ECONOMIC ANALYSIS FOR PROJECT 2

A. Background and Approach

1. The Assam Power Sector Investment Program is a multitranche financing facility (MFF) to fund the power generation and distribution efficiency improvement projects in the state of Assam, India. The main objective of the investment program is to achieve increased adequacy and efficiency of Assam's power system. Tranche 2 of the MFF includes the following components: (i) construction and extension of 33/11 kilovolt (kV) substations; (ii) construction and upgrading of 33 kV and 11 kV circuits; (iii) re-conductoring and refurbishment of low voltage lines; (iv) undergrounding of parts of the Guwahati distribution network; (v) establishment of two area load dispatch centers; (vi) establishment of an independent meter testing facility; and (vii) information technology upgrades to allow for centralized uniform revenue billing of 1.2 million customers. Subprojects have been selected by the Assam Power Distribution Company Limited (APDCL) to cater for demand growth, reduce medium and low voltage technical and commercial losses, improve public safety, split rural distribution lines from village distribution lines, and improve the metering and commercial interface with the company's customers.

2. The economic analysis was conducted in accordance with the Guidelines for Economic Analysis of Projects of the Asian Development Bank (ADB) and the Cost-Benefit Analysis for Development – A Practical Guide.[1] The key benefit of the proposed investment is an in improvement in APDCL's ability to meet demand for electricity. This is attributable to reduced technical and commercial loss reduction, increased substation and line capacity, and enhanced detection of electricity theft and improved revenue collection. Improved public and APDCL staff safety is a secondary benefit of the investment.

3. A power system master planning exercise was completed for Assam in late 2013.[2] The resulting master plan presents a least-cost, 10-year investment program for transmission and distribution (to the low voltage level) in the state to meet forecast demand growth and to ensure security and reliability of supply. The proposed Tranche 2 investment forms part of the master plan.

B. Demand Analysis

4. A 10-year electricity demand forecast was prepared for Assam as part of the master planning exercise for the state. This disaggregated forecast used a variety of techniques to estimate electricity demand for the next ten years—compound average growth rate, trend analysis, econometric analysis, and a partial end use approach. In all cases, electricity demand was forecast to grow at a faster rate than identified in India's official demand forecast for Assam (the Electric Power Survey), mainly because a number of transmission constraints assumed in the Electric Power Survey have now been relieved. The expected annual growth rate is now in the range of 7%–15%. It also confirmed that capacity and energy supply deficits are likely to continue for at least the next 10 years, even with the addition of planned new generation from state government, central government and private sectors. This means that Tranche 2 loss reduction

[1] ADB. 1997. *Guidelines for Economic Analysis of Project.* Manila.; ADB. 2013. *Cost-Benefit Development for Analysis – A Practical Guide.* Manila.

[2] 2012. *Technical Assistance to India Advanced Project Preparedness For Poverty Reduction - Updating Load Forecast And Power System Master Plan For Assam.* Manila

investments will result incremental consumption rather than a reduction in power purchases (this is discussed further below).

5. It was noted that the level of investment required in the distribution network to maintain supply reliability and security and to meet forecast demand growth is significantly higher than currently available funding. The total investment proposed in APDCL's 2013 multi-year tariff petition to the Assam Electricity Regulatory Commission (AERC) was around 30% of the capital investment requirement identified in the master plan for the same period. This expectation of a sustained under-investment underscores the need for APDCL and other state electricity entities to carefully target investment programs to maximize economic benefits and to ensure financial sustainability. In this context, the need for the Tranche 2 investment is confirmed.

C. Economic Rationale

6. The reduction in technical losses and medium– and low–voltage networks has a clear economic benefit in the context of a capacity– and energy–constrained power system. In addition, the quality of power supplied and the duration of supply are presently constrained by the poor performance of the aging network. The poor financial status of APDCL is directly attributable to the high losses incurred on its inadequate distribution network. Private sector appetite for large-scale involvement in Assam power distribution sector is limited due to the current physical condition of assets and the poor financial status and lack of autonomy for APDCL, meaning that ongoing public sector is required. There is consequently no possibility of crowding out private investments.

D. Least Cost Analysis

7. In general, there are, if any, viable alternatives to distribution system augmentation. The approach adopted in the power system master plan to distribution planning was to identify and adopt appropriate planning criteria and standardized designs so as to minimize cost while achieving or exceeding domestic and international standards. This included standardization of substation capacities, maximum loadings, conductor types and maximum circuit lengths, and metering arrangements (including automatic meter reading for high voltage and valuable customers). APDCL has adopted the same approach in preparing Tranche 2 investment. APDCL has confirmed that other means to achieve similar levels of technical and commercial loss reduction and capacity augmentation have been explored and least cost options have been selected. Some of the Tranche 2 subprojects, particularly the replacement of oil-filled distribution transformers with dry-type transformers and undergrounding of physically congested parts of the Guwahati urban distribution network are driven principally by safety concerns, for which there are no practical alternatives.

E. Cost-Benefit Analysis

8. Demand for grid electricity is currently unmet in Assam for two main reasons: (i) constraints on the distribution network; and (ii) supply deficits of inter-state and intra-state generation. Tranche 2 will address these issues by investing in line and substation capacity (to relieve distribution constraints) and by investing in loss reduction (to reduce the supply deficits). In both cases, the key benefit will be an increase in demand served by APDCL. That is, the proposed investments will mean that APDCL can supply consumer demand that is currently unserved, without the need for additional purchases of electricity from inter– and intra–state generators.

