatile and price variations can have an important impact in the marginal costs of generation.

B. Technical

66. As mentioned above, the project design is informed by a dispatch efficiency study followed by two frequency control trials conducted by the NLDC (see Annex-1). The trials were conducted as a coordinated effort involving all stakeholders in April and August 2016 for 2 and 8 hours respectively. They demonstrate that (i) the current +/-1Hz frequency fluctuation is mainly due to the absence of frequency control and (ii) fluctuation can be narrowed down to +/-0.5Hz with a relatively limited number of generator participants and limited amount of spinning reserve. In addition to confirming the feasibility of the exercise and the expected benefits, it showed the participants’ willingness to engage in a longer trial with other large generators and a higher volume of generation. It also showed that the cost of implementing such basic primary frequency control is minimal but AGC as well as an incentive mechanism need to be implemented to have a sustainable solution moving forward. In particular, provisions should be made in future PPAs with IPPs and a proper regulatory mechanism put in place.

67. Furthermore, PGCB benefits from the support of an international system operations consulting firm hired to design and conduct primary frequency control trial runs, impart training to NLDC staff and record frequency improvements with trials. The international consulting firm has conducted a training workshop on frequency control at NLDC.

68. A technical appraisal of the existing transmission infrastructure and system operations has been carried out and an action plan to improve system operations has been prepared. Locations for the SVC trials have also been identified by PGCB. The WB has hired an international consulting firm under the Korean Green Growth Trust Fund (KGGTF) to (i) carry out an optimum power flow (OPF) analysis of Bangladesh transmission system, (ii) suggest a flexible transmission plan for Bangladesh for mid and long term (2025), (iii) provide technical validation of SVCs and reconductoring identified by PGCB, and (iv) carry out a market analysis of items to be procured with project funds.

69. The international consulting firm assessed the SVC options using contingency analysis. Urgent transmission system upgrading needed to decongest the network was cross-checked by the OPF study. Some of the lines could be upgraded by reconductoring. Complementary assessment of the capacity of transmission line to allow reconductoring and determination of size and locations of SVCs for compensation of reactive power at critical points are also ongoing. Other technical alternatives of managing the transmission constraints were also explored, including (i) the use of phase shift transformers to control loop flows, (ii) the implementation of special protection schemes (SPSs) to allow greater utilization of transmission assets by making some load at risk and (iii) installation of DLR systems on selected transmission lines. SPS was recommended as a short term solution for one line without reconductoring option awaiting the implementation of broader reinforcement projects under consideration by PGCB.
70. Finally, the Bank is engaged at the portfolio level to improve PGCB’s capacity to procure and implement transmission projects in a timely manner. The three project components can be launched in parallel, which will reduce project implementation time.

C. Financial Management

71. From the implementation experience of Siddhirganj Power Project (P095965), it was noted that PGCB repeatedly failed to comply with a covenant on the preparation of the Ten Year Business Plan. Also, the external auditors expressed a qualified audit opinion on the financial statements of PGCB in last five consecutive years mainly for weaknesses on fixed asset management and reporting. Hence, the weaknesses which require immediate compliance are related to (i) fixed asset valuation, management and reporting, (ii) the submission of a training proposal on financial modelling work (with skill gap analysis, training needs, and business benefits), and (iii) the installation of Enterprise Resource Planning (ERP) and operationalization for all business functions.

72. However, financial management assessment per WB operational guidelines suggests that PGCB as implementing agency has acceptable financial management capacity to run FM functions of the project smoothly. The assessment includes IAs’ system of accounting, budgeting, reporting, auditing, and internal controls and oversight arrangement. The existing FM arrangement is considered acceptable as they are capable of maintaining reasonable records for all transactions and balances, supporting the preparation of regular and reliable financial statements for decision making, safeguarding the entity’s assets, and are subject to auditing. The assessment also prescribes the effective FM design which will outline strength and weakness of implementing entity, staffing, fund flow arrangement, accounting policy and procedure, audit requirements, periodic financial disclosure requirement, financial information systems, and format for financial statements. Assessed fiduciary capacity of PGCB is acceptable and associated risk from the financial management perspective is rated as “Moderate”.

D. Procurement

73. Procurement would be carried out in accordance with the World Bank Procurement Regulations for IPF Borrowers (the “WB Procurement Regulations”), July 2016. As per requirement of the New Procurement Framework of the World Bank (“NPF”), PGCB has prepared the Project Procurement Strategy for Development (PPSD) in consultation with the Bank staff. The PPSD may be updated based on the needs of the project. The updates will be made in agreement with the Bank.

74. The project cost is US$ 77.00 million, of which IDA contribution is US$ 59.00 million. Almost all funds of IDA will be subject to established procurement procedures except for training (US$ 1.5 to 2 million). The procurement will largely involve goods (supply and installation) and a few consulting contracts. Most contracts have estimated costs in excess of US$ 3 million (except consultancy) due to the capital intensive nature of these advanced and specialized technologies.

75. PGCB has experience and capacity in processing donor and Government-funded projects. About 179 staff of PGCB received training on country’s procurement laws (i.e. Public Procurement Rules, 2008 (PPR)) in the recent past. In addition, two international procurement and technical consultants hired under Bank’s Rural Electricity Transmission and Distribution Project have increased their procurement capacity.
Currently, no major complaint was received for the two Bank-funded projects. However there are only few staff who have adequate knowledge in donor funded projects like WB, Asian Development Bank etc. The number of qualified procurement staff is not adequate to provide efficient support. The Project Management Unit (PMU) of PGCB should have dedicated qualified procurement staff to carry out the procurement processes and contract management activities with support of consultants to be procured under package S-1 of the project.\(^{15}\)

76. PGCB Board will carry out oversight functions as well as approval of all contracts as laid down in their charter and if any, in the Financing Agreement (FA) of the project. The PMU headed by the Project Director, will consist of additionally two procurement trained staff (one for procurement and the other for contract management) of PGCB, one international procurement consultant (intermittent) and one international technical consultant (intermittent). The procurement staff and the procurement consultants will be responsible for planning and managing the entire procurement process and overseeing the contract management functions of the project. In order to enhance the capacity of the procurement staff of PGCB and bid evaluation committee related to NPF, necessary training will be provided on the Bank’s Procurement Guidelines.

77. Bangladesh operates in a challenging procurement environment. Procurement risks arise out of factors like weak capacity, unfavorable market, and weak governance etc. Most procurements under the project involve international competition with specific emphasis to ensure value for money. PGCB is not familiar with some of the good features of NPF such as “rated criteria”, “best and final offer (BAFO)”, “sustainable procurement” etc. which may be followed in this project to ensure best procurement outcome. Upon considering all factors, the overall procurement risk of the project is rated “Substantial”. Several measures have been agreed upon with PGCB to minimize the risks associated with procurement. Parts of these are already in place, while the remaining will be implemented during project supervision (details in Annex 2).

E. Social (including Safeguards)

Social

78. The project envisages rehabilitation of PGCB’s transmission network, comprising of improvements to existing 132 kV transmission lines; and installation of SVCs\(^{16}\) were considered along the route at required locations. All SVC locations were meant to be within existing PGCB premises. No land acquisition or displacement of people will be required for this project. No significant, irreversible social impact is expected under the project. However, minor and/or temporary impacts are expected due to rehabilitation of existing transmission lines in densely populated residential/commercial areas and open crop lands. Plying of vehicles on crop lands and equipment storage during construction may occur over several phases, resulting in repeated crop damage. Rehabilitation of lines over residential structures will create impositions on residents and may result in safety issues. Construction workers will have to be mindful of gender and social norms. The commercial structures may need to be temporarily closed (though not more than a few hours) which is likely to cause access issues and electricity disruption (which

\(^{15}\) Refer to Table A2.2 of Annex 2.

\(^{16}\) PGCB requires further studies to include SVCs in the current project scope. However, installation of SVCs are taken into account in all disclosed safeguard instruments.
may affect wages). WB operating procedures covering involuntary resettlement has been triggered for the project. Based on social screening and alternative route analyses, there are no indigenous people in the vicinity of project works. Hence, the WB procedures relating to indigenous peoples is not triggered for this project. The project has been assigned safeguard Category B.

79. Since the exact routes to be rehabilitated and the specific locations of possible SVCs which will ultimately be used was not known by Appraisal, an Environmental and Social Management Framework (ESMF), including a full and detailed Resettlement Policy Framework (RPF) have been prepared. The ESMF also includes detailed guidance on labor influx management. The ESMF and RPF have been prepared based on rigorous stakeholder analysis and multiple consultations with the latter as mandated by Bank policy. Social Impact Assessments (SIAs), Social Management Plans (SMPs) and Resettlement Action Plans (RAPs) will be prepared (as and when required) once the routes are determined, based on the guidance provided in the ESMF and RPF respectively. Adherence to the ESMF and RPF, including the preparation and full implementation of the site-specific SIAs, SMPs and RAPs (as and when required) including labor influx management will be incorporated in the bid documents and costed appropriately in the Bill of Quantities (BOQs).

80. The ESMF and RPF have been publicly disclosed by PGCB on their website (www.pgcb.org.bd) on January 2, 2017 and hardcopies have been made available at PGCB headquarters and subproject areas. Advertisement requesting public comments has been published in two daily newspapers (English and Bangla). Consultation with communities has been made mandatory for environmental screening/assessment of each subproject. The ESMF has also been disclosed in World Bank operational site. During the implementation phase, the subproject specific environmental screening/assessment will also be disclosed at PGCB website before the contractor mobilization.

81. PGCB has prior experience in implementing the IDA funded projects and has created an Environment and Social Management Unit (ESU) in their regular organogram. The ESU will be responsible for monitoring and reporting during implementation.

82. A National Consultation Workshop was organized by PGCB on March 16, 2017 and the draft ESMF and RPF were shared with all relevant stakeholders.

**Gender Mainstreaming**

83. Access to energy services is necessary for human development, and a lack of access can be a factor hindering poverty alleviation. Access to energy has been linked to improvements in women’s time use, health and employment opportunities. Other indirect linkages between gender and energy include enhanced access to information since access to energy also translates into enhanced access to channels of information such as mobile phones and television, and reduction in incidences of violence due to lack of reliable street lighting. The project does not easily lend itself to addressing gender issues since it does not have direct beneficiaries. However, a key gender gap is the employment of women in the energy sector. After discussions with PGCB officials, it has been decided to take the following steps to improve the gender sensitivity of the project: (i) the ESIA to be prepared for the transmission line investments will be gender-informed (i.e., it will incorporate gender disaggregated consultations and implement any follow up actions recommended to address the differential needs of male and female project affected people); and (ii) an organizational assessment of NLDC/PGCB will be undertaken to understand steps that have been taken to address barriers to women’s employment and working conditions in the organization.
(including standards that its contractors need to comply with when implementing projects for it) and to identify and support implementation of any aspects that can be improved in this regard. Both sets of actions would be monitored over the project’s life. Along with a gender disaggregated citizen engagement mechanism (see below) this would classify this project as being gender informed.

**Citizen Engagement**

84. As noted, the project does not have specific direct beneficiaries among the electricity consumers as far as the citizenry is concerned. However, the project provides an opportunity to interact with the wider public through stakeholder consultations in which broader issues of power supply reliability and quality can be raised, energy efficiency options discussed, and the project and its likely impact presented. This would be done in a gender disaggregated fashion so that the different viewpoints of men and women are captured. The discussion(s) will be summarized and conclusions made available on PGCB’s website (along with the World Bank website) and could provide a starting point for a conversation on energy sector issues that would continue in the course of subsequent Bank-supported projects in the sector.

**F. Environment (including Safeguards)**

**Environment**

85. In general, significant adverse impacts from the upgrading of 132 kV transmission lines and possible SVCs are unlikely. Noise and air pollution could result from a wide range of construction activities. Also movement of vehicles, operation of construction equipment and generators during the upgradation of transmission will affect agricultural land, reduce soil compaction and rutting in sensitive soils and natural areas. Water pollution may result from discharge of waste (from labor shed or site) and spills and leaks of oils/chemical into water bodies. These impacts are mostly temporary and limited within project boundary.

86. The proposed project is classified as a Category B project. There are no significant and/or irreversible environmental issues in the rehabilitation of transmission network of PGCB or the installation of SVCs. The Bank safeguard policy Environment Assessment has been triggered to ensure that the project investment are environmentally sound, sustainable and thus help to improve decision making.

