ECONOMIC ANALYSIS

I. INTRODUCTION

1. The economic analysis of the Southwest Transmission Grid Expansion Project was conducted in accordance with Asian Development Bank (ADB) guidelines and measured the costs and benefits in 2017 constant prices.[1] The economic internal rate of return (EIRR) was calculated by comparing the "with-project" and "without-project" scenarios. All financial prices were converted into economic prices by applying the corresponding conversion factors. A sensitivity analysis was conducted to ascertain the robustness of the investment.

2. The project includes (i) construction of a new 400/132-kilovolt (kV) Gopalganj subsation (component 1); (ii) construction of a 126-kilometer (km) Barisal–Gopalganj–Faridpur 230 kV line with two bay extensions at Barisal substation and the augmentation of Faridpur and Gopalganj substations (component 2); (iii) construction of a 104 km Bogra–Rohanpur 400 kV line and a 26 km Rohanpur–Chapainawabganj 132 kV line with two bay extensions at Chapainawabganj substation and line-in, line-out connections (component 3); and (iv) socially inclusive capacity development in the electric utility industry (component 4).

II. ECONOMIC RATIONALE

3. **Country and sector analysis.** The power sector in Bangladesh since 2000 has witnessed significant progress in power generation. However, the increase in generation has not been enough to meet the rapidly rising electricity demand, which causes frequent load shedding. Moreover, the country is confronted with a simultaneous shortage of both electricity and natural gas since the power sector heavily depends on natural gas-fired generation. In addition to deficiencies in generation capacity, the capacity constraints in transmission networks also cause load shedding in some areas of the country.[2] Power generated from some plants cannot be fully evacuated because of overloaded grid networks and high transmission losses.

4. In order to mitigate the demand-supply gap and frequent load shedding, the Government of Bangladesh prepared an ambitious development plan for the addition of new generation.[3] As part of the plan, 34 power generation projects with capacity 12,061 megawatts (MW) were under construction as of June 2017. The plan envisages the addition of about 17,752 MW of new generation by 2021.[4] The plan envisions setting up a new energy hub in the country's southern region through installing four mega power plant projects and a small liquefied natural gas (LNG) terminal at Payra in Patuakhali district.[5] Under the plan, around 9,000 MW of electricity will be produced from power plants in the Payra area.[6]

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[1] ADB. 2017. *Guidelines for the Economic Analysis of Projects*. Manila.

[2] Bangladesh experienced 14 outages (with a total duration of 20 hours and 36 minutes) because of transmission system problems during fiscal year (FY) 2017 (ended June 2017). Power Grid Company of Bangladesh Limited. 2017. *Annual Report, 2016–2017*. Dhaka.

[3] Government of Bangladesh; Ministry of Power, Energy and Mineral Resources. 2016. *Power System Master Plan 2016.* Dhaka.

[4] Bangladesh Power Development Board. 2017. *Annual Report, 2016–2017*. Dhaka.

[5] The planned power plants in Payra are (i) Payra 1,320 MW coal power plant by North-West Power Generation Company Limited (NWPGCL), with expected commissioning dates of April and October 2019; (ii) Payra 3,600 MW LNG power plant by NWPGCL, with expected commissioning dates of December 2020, June 2021, and December 2021; (iii) Payra 1,320 MW coal power plant by NWPGCL (second phase), with expected commissioning dates of June and December 2022; and (iv) Patuakhali 1,320 MW power plant by Rural Power Company Limited, with an expected commissioning date of June 2023.

[6] *Energy Bangla*. 2017. Move to Create 9,000 MW Power Hub at Payra. 24 December.

5. **Demand analysis.** Since 2000, peak electricity demand has risen annually by 6.8% while electricity generation has grown by 6.5% per year. The Power System Master Plan (footnote 3) estimates that the annual demand growth rate will be about 11% during 2018–2020 and 6% during 2020–2030, requiring about 25,000 MW of additional power generating capacity during 2017–2030. The domestic sector accounted for 50% of total demand in FY2017, followed by the industry sector (26%), the commercial sector (9%), and the agriculture sector (3%) (footnote 4).