87. Since the line routes to be rehabilitated were unknown at the project appraisal stage, a framework approach has been adopted for the Project. SVCs are required to regulate the voltage on the transmission system, particularly where there are contingencies that can cause a sudden and large drop in voltage. The requirement of SVCs was confirmed on the 230 kV network in several locations but PGCB required further study to install such new technology in its network. The ESMF has been prepared based on the sample site visits at PGCB intervention areas and several discussions with the relevant stakeholders. According to the ESMF, subproject specific Environmental Code of Practice (ECoP) and the Environmental Management Plans (EMP) need to be incorporated in the bid document and the cost for the implementation of EMP will be a line item of the Bill of Quantities (BOQ).

**Climate Change Screening**

88. Climate change screening of the project has been carried out. The screening considered the various types of infrastructures of the project (NLDC, grid network and power plants) and project locations that may be vulnerable to various climatic hazards. Bangladesh is prone to natural/climatic disasters and is particularly vulnerable to extremes in temperature, precipitation and flooding, and high winds. The
country periodically suffered from earthquakes. The historical experience in design and development of the large infrastructures (the NLDC building, power grid, and power plants) is that this routinely takes into account of these hazards.

89. In addition, the TA and capacity building of the project are intended to enhance awareness to reduce impacts of hazards and enhance ability of the plant management to keep it operating under extremes in weather. TA and capacity building will underscore the need to take extreme variations in the external environment into account while planning for operations and maintenance of the grid/NLDC and power plants. The main risks identified by the climate screening have been addressed through adherence to design and construction standards that take into account the environment in which the plant is sited and the likelihood exposure to these risks. The design criteria and specifications are expected to protect the physical project assets and plant operations from damage and loss due to climate hazards. Specific aspects that are addressed include the following: structural stability, drainage, effect of high temperature, floods, precipitation, high winds and earthquakes.

H. World Bank Grievance Redress

90. Communities and individuals who believe that they are adversely affected by a World Bank (WB) supported project may submit complaints to existing project-level grievance redress mechanisms or the WB’s Grievance Redress Service (GRS). The GRS ensures that complaints received are promptly reviewed in order to address project-related concerns. Project affected communities and individuals may submit their complaint to the WB’s independent Inspection Panel which determines whether harm occurred, or could occur, as a result of WB non-compliance with its policies and procedures. Complaints may be submitted at any time after concerns have been brought directly to the World Bank's attention, and Bank Management has been given an opportunity to respond. For information on how to submit complaints to the World Bank’s corporate Grievance Redress Service (GRS), please visit http://www.worldbank.org/en/projects-operations/products-and-services/grievance-redress-service. For information on how to submit complaints to the World Bank Inspection Panel, please visit www.inspectionpanel.org.
### VII. RESULTS FRAMEWORK AND MONITORING

**Results Framework**

**COUNTRY : Bangladesh**  
**Power System Reliability and Efficiency Improvement Project**

**Project Development Objectives**

Improve the reliability and efficiency of the power system in Bangladesh through optimization of dispatch operation.

**Project Development Objective Indicators**

<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Core</th>
<th>Unit of Measure</th>
<th>Baseline</th>
<th>End Target</th>
<th>Frequency</th>
<th>Data Source/Methodology</th>
<th>Responsibility for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Unserved energy due to underfrequency</td>
<td></td>
<td>Gigawatt-hour (GWh)</td>
<td>5.08</td>
<td>2.08</td>
<td>Annual</td>
<td>Progress report, NLDC reports</td>
<td>PGCB</td>
</tr>
</tbody>
</table>

**Description:** This indicator measures the unserved energy due to feeders tripping because of low frequency.

| Name: Projected fuel saving                        |      | Mega Joules (MJ)  | 0.00     | 1500506.70 | Annual  | NLDC report                   | PGCB                               |

**Description:** This indicator measures the fuel saved by not using oil fired generators (energy saved in KWh converted with a 9063KJ/KWh heat rate).
## Intermediate Results Indicators

<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Core</th>
<th>Unit of Measure</th>
<th>Baseline</th>
<th>End Target</th>
<th>Frequency</th>
<th>Data Source/Methodology</th>
<th>Responsibility for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Minimum frequency (Hertz)</td>
<td></td>
<td>Number</td>
<td>48.70</td>
<td>49.50</td>
<td>Annual</td>
<td>NLDC report</td>
<td>PGCB</td>
</tr>
<tr>
<td>Description: This indicator measures the lowest frequency on the national power system over the year.</td>
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</tbody>
</table>

| Name: Maximum frequency (Hertz)        |        | Number          | 51.40    | 50.50      | Annual    | NLDC report            | PGCB                              |
| Description: This indicator measures the highest frequency at which the national power system operates over the year. |

| Name: Dispatch Improvement Study completed | Yes/No | N  | Y | Annual | Progress report | PGCB |
| Description: Study to be undertaken by PGCB/NLDC. |

<p>| Name: Number of staff trained (cumulative) | Number | 0.00 | 45.00 | Annual | Progress report | PGCB |
| Description: Staff trained under the project. |</p>
<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Core</th>
<th>Unit of Measure</th>
<th>Baseline</th>
<th>End Target</th>
<th>Frequency</th>
<th>Data Source/Methodology</th>
<th>Responsibility for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Grid Code amended</td>
<td>Yes/No</td>
<td>N</td>
<td>Y</td>
<td>Annual</td>
<td>Progress report</td>
<td>PGCB</td>
<td></td>
</tr>
<tr>
<td>Description: Code amended to incorporate ancillary service requirement and frequency control standards.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name: Number of generation units with governor and excitation system upgraded/replaced (cumulative)</td>
<td>Number</td>
<td>0.00</td>
<td>15.00</td>
<td>Annual</td>
<td>Progress report</td>
<td>PGCB</td>
<td></td>
</tr>
<tr>
<td>Description: The indicator measures the progress in equipping selected generators to participate in frequency control.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name: EMS &amp; Optimization software installed</td>
<td>Yes/No</td>
<td>N</td>
<td>Y</td>
<td>Annual</td>
<td>Progress report</td>
<td>PGCB</td>
<td></td>
</tr>
<tr>
<td>Description: This indicator measures the progress in installing a optimization software and an EMS in the NLDC.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Name: NLDC control on generators (cumulative)</td>
<td>Number</td>
<td>0.00</td>
<td>15.00</td>
<td>Annual</td>
<td>Progress reports</td>
<td>PGCB</td>
<td></td>
</tr>
<tr>
<td>Description: This indicator measures the effective control of generation by NLDC after the upgrading of governors.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name: Number of DLR</td>
<td>Number</td>
<td>0.00</td>
<td>9.00</td>
<td>Annual</td>
<td>Progress reports</td>
<td>PGCB</td>
<td></td>
</tr>
<tr>
<td>Indicator Name</td>
<td>Core</td>
<td>Unit of Measure</td>
<td>Baseline</td>
<td>End Target</td>
<td>Frequency</td>
<td>Data Source/Methodology</td>
<td>Responsibility for Data Collection</td>
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</tr>
<tr>
<td>Transmission line constructed or rehabilitated under the project (cumulative)</td>
<td></td>
<td>Kilometers</td>
<td>0.00</td>
<td>40.00</td>
<td>Annual</td>
<td>Progress report</td>
<td>PGCB</td>
</tr>
<tr>
<td>Cumulative duration of power outages per year due to underfrequency</td>
<td></td>
<td>Hours</td>
<td>407.00</td>
<td>166.00</td>
<td>Annual</td>
<td>NLDC and Power sector technical reports</td>
<td>PGCB</td>
</tr>
<tr>
<td>Number of outages per year due to underfrequency</td>
<td></td>
<td>Number</td>
<td>2440.00</td>
<td>999.00</td>
<td>Annual</td>
<td>PGCB and NLDC reports</td>
<td>PGCB</td>
</tr>
<tr>
<td>Assessment of governor/SCADA/EMS/Telec</td>
<td></td>
<td>Yes/No</td>
<td>N</td>
<td>Y</td>
<td>Annual</td>
<td>Progress report</td>
<td>PGCB</td>
</tr>
</tbody>
</table>

Description: This indicator measures the progress in installing DLR.

Description: This indicator measures progress in re-conductoring.

Description: This indicator measures the duration of service disruptions due to feeder tripping after low frequency below the protection setting.

Description: This indicator measures the annual number of interruptions due to under-frequency.
<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Core</th>
<th>Unit of Measure</th>
<th>Baseline</th>
<th>End Target</th>
<th>Frequency</th>
<th>Data Source/Methodology</th>
<th>Responsibility for Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>om completed</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Description:** This indicator measures the progress in the assessment of the condition of governors and communication system.

**Name:** Percentage of female staff trained from total staff trained (cumulative)  
**Unit of Measure:** Percentage  
**Baseline:** 0.00  
**End Target:** 30.00  
**Frequency:** Annual  
**Data Source/Methodology:** Progress report  
**Responsibility for Data Collection:** PGCB

**Description:** This indicator measures the share of females staff out of the total staff trained under the project (cumulative).

**Name:** Number of citizen engagement event on power supply quality (cumulative)  
**Unit of Measure:** Number  
**Baseline:** 0.00  
**End Target:** 3.00  
**Frequency:** Annual  
**Data Source/Methodology:** Progress report  
**Responsibility for Data Collection:** PGCB

**Description:** This indicator measures the number of consultation events with specific groups of customers on quality of power supply.
## Target Values

### Project Development Objective Indicators

<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Baseline</th>
<th>YR1</th>
<th>YR2</th>
<th>YR3</th>
<th>YR4</th>
<th>YR5</th>
<th>YR6</th>
<th>End Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unserved energy due to underfrequency</td>
<td>5.08</td>
<td>6.35</td>
<td>5.08</td>
<td>4.06</td>
<td>3.25</td>
<td>2.60</td>
<td>2.08</td>
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<td>Projected fuel saving</td>
<td>0.00</td>
<td>0.00</td>
<td>1444932.00</td>
<td>1167060.00</td>
<td>1518952.00</td>
<td>1500507.00</td>
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### Intermediate Results Indicators

<table>
<thead>
<tr>
<th>Indicator Name</th>
<th>Baseline</th>
<th>YR1</th>
<th>YR2</th>
<th>YR3</th>
<th>YR4</th>
<th>YR5</th>
<th>YR6</th>
<th>End Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum frequency (Hertz)</td>
<td>48.70</td>
<td>48.70</td>
<td>48.80</td>
<td>49.50</td>
<td>49.50</td>
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<td>Maximum frequency (Hertz)</td>
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<td>50.80</td>
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<td>50.50</td>
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<tr>
<td>Dispatch Improvement Study completed</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Number of staff trained (cumulative)</td>
<td>0.00</td>
<td>5.00</td>
<td>15.00</td>
<td>30.00</td>
<td>40.00</td>
<td>45.00</td>
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</tr>
<tr>
<td>Grid Code amended</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Number of generation units with governor and excitation system upgraded/replaced (cumulative)</td>
<td>0.00</td>
<td>2.00</td>
<td>5.00</td>
<td>10.00</td>
<td>15.00</td>
<td>15.00</td>
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</tr>
<tr>
<td>EMS &amp; Optimization software</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Indicator Name</td>
<td>Baseline</td>
<td>YR1</td>
<td>YR2</td>
<td>YR3</td>
<td>YR4</td>
<td>YR5</td>
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<td>installed</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NLDC control on generators (cumulative)</td>
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<td></td>
<td></td>
<td>2.00</td>
<td>5.00</td>
<td>15.00</td>
<td>15.00</td>
<td></td>
</tr>
<tr>
<td>Number of DLR installed (cumulative)</td>
<td>0.00</td>
<td>2.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
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</tr>
<tr>
<td>Transmission line constructed or rehabilitated under the project (cumulative)</td>
<td>0.00</td>
<td>20.00</td>
<td>40.00</td>
<td>40.00</td>
<td>40.00</td>
<td>40.00</td>
<td>40.00</td>
<td></td>
</tr>
<tr>
<td>Cumulative duration of power outages per year due to underfrequency</td>
<td>407.00</td>
<td>508.00</td>
<td>406.00</td>
<td>325.00</td>
<td>260.00</td>
<td>208.00</td>
<td>166.00</td>
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</tr>
<tr>
<td>Number of outages per year due to underfrequency</td>
<td>2440.00</td>
<td>3048.00</td>
<td>2438.00</td>
<td>1951.00</td>
<td>1561.00</td>
<td>1248.00</td>
<td>999.00</td>
<td>999.00</td>
</tr>
<tr>
<td>Assessment of governor/SCADA/EMS/Telecom completed</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Percentage of female staff trained from total staff trained (cumulative)</td>
<td>0.00</td>
<td>20.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
</tr>
<tr>
<td>Number of citizen engagement event on power supply quality (cumulative)</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
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<td></td>
</tr>
</tbody>
</table>
ANNEX 1: DETAILED PROJECT DESCRIPTION

COUNTRY: Bangladesh
Power System Reliability and Efficiency Improvement Project

1. Apart from the investment needs, the main challenges faced by Bangladesh’s power sector are: (i) ensuring the quality and reliability of the power supplied, so that it is not subject to wide voltage fluctuations (which damage appliances and industrial equipment/machines) and outages; and (ii) safeguarding system security and making the system resilient, so that it is able to cope with swings in demand and supply and recover from unanticipated shocks such as major failure of a generator or transmission line. The country is planning to double its generation capacity in the next five years. As the system increases in size it will also become increasingly susceptible to cascading outages, for instance, following initial failure of a large generator or loss of a feeder, resulting in significant economic losses. There is, therefore, a need to mitigate such vulnerabilities to meet the level of quality as well as the reliability and the efficiency of service required by the different players in the economy.

2. A proper frequency control is key to delivering quality supply and enabling integration of large planned power plants and renewable energy. Mismatches between the demand and supply of power lead to deviations of system frequency from the norm (50 Hz in Bangladesh) and can result in outages and, in the extreme case, the system shutting down. To avoid this, the system’s frequency needs to be managed within a narrow band by adjusting supply (generation) or demand (load shedding), as needed, to bring them into balance. Implementation of primary frequency control (in which plants automatically adjust generation in response to frequency variations in the system) by large generating plants is essential for stabilizing the power system after a disturbance. In well performing systems, this is typically followed by the system operator bringing on reserve capacity (called spinning reserve) to address supply shortfalls and restore the balance between supply and demand. The latter is called secondary control and implemented in most advanced systems through an Automatic Generation Control (AGC) that “follows the variation in load.” The National Load Dispatch Center (NLDC), in charge of operating the system, would rely on its data acquisition and system management tools (commonly called SCADA/EMS) to collect information and manage the process of bringing plants on-line or taking them off and/or adjusting output in an automated way in real time. The frequency control spinning reserve constitutes a vital ancillary service for which generators are always financially compensated.

3. However, the primary frequency control is currently absent in Bangladesh. In addition, SCADA/EMS exist at both NLDC and the plant level but are not integrated or used for dispatch. This lack of system automation and integration implies the system operator faces considerable delays and uncertainty in balancing the demand and supply. As a result, (i) stand-by oil and diesel fired plants are often run pre-emptively to avoid a situation of demand-supply imbalance in the absence of spinning reserve, leading the system to use unnecessarily large amounts of expensive liquid fuels and (ii) the distribution feeders trip automatically in case of under-frequency.

4. Apart from participating in primary frequency control, a critical requirement for active management of the system by NLDC is for generators to cooperate in providing secondary control. For this, the NLDC needs to have the institutional authority to require cooperation, which is not the case currently. The incentives of generators to implement primary frequency control are also complicated. IPPs
are paid for power produced and would not necessarily wish to adjust their generation downward simply to provide a balancing service to the grid. In fact, it is often the case that IPPs respond in a counterproductive manner. For example, they react to a drop in system frequency by reducing their own generation or even shutting off or isolating it off the grid, in order to avoid damaging their turbines. Such reaction can exacerbate the system imbalance and make the grid even more unstable. In a situation of chronic shortages as in Bangladesh, even state-owned generators are not idled easily; as a result, an adequate spinning reserve is not maintained. Thus, understanding incentives and aligning them (e.g., by appropriately compensating the providers of ancillary services), is an important priority.

5. Voltage stability is a second element characterizing the quality of supply which need attention in Bangladesh. It is the indicator most readily apparent to consumers whose lights dim/brighten or fans slow down/speed up as voltage declines and increases. Industry must incur additional costs and make special efforts to stabilize voltage so that equipment is not damaged and manufacturing processes can continue unharmed when voltage fluctuates. Reactive power is required to compensate instantaneously for voltage drops and maintain the quality of supply. This is usually addressed through reactive power supply at the sub-station level or in the downstream distribution system, including capacitor placement at the load end. Reactive power compensation helps in avoiding network congestion. Re-dispatching generators to provide additional reactive power can also be followed in extreme cases, although it is generally cheaper to fix voltage problems by installing capacitor banks or, if needed, the more expensive Static VAR Compensator (SVC) at the sub-station/load end. SVCs, in particular, are very effective in providing dynamic/fast reactive power.

6. Finally, the dispatch of power by the NLDC is currently not fully consistent with the merit order (i.e., the concept that power plants are dispatched in increasing order of cost). Here also the lack of automation and proper dispatch optimization tools constitutes one of the major reasons. The dispatch process is handled inefficiently based on a manual process of a merit order list maintained on a spreadsheet. There is then, as mentioned earlier, a scope for considerable saving in system-wide fuel use by making sure that the system draws on the lowest cost power before calling upon more expensive power. This also begs the question of what underlies the absence of the merit order – in some instances, transmission bottlenecks prevent evacuation of power from low cost plants; alternatively, gas (fuel) shortages can result in more expensive oil fired plants being called into service in advance of cheaper gas fired ones; power purchase agreements (PPAs) themselves may restrict the freedom of NLDC; and, ultimately, vested interests may interfere with the order of plants for dispatch. A sustainable solution will need to address both the institutional/political economy and technical aspects of the issue.

7. The scope of the project components derives from an assessment of PGC’s transmission and system operations and frequency control trials undertaken by PGC with support of consultants and WB Team. First, an analysis of system operations points out that the operation is reliant on manual control and dispatch which result in wide frequency variations. Second, the lack of grid discipline has led to a reliance on expensive liquid fuel-fired generation to manage the peak demand. The NLDC will need the cooperation of generators to be able to manage fluctuations in frequency with minimal delay (first through primary control and then to implement AGC). Two frequency control trials were carried out17 with a selected set of generators on ‘free governor’ mode operation (FGMO). The trials permit their output to vary within a small (e.g., 5 percent) band of their nameplate capacity, which would permit them

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17 On April 4 and August 6, 2016, under the oversight of the Grid Stability Committee.
to provide a spinning reserve as required. The trials showed that the frequency band can be narrowed down to a range of 49.6 to 50.5 Hz from 49-51 Hz. It allowed also to identify implementation issues and address them as a precursor to future automated secondary control via AGC.

8. Additional 24 hour trials were conducted in October 2016 to fine tune the conclusions and help prepare for a month long trial. A review of dispatch efficiency carried out by the World Bank in collaboration with NLDC, using a standard dispatch optimization approach with actual 2014 data, determined that the observed deviation from optimal (“merit-order”) dispatch is largely attributable to the absence of modern, optimization-based dispatch protocols and related capacity in NLDC. In addition, an optimal power flow study identified key transmission bottlenecks that will have to be upgraded so as to enhance transmission capacity to transfer more electricity and reduce congestion.

9. A third FGMO trial was conducted during October 30 to November 20, 2016. Seven power plants totaling 1,517 MW of capacity participated and provided 300 MW of spinning reserve. The system frequency was kept in the bandwidth of +/-0.5 Hz. The system has experienced a drastic reduction of outages as the under-frequency relays did not activate to cause a feeder trip. Less oil-fired generation was also needed. However, the trial conditions may change drastically during the peak period (February-May) where less spinning reserve will be available and the transmission system is subjected to more constraints. New generation units coming on stream will improve such constraints during 2017-2021.

10. From the analysis and trials undertaken above, it appears that the retrofitting to an automated, modernized dispatch function with associated investment in transmission upgrading would ultimately (i) improve system security and reliability (minimizing outages and preventing wider blackouts or a sudden disturbance in network); and, (ii) increase the efficiency or cost effectiveness of system operation by ensuring that it follows merit-order dispatch.

11. The project is conceived as the first stage of a process of modernization of system dispatch in Bangladesh, recognizing that this is a long process that can best be implemented in phases as described in Table A.1.1 below:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| 0     | Limited duration Free Governor Mode Operation (FGMO)\(^{18}\) trials | • Satisfactory response of the 15 participating plants to frequency variation  
• Successful reduction of the frequency bandwidth to 50Hz+/-0.5 during 3hrs, 8hrs and 3 weeks trials.  
• Identification of technical and economic constraints for IPPs with regards to their contractual obligations.  
• Coordination through the Grid Stability Committee was effective but needs to be formalized through an MOU between stakeholders. |

\(^{18}\) FGMO refers to using the ability of generators to respond automatically to frequency variation by adjusting fuel injection (i.e. output). The generators’ governing systems can sense the frequency change and automatically load or unload (generally in the range of +/-5%) to support balancing of the system and bring back frequency within the limit.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| 1     | Continuous FGMO operation with full participation of generators prioritizing BPDB generators with technical assistance (TA) from international experts | • Fuel consumption and outage due to under-frequency protection are reduced  
• FGMO may not be fully effective during the yearly peak period between February-May due to unavailability of sufficient spinning reserve.  
• Agreement on basic operational and dispatch rules.  
• Plants for frequency control purpose prioritized  
• Detailed modeling of the system operation  
• Rules and incentives for IPP participation defined  
• NLDC staff trained  
• Grid Code amended accordingly  
• Assessment of the condition of power plant primary and secondary controls.  
• Assess existing SCADA/EMS and Telecom conditions  
• Institutional review to establish policies, rules and regulations required for optimal dispatch  
• Upgrading and replacement investment needs for generator integration estimated and related bidding documents prepared.  
• Roadmap for implementation of AGC & Frequency Control Ancillary Services (FCAS)  
• Roadmap for modernization and upgrading of NLDC and its operational practices in light of long term planning of electricity sector  
• Barriers to optimal dispatch identified and ways to address them recommended  
• Economic dispatch enabled  
• NLDC control on governors enabled |
| 2     | Supply & installation of (i) hardware and software needed for generators integration in existing NLDC SCADA/EMS; (ii) Optimization and Real time economic dispatch software | • Removal of transmission constraint to allow economic dispatch  
• Improvement of voltage quality to improve efficiency and reliability  
• Implementation of AGC & FCAS  
• Additional network upgrading  
• NLDC modernization and upgrading  
• Fully automated dispatch with increased number of participating generators  
• Compensation for ancillary services in place  
• NLDC/SCADA/EMS replaced/upgraded  
• NLDC operational practices designed and in force |

12. The project will further support the trials by providing technical guidance, capacity building and training to NLDC team. It will also support the progressive implementation of primary/secondary frequency controls as well as the needed investments on participating generators and transmission bottleneck removals.
13. Over the medium term it is envisaged that AGC and compensation for Frequency Control Ancillary Services (FCAS) will be key mandates of NLDC functioning as an Independent System Operator. In the event of the development of a regional electricity market, FCAS will also likely be traded with NLDC acting as the clearing house alongside generation. Over time, the existing SCADA/EMS will also need to be replaced to support fully automated dispatch and AGC, potentially with a smart grid. This part may be considered in a follow-on operation.

14. The project development objective is to improve the reliability and efficiency of the power system in Bangladesh through optimization of dispatch operation. The project comprises three main components namely (i) technical assistance, (ii) operational enhancements; and, (iii) removal of transmission bottlenecks and improvement of voltage quality. The project will support investments and technical assistance to improve the performance of NLDC to enable an optimal operation of the national power system based on merit order dispatch.

Component 1: Technical Assistance (US$8 million funded by IDA)

15. Sub-component 1.1 will support the primary frequency control trials and training for PGCB/NLDC engineers/operators on modern, state-of-the-art frequency control and dispatch protocols (US$4 million by IDA). The frequency control trials are pre-requisite to and will be followed by implementation of primary frequency control in at-least 15 power generation plants. Experienced power system control specialists and power system modelers will be engaged for six months to perform the following tasks before the trial starts:

(i) Assessment/diagnostic of the capabilities of all participating power stations to provide frequency control services to the national grid: The assessment will cover the status of their controls, the condition of governors and actions needed to enable them to provide frequency response.
(ii) Assessment of the SCADA system and modelling tools used to simulate the operation of the system: The inspection will also identify the hardware that will need to be procured to ensure effective implementation of primary and secondary control. The power system control specialists will help NLDC to prioritize the plants for frequency control purposes and set up a dispatch/merit order for these plants. Such support will also help PGCB to undertake detailed modelling to simulate operation of the system.
(iii) Assistance to NLDC operators and PGCB staff during the trial process to ensure the trial proceeds smoothly and to record frequency response, recalibrate parameters, and prepare a final report on the outcome of the trial.