III. COST–BENEFIT ANALYSIS

A. Components 1 and 2

6. **Transmission networks in southern region.** The 160 km Patuakhali (Payra) to Gopalganj 400 kV transmission line, funded by the Government of Bangladesh, is under construction to evacuate power from the future mega power plants (footnote 5) to be constructed in Payra to the power hub in Gopalganj. The construction of the new 400/132 kV Gopalganj subsation (component 1) will provide a strong grid connection point to the loads around Gopalganj to increase supply capacity. Electricity transmitted to the Gopalganj substation will be used firstly to meet unserved demand in the southwest economic corridor with construction of the 126 km Barisal Gopalganj–Faridpur 230 kV line (component 2). The remaining power will be transferred to the Dhaka load center through the new 400 kV double-circuit transmission line from Gopalganj to Aminbazar.[7]

7. **Demand in southern region.** After completion of the Padma Bridge project by 2018,[8] large-scale industrialization is expected to occur in Gopalganj, Faridpur, and Barisal areas. Bangladesh Economic Zone Authority has already planned to establish three economic zones in these threeareas. Within three years from 2019 to 2021, the electricity demand of these three areas is expected to rise significantly. Historically, the southern region, especially Barisal area, has experienced persistent load shedding because of inadequate supply of power; a recent report revealed that Barisal gets the least amount of electricity among the large cities in Bangladesh.[9]

8. **Methodology.** The proposed power transmission network under components 1 and 2 links generation capacity in power plants in Payra and evacuates power to the end users in the southern region. A systematic approach was used for appraisal by identifying both benefits and costs of generation, transmission, and distribution lines that are required in the power system. The 400 kV transmission line from Patuakhali (Payra) to Gopalganj, which is funded by the government, was also considered in the analysis to identify benefits.

9. **Assumptions.** The economic analysis of components 1 and 2 was conducted with the following assumptions:

(i) The incremental capacity of power plants in the Payra area was assumed to be 7,560 MW[10] and expected to be commissioned from 2019 to 2023 (footnote 5).

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[7] The construction of the new 400 kV double-circuit transmission line from Aminbazar–Gopalganj to Mongla is funded by ADB under Loan 3523-BAN. ADB. 2017. *Report and Recommendation of the President to the Board of Directors: Proposed Loans and Administration of Grant to the People's Republic of Bangladesh for the Bangladesh Power System Enhancement and Efficiency Improvement Project.* Manila.

[8] The Padma Bridge is a multipurpose road and rail bridge across the Padma River, linking the southwest region to the northern and eastern regions.

[9] As recorded on 18 April 2017, Barisal received only 2.18% (189 MW) of the total generation. *Energy Bangla*. 2017. Barisal Gets Least Power While Dhaka Consumes Most. 7 May.

[10] It was assumed that 2,750 MW of the total incremental generation capacity of 7,560 MW would serve the southern region through the proposed transmission network (component 2) and that the remaining power (4,810 MW) would be transferred to Dhaka and other regions.

(ii) The construction period was assumed to be 3 years (2018–2020) for component 1 and was assumed to be 4 years (2018–2021) for component 2, and the benefits were assumed to be realized from 2022.

(iii) The consumption by sector was assumed to be 39% for the domestic sector, 50% for the industry sector, 8% for the commercial sector, and 3% for the agriculture sector, reflecting the expected consumption in the southern region.

(iv) The carbon dioxide (CO_2) value was calculated based on $37.0 per ton in 2017 prices, with 2% annual increases in real terms.

(v) All costs and benefits were valued using the domestic price numeraire. Tradable inputs were adjusted by the shadow exchange rate factor of 1.03,[11] while unskilled labor was adjusted by a shadow wage rate factor of 0.75,[12] reflecting the level of unemployment and underemployment in the project area.

10. **Without- and with-project scenarios.** In the without-project scenario, the electricity produced in the power plants in Payra could not be transferred to end users since there is no secondary transmission network other than the proposed one.[13] Consumers would have to generate electricity using backup power at a higher cost to meet their current level of consumption. In the with-project scenario, the increased electricity supply would displace alternate energy forms (e.g., kerosene and diesel for self-generators) and consumers could also have the benefits of increased electricity consumption.