16. Sub-component 1.2 will also include capacity building activities and an institutional review (US$4 million by IDA) as follows:

(i) Training of NLDC staff to provide exposure to modern power system protection, dynamics, stability, operation and control theory as well as international standards, practices and technologies. They will be trained on practical aspects of real time primary/secondary frequency regulation through governor response and build power system dynamic modeling capability using PSSE or similar model.
(ii) Study on dispatch improvement to identify the critical path for implementing merit order dispatch and make recommendations for transitioning to AGC and a fully modernized dispatch system over
time. An in-depth review of the institutional and policy barriers (including plant level incentives) limiting NLDC control over generators will be undertaken to explore ways to restore merit order in dispatch. The study will also build awareness and capacity on the basics of system dispatch through training to be provided to stakeholders beyond PGCB/NLDC, i.e., BPDB, the Power Division of MPEMR and BERC.

Component 2: Operational Enhancements (US$47 million of which US$34 million plus US$5m contingency funded by IDA).

17. The NLDC in Dhaka is currently not integrated with the SCADA system of the power generation plants in the grid and is unable to send/receive signals for changing output; nor does it receive real-time demand forecasts from the distribution companies. The lack of cooperation between generators (to give NLDC control of their governors) and the demand side (to provide more reliable inputs to forecast demand) means that NLDC has little choice but to balance the system using guesswork and through instructions to generators over the phone. This component will fund three sub-activities:

18. Sub-component 2.1: Integration of generators to the SCADA/EMS system (US$16 million by IDA). Activities under the Component 1 will identify the hardware and software required to be procured for integration. This component will finance the design, supply and installation of the equipment needed for the plants to be fully effective in providing both primary and secondary frequency control. It will include Remote Terminal Units, enhancement of the plant SCADA system, replacement of generator controls, Automatic Voltage Regulators, power system stabilizers, etc.

19. Sub-component 2.2: Upgrading/modernization of the NLDC SCADA/EMS software (US$6 million by IDA). It will cover procurement of software for real-time economic dispatch control, operator load flow, AGC and modeling power system dynamics, including licenses for five years so that NLDC staff are able to fully utilize the SCADA/EMS system. The software will enable the monitoring of generators for frequency control and dispatch.

20. Sub-component 2.3: Optimization software for dispatch (US$12 million by IDA). The dispatch optimization software will include week-ahead, day-ahead and hourly simulation capabilities to run fuel and transmission constrained dispatch optimization in an off-line mode and online (integrated with the SCADA/EMS) system. The package will include a minimum of one license for five years, preparation of a dataset and analysis, and training on the dispatch system.

Component 3: Removal of Transmission Bottlenecks and Improvement of Voltage Quality (US$22 million of which US$10 million plus US$2m contingency funded by IDA).

21. The component will cover the needed network reinforcement including (i) the upgrade (of selected congested 132 kV and 230 kV lines and (ii) Dynamic Line Rating (DLR) to improve utilization of limited transmission capacity. Details are as follows:

22. Sub-component 3.1: Upgrade of selected congested transmission lines (US$4 million by IDA) to address existing bottlenecks and enhance system transfer capability. Optimal power flow (OPF) analysis was used to identify those transmission assets that are having the higher impact on dispatch efficiency.
Some of these assets could be upgraded using reconductoring. The transmission segments with highest levels of constraints are listed below:

<table>
<thead>
<tr>
<th>Table A1.2: Constrained Transmission Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
</tr>
<tr>
<td>Bogra-Sirajgonj</td>
</tr>
<tr>
<td>Ashuganj-Ghorasal</td>
</tr>
<tr>
<td>Faridpur-Rajbari</td>
</tr>
<tr>
<td>Kushtia-Jhenidah</td>
</tr>
<tr>
<td>Barishal (N) - Barishal</td>
</tr>
</tbody>
</table>

23. These lines are still under consideration by PGCB pending final decisions. Future planned or committed projects should provide a long term solution. However, the following two critical lines (132kV double circuit) that are needed urgently are included in the scope of this project:

(i) Reconducturing of Barisal (N)-Barisal 132 (10km);
(ii) Reconducturing of Saidpur-Purbasadipur (30km)

24. Sub-component 3.2: Dynamic Line Rating (DLR) to improve utilization of limited transmission capacity on 382 km of seven critical transmission lines identified by PGCB (US$6 million by IDA). They will be equipped with 9 DLRs based on their geographic layout. The following transmissions lines are identified based on the potential to increase current operational ratings in a safe way and reduce network constraints:

(i) Haripur 360 MW 230 kV double circuit line (1km)
(ii) Ishurdi-Bheramara 132 kV double circuit line (10km),
(iii) Bheramara-Kushtia 132 kV double circuit line (24km)
(iv) Haripur-Shyampur 132 kV double circuit line (29km)
(v) KhulnaCentral-Noapara 132 kV double circuit line (23km),
(vi) Hasnabad-Shitalakshya 132 kV double circuit line (13km) and
(vii) Haripur-Sonargaon-Daudkandi-Comilla(N)-Comilla(S)-Feni-Hathazari-Madunaghat-Shikalbaha-132 kV transmission line (282 km)
ANNEX 2: IMPLEMENTATION ARRANGEMENTS

COUNTRY: Bangladesh
Power System Reliability and Efficiency Improvement Project

Project Institutional and Implementation Arrangements

1. PGCB will be the implementing agency for the project and has set up a dedicated PMU. PGCB has already assigned a Project Director (PD) from NLDC. The PMU will be staffed as described below:
   - Dedicated Design & Supervision Engineers: two in design and four in supervision
   - Procurement Experts (two). PGCB will establish and strengthen a Corporate Procurement Team. PMU will also be supported by two procurement consultants.
   - Financial Management Experts (two)
   - Safeguard Experts: A dedicated Environmental and Social Unit is already established and permanent positions approved. It was agreed that one (1) Environmental, and one (1) Social Expert will be recruited no later than end of December 2016. They have started the recruitment process. PGCB has also assigned staffs in Design, Procurement and FM functions of the project.

2. While PGCB will implement the project, the Grid Stability Committee established in November 2015 will continue to carry out primary frequency trial runs to achieve a lower band of frequency fluctuation (plus/minus 0.5 Hz). It will hold periodic meetings for planning, executing and reviewing primary frequency trials exercises with generators. It will review results of the trial runs and impacts. The objective of the committee is to achieve system frequency to reduce outages, ensure quality of electricity in national grid and maintain supply stability. Close cooperation and coordination within committee members specially, between PGCB/NLDC and BPDB is essential. The complexity of the project will require a close cooperation between generators, BPDB, and PGCB that can be formalized through executing a Memorandum of Understanding (MOU) between BPDB and other stakeholders. The detail scope of the MOU will be worked out and signed between the parties taking into consideration the principles of the Grid Stability Committee. The implementation arrangement of the project has been depicted in the Figure A2.1 below.

3. Power system control consultants will support PGCB on the trial activities and the modelling to enable full transfer of know-how and on the job training.
4. The detail assessment of financial management as well as the actions to be taken are described below.

5. **Fiduciary Capacity:** Assessed fiduciary capacity of PGCB is acceptable and associated risk from the financial management perspective is rated as “Moderate”. The implementing agency (PGCB) is fully compliant with the audit covenants of IDA projects. There is no outstanding audit reports for the agency.

6. **Planning and Budgeting:** Overall risk rating is considered low for planning and budgeting. A budget will be maintained for the entire term of the project, and detailed budgets for each fiscal year will also be produced to provide a monitoring framework for financial management purposes. The annual budget will be prepared on the basis of the procurement plan and any other relevant annual work plans. These budgets will be monitored periodically to ensure actual expenditures are in line with the budgets, and to provide input for necessary revisions.
Internal Control

7. **Filing and Record-Keeping:** PMU under PGCB will preserve all accounting and financial records and these records must be made readily available on request for audit/investigation/review by the Government and the Bank. All project related documents must be filed separately to facilitate internal and external audits, as well as fiduciary reviews, which may be carried out by the Bank. The project will maintain assets tracking system for ensuring annual physical verification and reporting on assets procured under the project.

8. **Entity Accounting and Financial Reporting System:** PGCB has adequate budgeting accounting and financial reporting systems which will be used for accounting and generating the required financial reports under the project. An automated accounting system exists in PGCB and its unit offices for accounting and reporting purposes, but it takes unusually long time to prepare the financial statement as the accounting software of unit offices are not accustomed for real-time entry for consolidating all financial information in the head office. Since the implementing entity is a company incorporated as public limited company under the Companies Act, 1994 of Bangladesh, the financial reporting (Balance sheet and the profit and loss account) of the PGCB is therefore governed by the provisions of that Act. The annual financial statements are prepared on accrual principles following the accounting standards as applicable for this entity.

9. **Financial Management System for the Project:** The project would have a separate ledger and trial balance with separately identifiable accounting code.

10. **Internal Audit:** PGCB has an internal audit department which undertakes financial and commercial audit for the entity but the internal audit department could not conduct internal audit of the ongoing Bank projects every year due to insufficient staffs. The internal audit department requires strengthening by adding sufficient and adequate professional resources to undertake the internal audit of the entity and the project operations regularly.

Oversight Arrangements

11. **External Audit:** The annual accounts of the PGCB is audited by a private audit firm as per statutory requirement. It was agreed that the project audit will also be covered by the same audit firm, provided their terms of reference is expanded to reflect this. The annual audit report will be submitted to the Bank by December 31 each year which will be monitored and tracked in the Bank system. It has been noted from the previous external audit reports that the auditors expressed qualified audit opinion on the financial statements of PGCB in last five consecutive years mainly for weaknesses on fixed asset management and reporting. These issues need to be immediately addressed.

12. **Audit Committee and Audit Observation Resolution Mechanism:** To strengthen the Corporate Governance, an audit committee will be established at the entity level for oversight and settlement of the entity and project’s audit issues in a systematic manner. The audit committee will review the audit issues and ensure timely resolution of audit issues arising from both internal and external audits.
Financial Management Considerations in the Fiduciary Assessment

13. **Staffing:** PGCB is adequately staffed for carrying out its financial management functions. The Finance function in PGCB is headed by the Executive Director (Finance). However, the Project Director will have financial power to approve financial transactions of the project and a separate team from finance department of PGCB will be deputed to help Project Director on financial management issues.

14. **Accounting and Financial Reporting:** The project will provide quarterly unaudited financial reports (IUFR) within 45 days from the end of each quarter as per the reporting format acceptable to the Bank.

Disbursements

15. **Disbursements and Fund flow:** It was agreed that IDA funds will be on-lent to PGCB by the Ministry of Finance through a Subsidiary Loan Agreement (SLA). PGCB will have direct access to IDA funds through the PMU. The PD of the PMU will have all financial control of IDA funds and all project related eligible payments will be made by the PD using the banking system (except for small petty cash payments). Under the project, IDA funds will not finance salaries/operational costs of any nature for the PGCB nor sitting allowances or honoraria, import and supplementary duties and value-added taxes at import stage to be paid under contracts. Goods, works, and services including training will be financed by the credit. For each contract, IDA funds will be transferred directly to the contractors’ account or payment will be made through the Special commitment method. It was agreed that the project will follow the transaction based disbursements since there will be few large value contracts to be financed by Bank and use the Reimbursement, Direct Payment, and Special Commitment methods. Hence, the Project will not have a Designated Account facility. The operating costs of the project will be financed by GOB and funds for the same will be routed through the normal budgetary channels. Retroactive financing facility will be available for eligible expenditures incurred (mobilization advances and consultant's payments) on or after September 1, 2016 (that is, twelve months prior to expected date of signing of the financing agreement).

16. The estimated cost of the project is about US$77 million of which IDA financing is proposed to cover US$59 million and the government counterpart funding of US$18 million will cover staff salary, other operating and recurring expenditures\(^\text{19}\), costs for procuring vehicles as well as import and supplementary duties and value added taxes at import stage. IDA will finance all other applicable taxes. Government will also fund (i) the cost of land required for the purposes of the Project; and (ii) all resettlement and rehabilitation compensation and other assistance to Affected Persons in accordance with the RAPs.

Procurement

17. **General:** Procurement would be carried out in accordance with the World Bank Procurement Regulations for IPF Borrowers (the “WB Procurement Regulations”), July 2016. As per requirement of the NPF, PGCB has prepared the PPSD in consultation with the Bank staff.

\(^{19}\) Such as workshop allowances, sitting allowances, cash per diems, honoraria and fuel.
18. **Procurement Significance:** The total project cost is about US$ 77.00 million, of which IDA contribution is about US$ 59.00 million. Almost all funds of IDA will be used through procurement processes except for training (US$1.5 to 2 million). Procurement under this project will largely involve goods (supply and installation contract) and consulting services.

19. **Procurement Responsibility:** The PMU at PGCB will carry out the procurement processes and contract management activities with support of the consultant (procured under package S-1). The PGCB Board will carry out oversight functions as well as approval of all contracts as laid down in their charter and as described in the Financing Agreement (FA) of the project.

20. **Procurement Capacity:** PGCB has experience and capacity in processing donor-funded and Government-funded projects. It already completed one WB funded project (Siddhirganj Power Project), is in the process of implementation of one WB funded project (Rural Electricity Transmission and Distribution Project). They have experience of implementing ADB funded projects, JICA funded projects and other donor funded projects. About 179 staff of PGCB received training on country’s procurement laws (i.e. Public Procurement Rules, 2008 (PPR)) in the past few years. Currently, there are no major complaints received for the above two WB funded projects. However, there are only few staff who have adequate knowledge in donor funded projects like World Bank, Asian Development Bank etc. The number of qualified procurement staff is not adequate to provide efficient support. The Project Management Unit of PGCB should have dedicated qualified procurement staff to carry out the procurement processes and contract management activities with support of consultants to be procured under package S-1 of the project.

21. **Procurement Implementation Arrangement:** The PMU headed by the PD will consist of additionally two procurement trained staff (one for procurement and the other for contract management) of PGCB, one international procurement consultant (intermittent) and one international technical consultant (intermittent). The procurement staff and the procurement consultant are responsible for planning and managing the entire procurement process and overseeing the contract management issues of the project. In order to enhance the capacity of the procurement staff of PGCB and the bid evaluation committee, necessary training related to NPF will be provided.

22. **Procurement Risks:** Bangladesh operates in a challenging procurement environment. Procurement risks arise out of many factors such as weak capacity, unfavorable market, and weak governance. PGCB deals with a large number of specialized suppliers and contractors in their day to day business of transmission line construction, establishment of sub-stations and SCADA system, and establishment and coordination of protection system. Most procurements under this project involve international competition to ensure value for money. PGCB is not familiar with some of the good features of NPF such a “rated criteria,” “BAFO,” “sustainable procurement,” etc. which may be followed in this project to ensure best procurement outcome. Upon considering all factors, the overall procurement risk is rated as “Substantial.”

23. **Managing Procurement Risks:** The following measures have been agreed upon with PGCB to minimize the risks associated with procurement. Parts of these measures are already in place, while the remaining will be implemented during project supervision.
## Table A2.1: Key Risks and Proposed Mitigation

<table>
<thead>
<tr>
<th>Procurement Core Principles</th>
<th>Possible Risks</th>
<th>Proposed Mitigation Measures</th>
</tr>
</thead>
</table>
| **Value for Money (VFM)** | a) High priced bid  
   b) High maintenance cost  
   c) Less life time of the product  
   d) Less quality of the finished product  
   e) High cost of ownership over the life of the product.  
   f) Negative impact in terms of social and environment  
   g) Lack of knowledge at PGCB to ensure VFM  
   h) Inadequate understanding of the bidders related to VFM | a) Incorporate rated criteria considering contractor’s performance, capacity, social and environment aspect.  
   b) Introduce key performance indicator (KPI) for green procurement (Social and environment) in contract management.  
   c) Comprehensive training for Borrower on VFM.  
   d) Awareness and hands on training program for the prospective bidders on VFM customized for specific bidding opportunities. |
| **Economy** | a) High bid price  
   b) High cost of ownership  
   c) Contract will not complete on time; cost over run | a) Conduct bidder’s awareness to ensure better completion which may ensure reasonable price  
   b) Conduct BAFO / negotiation for significantly high priced bid with prior approval from the Bank. |
| **Integrity** | a) Possibility of wrong doing | a) Engage independent Probity Assurance Provider (independent third party) for high value contract to be present during different stages of the procurement process, including: engagements/ discussions with firms, bid/ proposal opening, evaluation, negotiations, contract award decisions, and/or contract execution  
   b) PGCB will carry out extra due diligence on the local agents of bidders. Bidding documents of the Bank have explicit requirements for disclosure regarding local agents, if any. As part of bid evaluation, PGCB will carefully look at who the proposed local agents are and what their roles are with respect to the particular bidding. |
| **Fit-for-Purpose** | a) For some of the procurement items such as dynamic line rating, power station governors there are only few reputed manufacturers / bidders in the market. There is risk of less competition and high price. | a) Extensive bidder’s awareness program even though the value of contracts are not relatively high.  
   b) Use “BAFO” |
24. **Procurement Plan:** For each contract to be financed under the project, estimated costs, procurement methods, prior review requirements, whether bidders are to be pre- or post-qualified, and time frame would be agreed between the implementing agency and the Bank in the procurement plan. All expected major procurements will be announced in the General Procurement Notice (GPN) – published in the Bank’s external website and in United Nations Development Business (UNDB). The procurement plan will be updated semi-annually (or as required) using the World Bank Online Procurement Planning and Tracking System (STEP).

25. **Use of Standard Procurement Documents:** For procurement with international competition and for selection of consultants, the Bank’s Standard Documents and Standard Request for Proposals will be used. For procurement with national competition and shopping, PGCB will use model bidding document agreed with the Bank.
26. **Market Analysis:** A market analysis was carried out for items: generator governors, DLR technologies, SVC and dispatch optimization software. The study shows that except for DLR technologies, all other solutions are mature technologies. The world market, especially large manufacturers, are keen to participate in the bidding process under PGCB. They are aware of PGCB’s business and reputation. A reasonable good competition is expected subject to political stability.

27. **Prior review Thresholds:** The Procurement Plan shall set forth those contracts which shall be subject to the Bank’s prior-review.

28. **Post Review:** For compliance with the Bank’s procurement regulations, the Bank will carry out sample post-review of contracts that are below the respective prior-review thresholds

### Table A2.2: Summary of Procurement Packages/ Procurement Plan:

<table>
<thead>
<tr>
<th>Contract No.</th>
<th>Title/ Description</th>
<th>Value (US$ million)</th>
<th>Preferred Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consultancy Packages:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REIP/S1</td>
<td>Study to improve electricity transmission system reliability and efficiency in dispatching power station generators and develop technical specifications of supply and installation contracts including supervision of supply and installation contracts and related training.</td>
<td>4</td>
<td>Quality and Cost Based Selection (QCBS), International Market, Open competition, Prior Review</td>
</tr>
<tr>
<td>REIP/S2</td>
<td>Study of the institutional requirements to integrating power station generators with NLDC through remote control.</td>
<td>4</td>
<td>QCBS, International Market, Open competition, Prior Review</td>
</tr>
<tr>
<td></td>
<td>Sub-total:</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Goods/Supply Installation Packages:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REIP/G1</td>
<td>Supply, installation, testing and commissioning of conductors in some 132/230 kV lines by replacing old conductors</td>
<td>4</td>
<td>Request for Bids (RFB), International Market, Open competition, Prior Review</td>
</tr>
<tr>
<td>REIP/G2</td>
<td>Supply, installation, testing and commissioning of power station governors, and related hardware and software</td>
<td>16</td>
<td>RFB, International Market, Open competition, Prior Review</td>
</tr>
<tr>
<td>REIP/G3</td>
<td>Supply, installation, testing and commissioning of dispatch optimization software</td>
<td>12</td>
<td>Request for Proposal (RFP), International Market, Open competition, Prior Review</td>
</tr>
<tr>
<td>REIP/G4</td>
<td>Supply, installation, testing and commissioning of EMS/SCADA system including other communication system</td>
<td>6</td>
<td>RFB, International Market, Open competition, Post Review</td>
</tr>
<tr>
<td>REIP/G5</td>
<td>Supply, installation, testing and commissioning of DLR technologies to three places</td>
<td>6</td>
<td>RFB, International Market, Open competition, Post Review</td>
</tr>
</tbody>
</table>
Environmental and Social (including safeguards)

Environmental

29. The applicable environmental category and safeguard polices for the proposed project is based on the need to provide support for rehabilitation of the transmission network of PGCB. PGCB will implement the upgrading of 132 kV transmission lines in different routes and will further consider installation of new SVCs\(^{20}\) at different locations. The proposed project is classified as a Category B project since there are no significant and/or irreversible environmental issues in the rehabilitation of transmission network of PGCB or possible installation of SVCs. The Bank safeguard policy Environment Assessment (OP/BP 4.01) has been triggered to ensure that the project investment is environmentally sound and sustainable.

30. In order to address environmental safeguard issues, the project intends to ensure that the proposed infrastructure takes environmental concerns into account. Since the line routes to be rehabilitated remains unknown at the project appraisal stage, a framework approach has been adopted for the project. SVCs are required to regulate the voltage on the transmission system, particularly where there are contingencies that can cause a sudden and large drop in voltage. The ESMF meets the requirements of Environment Conservation Rules 1997 of Bangladesh, the Safeguard Policies of the World Bank and the Environmental, Health and Safety Guidelines of the World Bank Group/International Finance Corporation (IFC).

31. The ESMF has been prepared based on the sample site visits at PGCB intervention areas and several discussions with the relevant stakeholders. The ESMF provides for general policies, guidelines, and procedures to be integrated into the design and implementation of all subprojects under the project. The ESMF will be the guiding document for subproject-specific (i) environmental screening and assessment; (ii) establishment of “baseline environment”; (iii) analysis of alternatives; (iv) identification of major subproject activities and evaluation of the overall potential environmental impacts; (v) public consultations; (vi) identification of mitigation measures and preparation of EMP; (vii) selection of ECoP; (viii) implementation of the EMP and ECoP; and (ix) monitoring of the implementation of EMP and ECoP. The ESMF also identifies the institutional barriers and capacity building needs for PGCB for proper environmental management.

32. The ESMF has the provisions for subproject specific alternative analysis. In general, for any subproject, the analysis of alternative should focus on: alternative location (for substation) or route (for power line); alternative design and technology; costs of alternatives; and no subproject scenario.

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\(^{20}\) PGCB requires further studies to include SVCs in the current project scope. However, installation of SVCs are taken into account in all disclosed safeguard instruments.
33. According to the ESMF, subproject specific ECoP and the EMP need to be incorporated in the bid document and the cost for the implementation of EMP will be a line item of the Bill of Quantities (BOQ). The ESMF also provides the special environmental clauses (SECs) for the technical specification of the bidding documents.

34. When the site will be identified, based on the ESMF, PGCB will be responsible to carry out environmental screening/assessment along with analysis of alternatives and to prepare an EMP with budget. The bidding document will incorporate the scope and EMP cost. The screening will help to determine whether a proposed subproject needs the environmental assessment or whether it would be required to follow the Environmental Code of Practices (ECoP) to mitigate or avoid adverse impacts. If additional environmental assessment is necessary, PGCB will take necessary steps for carrying out the assessment. The environmental assessment will be carried out following the ESMF. The PGCB will also be responsible for getting necessary environmental clearance from the Department of Environment (DoE).

Environment Impacts and Mitigation Measures

35. In general, there might be no significant adverse impacts expected from the upgrading of 132 kV transmission lines and possible SVCs. Noise and air pollution could result from a wide range of construction activities. Also movement of vehicles, operation of construction equipment and generators during the upgradation of transmission will affect agricultural land, reduce soil compaction and rutting in sensitive soils and natural areas. Water pollution may result from discharge of waste (from labor shed or site) and spills and leaks of oils/chemical into water bodies. These impacts are mostly temporary and limited within project boundary.

36. To mitigate these impact, site specific EMP shall be prepared in accordance with ESMF after the subproject identification and the EMP shall be followed during implementation. Also necessary mitigation measures for working at overhead lines against accidental fall from elevated height or dangers from live electric line shall be taken during execution of work (e.g. using body harness, waist belts, secured climbing devices, etc.).

37. **Borrower’s Capacity on Environmental Safeguard.** PGCB has prior experience in implementing the IDA funded projects and it has implemented the “Siddhirganj and Maniknagar 230kV Transmission Line Project” under IDA financed Siddhirganj Power Project. Also they are implementing the subprojects under Rural Electricity Transmission and Distribution Project of WB. PGCB created an Environment and Social Management Unit (ESU) in their regular organogram. PGCB has kept the provision of short and long-term training courses of their concerned officials on environmental management for the institutional capacity building. ESU has been set-up and PGCB is expected to recruit two Safeguard Specialists by April, 2017.

38. The ESMF has elaborated the supervision and monitoring requirements of the EMP and ECoP. The quarterly progress on environmental implementation will be reported in detail along with the Project Progress Report.