11. **Meeting unserved demand in the southern region.** The economic benefits include (i) benefits due to electricity consumption by new customers, divided into non-incremental benefits (i.e., replacement of substitutes such as kerosene and diesel) valued at resource cost savings, and incremental benefits (i.e., increased electricity consumption) valued at willingness-to-pay; and (ii) benefits due to incremental consumption of existing customers, valued at willingness-to-pay. In the without-project case, such benefits would be foregone due to the curtailment of the electricity supply due to shortages, and transmission loss reductions and related environmental benefits through the reduction of CO_2 emissions. Transmission loss reduction is considered as non-incremental benefit and valued at resource cost savings.

12. **Loss savings and environmental benefits.** The proposed transmission line will be installed using aluminum conductor composite core cable, which will result in transmission loss reduction from the current level of 2.7% to 1.9%. The total savings in losses would amount to 125 gigawatt-hours from 2023 onwards, with the loss savings valued at resource cost savings. The loss savings will also generate environmental benefits through the reduction of CO_2 emissions, which were estimated using the grid emission factor of Bangladesh (0.67 tons of CO_2 per megawatt-hour) taken from the Department of Environment of Bangladesh.[14] The annual emissions reduction expected from component 2 upon full implementation is 83,727 tons of CO_2.[15]

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[11] Government of Bangladesh, Ministry of Finance. *Bangladesh Economic Review 2017*. Dhaka.

[12] Shadow wage rate factor = Tk248 per day (average wage for unskilled laborers in all industries) /Tk330 per day (actual wage rate paid by contractors to unskilled labors). Government of Bangladesh, Ministry of Planning, Statistics and Informatics Division, Bangladesh Bureau of Statistics. 2016. *Statistical Pocket Book Bangladesh 2015.* Dhaka.

[13] The first part of the 1,320 MW power plant in Payra will come into operation by April 2019 and the second part will come into operation by October 2019.

[14] Government of Bangladesh, Department of Environment. 2013. *Grid Emission Factor of Bangladesh.* Dhaka.

[15] The computation of net environmental benefit considers both the supply and demand side.

13. **Investment costs.** The generation costs of thermal power plants in Bangladesh were calculated based on recent power plant parameters in Bangladesh.[16] All investment costs of the transmission network that transmits power generated in Payra to the southern region were included.[17] This analysis also included the capital investment costs in distribution networks for new customers. Operation and maintenance costs were estimated at 2.0% of capital costs for the generation and transmission lines and 2.5% of capital costs for the distribution lines.

B. Component 3

14. **Demand in the western region.** The western region, including Bogra, Chapainawabganj, Rajshahi, Noagaon, and Niyamatpur, is the major grain cultivation zone of Bangladesh. It has recurring and prolonged periods of drought. Because of inadequate surface water supply, cultivation in the region mostly depends on groundwater. Hence, electricity demand hits peak levels during the irrigation season. There is an increasing demand for electricity in the western region, but there are insufficient generation sources in this region. Long distances between the power plants and these cities, low-voltage transmission lines in the western region, and high demand result in a severe power shortage in the western region

15. **Assumptions.** The economic analysis of component 3 was conducted with the following assumptions:

(i) The construction period was assumed to be 5 years (2018–2022) and the benefits were assumed to be realized from 2023.

(ii) The incremental load flow to the proposed transmission line was estimated at 2,900 MW from 2023 onwards.[18]

(iii) The consumption by sector was assumed to be 43% for the domestic sector, 37% for the industry sector, 9% for the commercial sector, and 10% for the agriculture sector, reflecting the expected consumption in the western region.

16. **Without- and with-project scenarios.** In the without-project scenario, farmers and other consumers in this region would face persistent power outages, especially during peak irrigation season. In the with-project scenario, electricity could flow to scattered areas in the western region and would be used to meet any unserved power demand through strengthened transmission networks. In the without-project scenario, consumers would have to generate electricity using backup power generators at a higher cost to meet their consumption needs. The western region has high demand for irrigation, in particular, and farmers have relied on expensive diesel-powered irrigation pumps to meet this demand. The persistent load shedding during the irrigation season also forces farmers to operate electricity-run pumps at night when electricity consumption decreases, and power failure happens.