39. **Grievance Redress System.** Environmental issues will be integrated into the project Suggestions and Complaints Mechanism (SCM) referred to in the ESMF.
40. **Consultation and Disclosure.** The ESMF was prepared in consultation with the key stakeholders including the PGCB field level staffs and communities. National consultation workshop has been planned by PGCB for March 9, 2017 to share the draft ESMF with all stakeholders. Consultation with communities has been made mandatory for environmental screening/assessment of each subproject. The ESMF was disclosed by PGCB in their websites ([www.pgcb.org.bd](http://www.pgcb.org.bd)) on January 2, 2017 and hardcopies are made available at PGCB headquarters and subproject areas. Advertisement requesting public comments was published in two daily newspapers (English and Bangla). The ESMF has been disclosed in the World Bank operational site also. During the implementation phase, the subproject specific environmental screening/assessment will also be disclosed at PGCB website before the contractor mobilization.

41. **Social**

The project envisages rehabilitation of PGCB’s transmission network, comprising of improvements to existing 132 kV transmission lines and installation of possible new SVCs along the route at required locations. All SCV locations will be within existing PGCB premises. No land acquisition or displacement of people will be required for this project. The project is expected to deliver positive results in enhancing efficient electricity generation and supply, and voltage stabilization. No significant, irreversible social impact is expected under the project. However, minor and/or temporary impacts are expected due to rehabilitation of existing transmission lines in densely populated residential/commercial areas and open crop lands. Plying of vehicles on crop lands during construction may occur over several phases, resulting in repeated crop damage; rehabilitation of lines over residential structures will create impositions on residents, may result in safety issues and have to be mindful of gender and social norms; commercial structures may need to be temporarily closed (though not more than a few hours) and suffer from access issues and electricity disruption (which may affect wages). WB policy covering Involuntary Resettlement has been triggered for the project. Based on social screening and alternative route analyses, there are no indigenous people in the vicinity of project works. Hence, WB policy relating to Indigenous Peoples is not triggered for this project.

42. Since the exact routes to be rehabilitated and the specific SCV locations which will ultimately be used is not known by appraisal, an ESMF, including a full and detailed Resettlement Policy Framework (RPF) and detailed guidance on labor influx management have been prepared. The ESMF and RPF have been prepared based on rigorous stakeholder analysis and multiple consultations with the latter as mandated by Bank policy. Site specific Social Impact Assessments (SIAs), Social Management Plans(SMPs) and RAPs, as and when required, will be prepared once the route and possible SCV locations are determined, based on the guidance provided in the ESMF and RPF respectively. Adherence to the ESMF and RPF, including the preparation and full implementation of the site-specific SIAs, SMPs and RAPs, as required, will be incorporated in the bid documents and costed appropriately in the Bill of Quantities (BOQs).

43. The ESMF and RPF provide detailed guidance on project background, analyses of expected impacts, applicable policy framework, eligibility criteria, entitlement matrix, guidance on consultation and communication strategy, labor influx risk assessment and management, grievance redress mechanism, implementation arrangements and disclosure procedures (among others). The site-specific SIA, SMPs and RAPs, as required, will be prepared based on guidance provided in the ESMF and RPF, detailed screening and route survey exercise, stakeholder analysis and community consultation (public consultations, focus group discussions, female only groups). The SIA will identify likely impacts in the broader area around the
right of way and possible SVC sites, including risks of workers’ influx on host communities. The RAPs will identify all affected people. Expected impacts can be through temporary impacts such as brief road closures, works on top of residential houses (when lines are running on top of houses), crop damages (where lines run across open crop lands). The RAPs will provide an entitlement matrix, along with individual entitlements, labor influx management plans and other mitigation measures; lay out the implementation arrangements for RAP implementation, including conducting iterative consultations with affected communities and stakeholders, establishment of a Grievance Redress Mechanism and the requisite budget for the implementation of the RAP. The SIA and RAP are fully cognizant of, and incorporate the relevant aspects of the Gender Mainstreaming and Citizen’s Engagement issues discussed below.

44. **Consultation and Communication.** Although no major or significant irreversible social impact is expected under the project, consultation and communication will play a major role, not just as a means of garnering feedback, but also as a mitigation tool. The lines pass over densely populated residential areas, commercial structures, and public spaces. Ensuring safety and security of people residing, and/or conducting businesses underneath the lines is a key objective of the consultation and communication strategy laid out in the RAP. Disseminating advance notification; seeking permission from households, dealing with residents, especially female members and children, provision of sufficient information on the nature of the works and any risks emerging both from the rehabilitation works and from living under these lines are some issues discussed in the RAP. Crop lands may be affected multiple times, as construction activities are usually phased over stages in these types of interventions, requiring vehicular movements, equipment storage etc. Local communities, local government officers, businesses, and schools, and all relevant stakeholders identified in the ESMF and RPF, as well as the SIA and RAP will be consulted as many times as appropriate during RAP preparation and implementation. The documents will incorporate gender analysis and citizen’s engagement aspects.

45. Repeated community consultation, chalking out activity schedules around works contracts designed in a participatory manner, advanced notification for commencement of activities and detailed discussions on labor influx management, and safety issues will be imperative. A detailed and robust communication and consultation strategy is provided in the ESMF and RPF. This will be adopted and developed into actionable plans in the site-specific RAPs.

46. **Influx Management.** Influx of workers and setting up labor camps may have adverse impacts on local communities. The ESMF and RPF include risk assessment due to worker influx and its management in accordance with the Bank’s Guidance Note on the subject. The site specific SIAs and RAPs will assess associated risks, and include plans to reduce influx (by using local labor as far as possible), mitigate risks and implement the plans. This will be mandatory for contractors to follow, and will be specified as the contractor’s obligation in bid documents.

**Gender Mainstreaming**

47. Access to energy services is necessary for human development, and a lack of access can be a factor hindering poverty alleviation. Access to energy has been linked to improvements in women’s time use, health and employment opportunities. Other indirect linkages between gender and energy include enhanced access to information since access to energy also translates into enhanced access to channels of information such as mobile phones and television, and reduction in incidences of violence due to lack
of reliable street lighting. The project does not easily lend itself to addressing gender issues since it does not have direct beneficiaries. However, a key gender gap is the employment of women in the energy sector. After discussions with PGCB officials, it has been decided to take the following steps to improve the gender sensitivity of the project: (i) the ESIA for the transmission line investments will be gender-informed (i.e., it will incorporate gender disaggregated consultations and implement any follow up actions recommended to address the differential needs of male and female project affected people); and (ii) an organizational assessment of NLDC/PGCB will be undertaken to understand steps that have been taken to address barriers to women’s employment and working conditions in the organization (including standards that its contractors need to comply within the course of project implementation) and to identify and support implementation of any aspects that can be improved in this regard. Both sets of actions would be monitored over the project’s life. Along with a gender disaggregated citizen engagement mechanism (see below) this would classify this project as being gender informed.

Citizen Engagement

48. As noted, the project does not have specific direct beneficiaries among the electricity consumers as far as the citizenry is concerned. However, the project provides an opportunity to interact with the wider public through stakeholder consultations in which broader issues of power supply reliability and quality can be raised, energy efficiency options discussed, and the project and its likely impact presented. This would be done in a gender disaggregated fashion so that the different viewpoints of men and women are captured. The discussion(s) will be summarized and conclusions made available on PGCB’s website (along with the World Bank website) and could provide a starting point for a conversation on energy sector issues that would continue in the course of subsequent Bank-supported projects in the sector.

49. PGCB has prior experience in implementing the IDA funded projects and the ESU mentioned above will be responsible for monitoring and reporting on safeguards issues during implementation.

Monitoring and Evaluation

50. The monitoring of the project will be done in two phases. In the first phase, the focus will be on efficient and timely implementation of the TA, operational enhancements and installation of transmission infrastructure which will be ensured through regular monitoring of project activities and quality assurance. In the second phase, once the upgraded transmission system is in place and comes into operation, there will be regular operational reporting by NLDC on the improved reliability and efficiency of the power supply system to be assessed though various parameters such as, unserved energy due to under frequency outages, fuel savings; minimum/maximum frequency (Hz), number of staff trained, number of generation units with governors and excitation system upgraded/replaced, number of DLRs installed, transmission lines constructed or rehabilitated under the project, cumulative duration of power outages per year due to under-frequency and number of power outages per year due to under-frequency. Additionally, gender and citizen engagement indicators will also be monitored.

51. Finally, GOB has been monitoring performance of the public sector entities through a set of KPIs and PGCB’s operational performance is already being monitored by the MPEMR. The specific result indicators will be agreed with the implementing agency (PGCB) for this project and the progress according to the Results Framework and Monitoring table (Section VII) will be part of the monitoring process.
The PGCB MIS Reports and Progress Reports of the project, to be provided on a quarterly basis by PGCB, will include updates on these results. The monitoring and evaluation capacity of PGCB will be bolstered through the consultancy support during trial runs and periodic supervision of the Bank.
ANNEX 3: IMPLEMENTATION SUPPORT PLAN

COUNTRY: Bangladesh
Power System Reliability and Efficiency Improvement Project

Strategy and Approach for Implementation Support

1. The Implementation Support Plan (ISP) will include technical, fiduciary and environmental support to the client to help in smooth implementation of the project. The plan would be reviewed regularly and revised as and when required during the implementation. The implementation support will be provided through at-least two implementation support missions in a year and regular exchanges of correspondences. Technical training will be arranged for the client on system reliability and efficiency improvements and transmission analysis and planning. Procurement and FM training will also be arranged.

2. Technical. The Bank will provide continuous support with power system/energy specialists (engineers, economists) as well as institutional specialists. They will provide implementation support through at least two missions per year. In between, Dhaka-based specialists will ensure a regular exchange with the implementing agency and it will maintain close coordination with the Bank team using available communication tools (phone, email, video conference, etc.).

3. Procurement. The project has six medium sized goods and two consulting contracts. The procurement process will start from early 2017. The support from the Bank would be to help PGCB prepare PPDS, provide procurement review and issue timely no-objection. The support would also include monitoring of the procurement process, providing detailed guidance on the Bank’s NPF to project staff and consultants, identifying capacity building /training needs of project staff/officials and imparting necessary trainings. The support of the Bank will also include review of contract management activities and advise as needed.

4. Financial Management. Implementation support team will also review the project’s financial management system, including but not limited to, accounting, reporting, and internal controls.

5. Safeguards. The Bank’s Safeguards specialists in the team will supervise various activities, including regular field visits, to ensure full compliance with the Bank’s operational policies, procedures related to the environment and social safeguards.

Implementation Support Plan and Resource Requirements

6. Members of the implementation support team will be based mainly in the Bangladesh country office, including Task Team Leader, technical, procurement, financial management and safeguards specialists, which would facilitate timely, efficient, and effective implementation support to the client. The team will draw support also from the Bank’s Headquarters. A Mid-Term Review (MTR) would be conducted once the project is about half way in project implementation/loan tenure to review the progress and assess the need for correction, if any. The following activities are envisioned:

- Organize a project launch after approval to enable a common understanding, between all
stakeholders, of the project scope, implementation process and responsibilities.

- Undertake at least two implementation support missions in the country annually
- Undertake specific technical missions as needed
- Review quarterly technical and financial progress report prepared by implementation agency.
- Preparation of an Implementation Completion and Results reports within 6 months of the project closure.

7. The main focus of implementation support is summarized below:

<table>
<thead>
<tr>
<th>Time</th>
<th>Focus</th>
<th>Skills Needed</th>
<th>Resource Estimate</th>
<th>Partner Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-48 months</td>
<td>Implementation of TA and Investment Components (1, 2 &amp; 3)</td>
<td>Task Team Leaders, Technical Specialists, Procurement Specialist, Environmental Specialist, Financial Management Specialist, Social Development Specialist</td>
<td>80 Staff Weeks (SW) 32 SW 20 SW 10 SW 15 SW 10 SW</td>
<td>There are no partners or donors associated with similar activities.</td>
</tr>
</tbody>
</table>
ANNEX 4: ECONOMIC ANALYSIS

1. This annex discusses the rationale for public financing of the project, the valued added from the Bank support, and presents the analysis of the project’s development impact in terms of a quantitative and qualitative assessment of the expected benefits and costs. The economic analysis covers transmission and operational enhancement investments that will be undertaken under the project. This economic analysis is consistent with the Bank’s guidelines on economic analysis of projects.

RATIONALE FOR PUBLIC SECTOR PROVISION/FINANCING

2. Energy resources in Bangladesh are not managed efficiently. This is evident from the fact that power plants running on heavy fuel oil (HFO) and diesel are used even when gas based capacity is available at a fraction of the cost. There are several factors underlying this anomaly— including limitations in gas supply, lack of proper dispatch optimization tools and procedures, no recognition to ancillary services (e.g. frequency control, spinning and operating reserves) and transmission network congestion.

3. Transmission constraints are significantly affecting the generation dispatch efficiency by not allowing dispatch of low cost generation. Such constraints are extensive at peak load and, to a lesser extent but still with significant impact, at lower levels of demand.

4. The electricity grid is subject to very high frequency fluctuations. In the absence of a primary frequency control regime, it will not be possible to add larger generation units to the grid, attract IPPs or integrate renewable energy into the system.

5. There are pressing needs for public sector investment in frequency control measures, operational enhancements and transmission decongestion. Such measures will significantly improve efficiency with regard to power dispatch and transmission and will enable the integration of indigenous energy resources (e.g. solar and wind) in the future.

6. Public sector support and financing for power system improvements will also reduce the use of carbon intensive generation (HFO) and associated global GHG externalities.

VALUE ADDED OF THE BANK’S SUPPORT

7. Investments aimed at improving power system reliability and transmission efficiency need to be managed effectively to be successful. The World Bank Group can play a valuable role in this transition by:

(i) making long term concessional financing available for power system improvements;
(ii) sharing international knowledge, best practices and experience on how modern electricity grids are managed across the world; and
(iii) providing technical assistance and capacity building support to the implementation of the project.

PROJECT COUNTERFACTUAL

8. In the absence of the project, the power system will be reliant on manual dispatch and frequency control, exposing it to very high frequency fluctuations and out-of-merit dispatch of expensive power stations. In the absence of the project, transmission bottlenecks will prevent dispatching of the most efficient power plants during peak periods. Such network congestion results in the dispatch of localized
oil-fired generations and violation of the merit order dispatch.

**COST BENEFIT ANALYSIS**

9. The economic viability of the project was assessed through a cost-benefit analysis. Net benefits for the project were calculated by comparing total system costs and benefits for the “with project” and “without project” scenario. Scenarios that meaningfully reflect the uncertainties of key input variables are evaluated. The analysis includes consideration of greenhouse gas externalities.

**PROJECT COSTS**

10. The estimated cost of the project is US$ 77 million of which IDA financing is proposed to cover US$ 59 million. Counterpart GOB funding of US$ 18 million will cover tax and duties associated with goods and works, salary and operating costs. IDA financing includes technical assistance and investments for frequency control trials, operational enhancements, removal of transmission bottlenecks and improvement of voltage quality. The project includes US$7 million for contingencies. These are assumed to be physical contingencies and are included in the cost benefit analysis. Out of the US$ 18 million counterpart’s funding, US$ 12 million is to cover domestic taxes, i.e. VAT on imported goods and custom duties. The tax amounts paid by IDA (US$ 7 million) and the government (US$ 12 million) are not included in the economic analysis since they represent transfer payments within the society. That is, from a society standpoint, the tax is a cost for the project entities, but an income for the government.21

**PROJECT BENEFITS**

**Frequency Control**

11. Frequency control is an essential pre-requisite to ensure system security and to avoid unnecessary loading of expensive generators to maintain desired frequency levels. The benefits of keeping frequency within a reasonable band (of ±0.5 Hz around 50 Hz nominal frequency) are well known, and include:

- Reduction in the risk of partial/full grid failure;
- Avoided damages to generator/customer equipment;
- Avoided liquid fuel generation needed to support frequency;
- Ability to expand the system to bring in larger more efficient generating units that in turn also render the system greater inertia that can help to maintain system frequency;
- Ability to interconnect with other power systems (including India) in a synchronous mode, which again renders the system frequency more stable; and
- Ability to integrate higher volume of variable renewable energy resources.

12. Frequency control can avoid catastrophic events such as the November 2014 blackout that caused power outage for the entire country for nearly 10 hours.

13. The trials also showed that:

- The wide band within which system frequency fluctuates (ranging between 49 and 51 Hz) is largely attributable to the absence of primary frequency control.

The cost of implementing a basic primary frequency control scheme is small. NLDC will need the cooperation of generators to be able to manage fluctuations in frequency with minimal delay (first through primary control and then, to implement AGC). In due course, it will need a compensation mechanism and regulatory changes (e.g., mandating governor control in future PPAs with the IPPs).

- Frequency control leads to demonstrated fuel savings.

14. The benefits of frequency control are quantified as the sum of: (i) fuel savings due to frequency improvement (Table A4.1), plus (ii) benefits due to reduction of unserved energy (Table A4.2).

**Table A4.1: Fuel Savings Due To Frequency Improvement**

<table>
<thead>
<tr>
<th>Year</th>
<th>Demand (MW)</th>
<th>Frequency Improvement (Hz)</th>
<th>Frequency Target (Hz)</th>
<th>Load Variation (MW)</th>
<th>Energy Savings (GWh)</th>
<th>Energy Savings – adjusted (GWh)</th>
<th>Savings (million Taka)</th>
<th>Savings (million US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>11,448</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>12,364</td>
<td>0.0</td>
<td>50.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>13,353</td>
<td>0.1</td>
<td>50.7</td>
<td>40</td>
<td>350</td>
<td>193</td>
<td>1,542</td>
<td>19</td>
</tr>
<tr>
<td>2021</td>
<td>14,421</td>
<td>0.2</td>
<td>50.5</td>
<td>70</td>
<td>613</td>
<td>337</td>
<td>2,698</td>
<td>34</td>
</tr>
<tr>
<td>2022</td>
<td>15,575</td>
<td>0.2</td>
<td>50.3</td>
<td>70</td>
<td>613</td>
<td>337</td>
<td>2,698</td>
<td>34</td>
</tr>
<tr>
<td>2023</td>
<td>16,821</td>
<td>0.1</td>
<td>50.2</td>
<td>40</td>
<td>350</td>
<td>193</td>
<td>1,542</td>
<td>19</td>
</tr>
</tbody>
</table>


**Table A4.2: Benefits Due To Reduction of Unserved Energy**

<table>
<thead>
<tr>
<th>Year</th>
<th>Unserved Energy (MWh)</th>
<th>Reduction in Unserved Energy (MWh)</th>
<th>Benefits (million US$) at 0.5$ per KWh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>with frequency control</td>
<td>Without frequency control</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>7,407</td>
<td>7,407</td>
<td>0</td>
</tr>
<tr>
<td>2019</td>
<td>7,999</td>
<td>7,999</td>
<td>0</td>
</tr>
<tr>
<td>2020</td>
<td>6,399</td>
<td>8,639</td>
<td>2,240</td>
</tr>
<tr>
<td>2021</td>
<td>5,119</td>
<td>9,330</td>
<td>4,211</td>
</tr>
<tr>
<td>2022</td>
<td>4,096</td>
<td>10,077</td>
<td>5,981</td>
</tr>
<tr>
<td>2023</td>
<td>3,276</td>
<td>10,883</td>
<td>7,606</td>
</tr>
<tr>
<td>2024</td>
<td>2,621</td>
<td>11,753</td>
<td>9,132</td>
</tr>
</tbody>
</table>

Key assumptions: frequency control leads to 20% reduction in the unserved energy per year starting in 2018. Unserved energy without frequency control grows at the same rate as demand (about 8% per year). Value of unserved energy: US$ 0.5 per KWh.

**Benefits of Improved Dispatch**

15. The benefits of improved dispatch are easier to conceptualize although methodology and data issues pose very significant challenges. We propose to use an idealized optimal (“merit order”) dispatch and compare it with the actual dispatch. The difference in dispatch costs are the (maximum) benefits.
16. The World Bank has carried out a review of dispatch efficiency in collaboration with NLDC, using a standard dispatch optimization approach (Nikolakakis et al., 2017). The following are the key findings of this analysis, which used actual hourly dispatch data from 2014:

i) The estimated total system-wide cost of power supplied to the grid in 2014 was US$2.2 billion. Under an optimal dispatch scenario this would have been US$0.55 billion, pointing to the potential to reduce system costs by 76 percent (US$1.65 billion);

ii) Ongoing out-of-merit dispatch of oil-based generation costs the system US$1 billion per year. Optimal dispatch would reduce reliance on oil-based generation; and,

iii) Rapid expansion of the power system is likely to further challenge system stability.

17. As Table A4.3 shows, the bulk of the savings come from shifting generation from more expensive generation (> 5 Tk/kWh) to substantially underutilized gas capacity (< 1 Tk/kWh). Generation from units with costs in excess of 5 Tk/kWh in the “Actual” scenario represent less than a quarter of total generation but accounts for Tk 141 billion or 77% of the total dispatch costs. Average generation cost in “Actual” is Tk 3.98 (~5 c/kWh) compared to Tk 0.96/kWh (~1.2 c/kWh) in “Optimal”. The Actual dispatch has 9.7 TWh less of gas compared to the Optimal that is instead generated using HFO (6.3 TWh), diesel (1.8 TWh) or is imported (1.4 TWh).

<table>
<thead>
<tr>
<th>Category of Generation (Tk/kWh)</th>
<th>Actual (2014)</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GWh</td>
<td>million Taka</td>
</tr>
<tr>
<td>&lt; 1 Tk/kWh</td>
<td>19,818</td>
<td>15,697</td>
</tr>
<tr>
<td>1-5 Tk/kWh</td>
<td>15,154</td>
<td>25,418</td>
</tr>
<tr>
<td>5-10 Tk/kWh</td>
<td>5,323</td>
<td>50,882</td>
</tr>
<tr>
<td>10-20 Tk/kWh</td>
<td>4,598</td>
<td>68,914</td>
</tr>
<tr>
<td>&gt;20 Tk/kWh</td>
<td>863</td>
<td>21,338</td>
</tr>
<tr>
<td>TOTAL</td>
<td>45,757</td>
<td>182,249</td>
</tr>
</tbody>
</table>

Source: World Bank analysis reported in Nikolakakis et al. (2017)

18. Nikolakakis et al. (2017) determined that the observed deviation from optimal (merit-order) dispatch is largely attributable to the absence of modern, optimization-based dispatch protocols and related capacity in NLDC.

19. One key issue affecting Bangladesh’s power sector since 2011 is the reduced availability of gas for power generation. The daily gas production in 2014 was 2,800 million cubic feet per day (mmcmd) of which
only 919 mmcmd were allocated for power generation, excluding around 300 mmcmd for captive power generation.\textsuperscript{23}

20. The gas consumption corresponding to the Optimal scenario is 1,161 mmcmd compared to 919 mmcmd consumed for the Actual dispatch. Given the massive reduction in cost, the gas allocation policy, especially allocating for gas for inefficient usage including small captive power stations ahead of larger efficient generators, should be revisited.

21. In order to understand the relative impact of dispatch efficiency and gas supply constraints, we have created two intermediate Constrained Optimal Scenarios restricting the total gas supply to 919 and 1000 mmcmd (Figure A.4.1). With gas limited to 919 mmcmd, the Constrained Optimal scenario costs are Taka 68 billion, which is still 63\% below the Actual indicating the bulk of the cost difference can be attributed to poor dispatch practices and unnecessary use of HFO/diesel based generators ahead of efficient gas units. The inefficient dispatch, even accounting for limited gas supply, cost the country Taka 113 billion or US\$ 1.4 billion in a single year. Increasing gas supply marginally to 1,000 mmcmd helps to reduce system costs sharply down to Taka 52 billion. Dispatch efficiency enhancement and gas allocation policies should consider the significant cost reduction benefits.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure_a4.1.png}
\caption{Constrained Gas Supply Scenarios}
\footnotesize
\textit{Source: World Bank analysis reported in Nikolakakis et al. (2017)}
\end{figure}

22. The optimization model assumes that an efficient allocation for generation and ancillary services would exist, proper frequency control has been established, the network is congestion-free, voltage is

\textsuperscript{23} M. Rahman, \textit{Primary energy supply challenge for Power}, The Daily Star, March 2015 (http://www.thedailystar.net/primary-energy-supply-challenges-for-power-4874)
properly handled, and fuel is available at all times. The project implementation would result in (significant) improvements towards the right direction; but certain factors are outside of the project boundaries, and cannot be controlled.

**Benefits of Transmission Line Capacity Improvement**

23. The potential benefits of transmission line capacity improvement were estimated by an international consulting firm study using an Optimal Power Flow (OPF) Model. Existing transmission bottlenecks require the grid operator to balance flows towards localized oil-fired generation to augment supply that overturns the merit order. This study identified key transmission lines needing upgrades to reduce transmission bottlenecks and system congestion.