17. **System loss savings and environmental benefits.** The total savings in transmission losses for component 3 would amount to 136 gigawatt-hours from 2023 onwards. The annual emissions reduction expected from component 3 upon full implementation is 90,868 tons of CO_2.

18. **Investment costs.** The generation costs of thermal power plants in Bangladesh were calculated based on recent power plant parameters in Bangladesh per Bangladesh Power

[16] The investment costs of the Payra 1,320 MW coal power plant and the Rupsha 800-megawatt LNG combined cycle power plant were used to estimate the generation cost.

[17] The capital cost of the 160 km Patuakhali (Payra) to Gopalganj 400 kV transmission line, funded by the government, and the cost of component 4 (socially inclusive capacity development) were also considered in the analysis.

[18] It was assumed that half the maximum transmission capacity of the proposed transmission line (5,800 MW) would be utilized.

Development Board annual report.[19] Operation and maintenance costs were estimated at 2.0% of capital costs for the generation and transmission lines and 2.5% of capital costs for the distribution lines.

C. Conclusion

19. **Economic internal rate of return.** The economic analysis confirms that the proposed project is economically viable. The proposed project's overall EIRR is 17.4% and the overall economic net present value (ENPV) is Tk476,932 million (for components 1 and 2 the EIRR is 17.6% and the ENPV is Tk242,282 million, and for component 3 the EIRR is 16.7% and the ENPV is Tk226,697 million). Without environmental benefits, the overall EIRR for the proposed project is 17.3% and the ENPV is Tk472,036 million (for components 1 and 2 the EIRR is 17.5% and the ENPV is Tk239,851 million, and for component 3 the EIRR is 16.6% and the ENPV is Tk224,231 million).

Table 1: Calculation of Economic Internal Rate of Return
(Tk million)

	Benefits			Costs					Net Benefit
Year	**Non-incremental**	**Incremental**	**Environmental**	**Generation**	**Transmission**	**Distribution**	**Fuel**	**O&M**	
2018				108,869	5,609	990			(115,468)
2019				124,093	15,086	1,794			(140,973)
2020				140,435	16,157	2,309	8,504	1,060	(168,465)
2021				124,553	4,856	1,161	22,678	1,434	(154,683)
2022	18,254	96,841	245	52,004	1,615	343	51,025	2,620	7,731
2023	46,828	239,408	621				83,071	10,518	193,268
2024	46,828	239,408	633				104,416	10,518	171,935
2025	46,828	239,408	646				127,958	10,518	148,406
2030	46,828	239,408	713				140,798	10,518	135,633
2040	46,828	239,408	869				140,798	10,518	135,789
2048	46,828	239,408	1,018				140,798	10,518	135,938

( ) = negative, O&M = operation and maintenance.
Note: Only selected years are shown for brevity. Numbers may not sum precisely because of rounding.
Source: Asian Development Bank estimates.

20. **Sensitivity analysis.** Sensitivity analysis was carried out for adverse changes to five inputs: (i) a 10% increase in capital costs, (ii) a 10% increase in operation and maintenance costs, (iii) a 10% reduction in incremental load flow, (iv) a 10% decrease in fuel price, and (v) a 1-year construction delay. The results indicated that the proposed project is robust against adverse changes (Table 2).

Table 2: Sensitivity Analysis
(%)

Parameter	EIRR of Components 1 and 2	EIRR of Component 3	Overall EIRR
Base case	17.6	16.7	17.4
10% increase in capital cost	16.3	15.4	16.7
10% increase in O&M cost	17.5	16.6	17.3
10% decrease in incremental load flow	14.4	13.8	15.8
10% decrease in fuel price	16.9	16.0	17.0
1-year delay in commissioning	15.7	14.7	15.4

EIRR = economic internal rate of return, O&M = operation and maintenance.
Source: Asian Development Bank estimates.

[19] It is assumed that the half of the generation capacity comes from LNG power plants and other half comes from coal power plants.