24. The study shows that nine lines have overloading in the base power flow (i.e., without any contingency) and more than 40 lines were seriously overloaded under contingencies. Table A.4.4 shows the hourly estimated savings when transmission congestions are removed from the system. Such savings are close to Taka 18 million, leading to annual savings of Taka 39.5 billion, or close to half a billion US Dollars.

25. Nikolakakis et al. (2017) concluded that optimal dispatch could result in benefits over US$1 billion per year. The consultant study suggests that half of these benefits could come from de-congesting the network.

**Table A4.4: Calculation of transmission upgrade benefits using difference of constrained and unconstrained OPF results**

<table>
<thead>
<tr>
<th>Demand MW</th>
<th>Percent (%)</th>
<th>Contingency Constrained OPF production cost (Taka per hour)</th>
<th>Unconstrained OPF production cost (Taka per hour)</th>
<th>Cost of transmission constraints (Taka per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,665</td>
<td>100</td>
<td>29,217,261</td>
<td>11,435,182</td>
<td>17,782,079</td>
</tr>
<tr>
<td>8,015</td>
<td>92.5</td>
<td>20,857,661</td>
<td>7,047,046</td>
<td>13,810,615</td>
</tr>
<tr>
<td>7,019</td>
<td>81</td>
<td>14,139,365</td>
<td>5,995,602</td>
<td>8,143,763</td>
</tr>
<tr>
<td>5,979</td>
<td>69</td>
<td>9,489,066</td>
<td>4,950,334</td>
<td>4,538,732</td>
</tr>
<tr>
<td>4,766</td>
<td>55</td>
<td>3,810,374</td>
<td>3,737,230</td>
<td>73,144</td>
</tr>
<tr>
<td>3,553</td>
<td>41</td>
<td>2,570,481</td>
<td>2,560,533</td>
<td>9,948</td>
</tr>
</tbody>
</table>

**Environmental Benefits**

26. Reductions in fuel use due to frequency controls will lead to GHG emission reductions. GHG reductions for the period 2018 – 2023 are quantified on the basis of the frequency control analysis. The analysis considers Intergovernmental Panel on Climate Change (IPCC) emissions factors and average heat rates for power plants provided by BPDB. Table A.4.5 shows data and results of the GHG benefits quantification. GHG emissions reductions are projected at 0.74 million tons of CO₂ over the 2018 – 2023 period.
Table A4.5: GHG Emission Reductions

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy Savings – (GWh)</th>
<th>HFO Fuel Savings (TJ)</th>
<th>GHG emissions reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2019</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2020</td>
<td>193</td>
<td>1,747</td>
<td>135,627</td>
</tr>
<tr>
<td>2021</td>
<td>337</td>
<td>3,057</td>
<td>237,348</td>
</tr>
<tr>
<td>2022</td>
<td>337</td>
<td>3,057</td>
<td>237,348</td>
</tr>
<tr>
<td>2023</td>
<td>193</td>
<td>1,747</td>
<td>135,627</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>745,950</td>
</tr>
</tbody>
</table>

Data Sources:
Emission Factors (Source: IPCC)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>CO₂ (kg/TJ)</th>
<th>CH₄ (kg/TJ)</th>
<th>N₂O (kg/TJ)</th>
<th>CO₂e* (kg/TJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil</td>
<td>77,400</td>
<td>3</td>
<td>0.6</td>
<td>77,649</td>
</tr>
</tbody>
</table>

Estimated using 100-yr Global Warning Potential data below (source IPCC).

<table>
<thead>
<tr>
<th>GHG</th>
<th>100 yr GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>1</td>
</tr>
<tr>
<td>CH₄</td>
<td>21</td>
</tr>
<tr>
<td>N₂O</td>
<td>310</td>
</tr>
</tbody>
</table>

Average Heat Rate (Source: BPDB)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Heat Rate (Kcal/Kwh)</th>
<th>Heat Rate (KJ/Kwh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil</td>
<td>2166</td>
<td>9063</td>
</tr>
</tbody>
</table>

Other Non-Quantified Benefits

27. The proposed project will improve electric power service reliability. This results in benefits across end-use consumers and increase business confidence. Activities related to manufacturing and production need reliable power for factories and equipment. Commercial sector (including the service sectors and retail) need reliable power for lighting, heating, cooling, and operating computers and business equipment. These benefits can be significant, but are difficult to quantify ex-ante.

DO PROJECT BENEFITS OUTWEIGHT THE COSTS?

28. To estimate the project’s net present value and economic internal rate of return (EIRR) we only focus on the economic benefits attributed to frequency control. While the benefits of improved dispatch and transmission decongestion are expected to be substantial, those are excluded from this calculation due to high level of uncertainties. Tables A4.6a and 6b show the project NPV and EIRR considering different assumptions in the marginal costs of generation (fuel only) and Energy Savings adjustment. This
estimate conservatively considers a benefits stream attributable to the project between 2018 and 2024. There will still be benefits from the project for the remaining lifetime of the assets. However, the improvement of the system after 2024 will be mainly due to the much broader ongoing/planned investments in the generation and transmission. Therefore, the NPV is likely to be lower boundary of present value estimates.

**Table A4.6.a: NPV and EIRR Considering Different Assumptions in the Marginal Costs of Power Generation (Energy Savings reduced by 45%)**

<table>
<thead>
<tr>
<th>Marginal cost of power generation (fuel only) Taka/kWh</th>
<th>Net Present Value (USD million)</th>
<th>Economic Internal Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>31.7</td>
<td>37%</td>
</tr>
<tr>
<td>8</td>
<td>41.1</td>
<td>46%</td>
</tr>
<tr>
<td>9</td>
<td>50.5</td>
<td>54%</td>
</tr>
</tbody>
</table>

Key assumptions. Discount rate: 12%; only benefits of frequency control over 2017 – 2024 are included. Estimated total project costs, excluding taxes are: IDA US$ 52 million and counterpart financing US$ 6 million.

**Table A4.6.b: NPV and EIRR Considering Different Assumptions in Energy Savings Adjustment (with HFO fuel costs of 8 Taka/KWh)**

<table>
<thead>
<tr>
<th>Energy Savings Adjustment Factor</th>
<th>Net Present Value (USD million)</th>
<th>Economic Internal Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce by 50%</td>
<td>34.2</td>
<td>40%</td>
</tr>
<tr>
<td>Reduce by 45%</td>
<td>41.1</td>
<td>46%</td>
</tr>
<tr>
<td>Reduce by 40%</td>
<td>47.9</td>
<td>52%</td>
</tr>
</tbody>
</table>

29. GHG emission reductions are 0.75 million tons of CO$_2$e over the 2018 – 2024 period (in the scenario with energy savings adjustment of 45% reduction). Operational enhancements will enable adding variable renewable energy sources (e.g. solar and wind) in the future, leading to additional GHG reductions.

30. Beyond the frequency control benefits, the World Bank analysis reported in Nikolakakis et al. (2017) demonstrates that the gross benefit of dispatch efficiency can be potentially very high with proper frequency control, a reasonably congestion free transmission network, appropriate voltage control mechanism in place, and sufficient availability of gas.

31. This economic analysis demonstrates that the project benefits outweigh the costs.

**FINANCIAL ANALYSIS**

32. The economic analysis presented a set of procedures to evaluate and compare the costs and benefits of the project from the standpoint of the society as a whole. The financial analysis follows a similar framework to the economic analysis, but it evaluates the project cash flows from the viewpoint of the project implementing agency, PGCB.
33. From a financial analysis perspective, the following benefit streams would not be relevant to PGCB:

- Benefits of fuel cost savings;
- Benefits to consumers by reducing unmet demand as a consequence of frequency control;
- Benefits to consumers by reducing equipment damage caused by frequency variations;
- Global benefits to the society by reducing GHG emissions.

Likewise, from a financial analysis perspective, the following costs would be relevant:

- Government taxes, for instance taxes on imported equipment and materials;
- Capacity charges (take or pay) that are imposed to the utility even when energy is not required/delivered.

34. One complexity in the financial analysis for this project is that the entity undertaking the investments (PGCB) does not receive a direct financial gain resulting from the impact of investments, for instance, the reduction in generation costs. The reduced generation costs will benefit the off-taker Bangladesh Power Development Board (BPDB).

**Financing Impacts on PGCB**

35. PGCB was established as a public company in 1996 to own and operate the country’s power transmission network of 132kV and above. The transmission network currently comprises of 220.70 circuit km of 400 kV lines, 3185.166 circuit km of 230 kV lines, 6401.628 circuit km of 132 kV lines PGCB generates revenue from transmission/wheeling charges determined by the regulator. With about a quarter of its shared off-loaded in the market, PGCB is run by professional management under an oversight of a Board.

36. The full amount of IDA borrowed by the government (US$ 59 million) for this Project will be on-lent to PGCB. The Government of Bangladesh component (US$18 million) is also on-lent to PGCB at similar IDA rates. The project is expected to increase the value of the assets of PGCB and the loan will become a liability to PGCB to be repaid on terms set by GoB to be laid out under a Subsidiary Loan Agreement.

37. Wheeling charges are currently Taka 0.28/kWh. Operating revenues, transmission expenses and profits are shown in table A4.7 per PGCB audit reports.

| Table A4.7: Accounting Data from Audit Reports (in million Taka) |
|--------------------|---------------|---------------|---------------|
| Operating Revenues | 9,378        | 8,672        | 7,870         |
| Transmission Expenses | 6,904      | 6,146        | 4,719         |
| Gross Profit       | 2,474        | 2,526        | 3,151         |
| Profit after finance expenses, finance income and admin costs | -71.6        | 571          | 2,015         |
Accounting Data from Audit Reports (in million US$)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Revenues</td>
<td>120.2</td>
<td>111.2</td>
<td>98.4</td>
</tr>
<tr>
<td>Transmission Expenses</td>
<td>88.5</td>
<td>78.8</td>
<td>59.0</td>
</tr>
<tr>
<td>Gross Profit</td>
<td>31.7</td>
<td>32.4</td>
<td>39.4</td>
</tr>
<tr>
<td>Profit after finance expenses, finance income and admin costs</td>
<td>-0.92</td>
<td>7.32</td>
<td>25.19</td>
</tr>
</tbody>
</table>


38. PGCB would receive a subsidiary loan from the Government of Bangladesh. Terms for the subsidiary loan are to be finalized. If we assume that the subsidiary loan replicates the amortization profile for a SUF Credit, then interest expenses for paying the US$ 77 million loan would be close to the values shown in Table A4.8. Such interest payments would increase financial costs for PGCB triggering the need to earn additional income from transmission fees.

Table A4.8. Projected interest payments under different amortization schedules for a US$ 77 million subsidiary loan under different assumptions

<table>
<thead>
<tr>
<th>Grace Period</th>
<th>Interest Rate</th>
<th>Total Interest Paid (US$)</th>
<th>Average Interest Paid per year (after grace period) (US$)</th>
<th>Average Interest Paid per year (after grace period) Taka</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 year</td>
<td>5% p.a. for yrs 6-14 5.5% p.a. for yrs 15-24</td>
<td>45,256,515</td>
<td>2,381,922</td>
<td>190,553,745</td>
</tr>
<tr>
<td>8 year</td>
<td>5% p.a. for yrs 9-17 5.5% p.a. for yrs 18-27</td>
<td>45,256,515</td>
<td>2,381,922</td>
<td>190,553,745</td>
</tr>
<tr>
<td>9 year</td>
<td>4.7% p.a. for yrs 10 - 23 4.9 p.a. for yrs 24- 30</td>
<td>46,019,274</td>
<td>2,191,394</td>
<td>175,311,520</td>
</tr>
</tbody>
</table>

39. It is not yet clear whether the existing wheeling charges of Taka 0.28/kWh can cover future finance expenses. A thorough assessment and analysis of transmission pricing is therefore recommended.

40. A sound transmission pricing study for PGCB would need to consider key principles including:

- Promotion of efficiency: provision of appropriate price signals to generation and demand; incentives for appropriate location of investments
- Recovery of costs: for capital, O&M, losses and congestion
- Transparency, fairness and predictability: clear and straightforward to apply, stable-immune to “price shocks”, and fair
- Non-discriminatory: treat the network users equally in non-discriminating nature.
41. There are several types of transmission pricing approaches such as marginal cost methods, embedded cost methods and incremental cost methods. It is recommended to initiate a discussion with the client on the timing and approach for a transmission pricing study. IFC is re-starting its discussion with PGCB for a corporate finance support and the revision in wheeling charges is likely to be the main item for discussion. The task team will coordinate with IFC on the issue and will start a dialogue with PGCB for ensuring financial sustainability of the ever expanding operation of PGCB.

REFERENCES