9. **Investment Costs.** Investment costs for Tranche 2 were taken from APDCL's detailed project reports. Costs were expressed in first quarter 2015 terms. The domestic price numeraire was used. Cost components were broken down into the following categories: equipment; civil works and construction; land; preparatory work; external project management; and environmental mitigation. For each of these categories, a percentage weighting was estimated for each of tradable and non-tradable goods and services, foreign and local skilled and unskilled labor, transfers and fuel. Traded inputs and fuel were valued at their border price equivalent values and then adjusted to the domestic price numeraire by multiplying by the shadow exchange rate factor (SERF) of 1.03, which was calculated using a simple trade-weighted approach. Non-traded inputs were valued at domestic prices. It was assumed that there are no significant distortions in the wage rates for skilled labor. In the case of unskilled labor, underemployment exists in the economy, and a shadow wage rate (SWR) of 0.75 was adopted. Land was valued at its opportunity cost. Taxes, financing charges and price contingencies were excluded. Table 1 summarizes the conversion of financial capital costs to economic costs.

Table 1: Capital Cost Conversion ($ million)

Investment Costs[a]	Goods and Services		Labor			Fuel	Transfers	Total
	Tradeable	Non-Tradeable	Foreign Skilled	Local Skilled	Un-skilled			
Financial	29.59	12.87	0.32	12.19	1.64	0.94	1.58	59.13
Economic	30.48	12.87	0.32	12.19	1.23	0.97	0.00	58.07

[a] Includes physical contingencies but excludes price contingencies and financing costs.
Source: Asian Development Bank staff estimates.

10. An average operating and maintenance costs of 2% of total capitalized project cost was adopted, reflecting international experience and AERC's typical benchmarks. Because no new generation purchases are required, it was not necessary to estimate the marginal cost of generation purchases to APDCL.

11. **Investment Benefits.** Tranche 2 investments focus on increasing the capacity of the distribution system to meet peak demand and on reducing technical and non-technical losses. APDCL has estimated that Tranche 2 investments in new lines and substation capacity will enable it to supply an additional 8.7 gigawatt-hours (GWh) of demand per year. APDCL estimates that approximately 186 GWh of additional electricity will be available for sale through reduced technical losses [approximately 50% or 50 megawatts (MW) of peak demand] on rehabilitated distribution lines. However, APDCL's estimate of technical loss reduction adopted some optimistic assumptions and therefore has been conservatively reduced by 50% (to 84 GWh) for the purposes of economic analysis. As noted above, an expectation of persistent capacity and energy deficits in Assam means that the economic benefits of loss reduction will manifest as incremental consumption of electricity, rather than as a reduction in electricity purchases.

12. APDCL also estimates that improved metering and billing practices extended to an additional 1.2 million consumers will reduce commercial losses by 50%–60% (576 GWh) in the targeted areas. This estimate was based on an assumption of a reduction in the overall distribution loss level of 10 percentage points based on APDCL's experience with a similar centralized metering and billing implementation in the Guwahati distribution circle. For conservatism, in the economic analysis it has been assumed that the average commercial loss reduction achieved in the project area will only be 2.5 percentage points (144 GWh), significantly lower than APDCL's estimate. While it is expected that these commercial losses would be

converted to sales, from an economic perspective, the impact of a reduction in commercial losses is ambiguous; for conservatism, it has been assumed that only 20% of commercial loss reduction (29 GWh) would result in incremental consumption.

13. The benefits identified in the preceding paragraph are not strictly additive; saved losses will be used to "supply" electricity to serve the 8.7 GWh of incremental consumption attributable to increased capacity. Therefore, the total benefit is 122 GWh, as summarized in **Table 2**. Although it is likely that some unserved demand for grid electricity would be met by alternative energy sources in the absence of the Tranche 2 investment, insufficient information is available to reasonably assess the likely scale of the use of alternative sources. Therefore, it has conservatively been assumed that all consumption attributable to the investment is incremental. All benefits were assumed to be constant across the evaluation period.

Table 2: Tranche 2 Economic Benefits–Quantities and Values

Economic Benefits	Units	2018	2019	2020	2021	2022
Quantities						
Increased capacity	GWh	8.7	8.7	8.7	8.7	8.7
Reduced technical losses	GWh	84.3	84.3	84.3	84.3	84.3
Reduced commercial losses	GWh	28.8	28.8	28.8	28.8	28.8
Total output	GWh	121.7	121.7	121.7	121.7	121.7
Values						
Project revenue	INR m	846.9	846.9	846.9	846.9	846.9
Consumer surplus	INR m	16.7	16.7	16.7	16.7	16.7
Total value	INR m	863.6	863.6	863.6	863.6	863.6

GWh = gigawatt-hour, INR = Indian rupees.
Source: Asian Development Bank staff estimates.

14. Tranche 2 investments include subprojects that are primarily driven by safety and regulatory concerns (establishment of a meter testing laboratory and replacement of oil-filled with dry-type transformers) and for reasons of system control and supply security (establishment of two area load dispatch centers and undergrounding of parts of the Guwahati urban network). Economic benefits are not readily observable for these subprojects and have therefore been excluded from the analysis.

15. The additional energy consumption by consumers was evaluated using the area under the assumed aggregate consumer demand curve. The total benefits can be divided into project revenue and consumer surplus. Project revenue is simply the average consumer tariff multiplied by incremental consumption. Although APDCL's financial projections show that tariffs are expected to increase in real terms, no real tariff increases were modeled beyond the first year of benefits in this economic analysis. Consumer surplus was estimated using the following equation: consumer surplus = $0.5(P1[\Delta Q]^2])/(e_d\ Q1)$, where ΔQ is the incremental consumption and e_d is the absolute value of the price elasticity of demand. P1 (average price prior to the project), Q1 (current consumption), and Q2 (consumption after the project) are observable, while a value of 0.4 was adopted for e_d, based on published guidelines.[3] Note that this method provides a theoretically correct estimate of benefits of additional power consumed. However, the estimates are conservative because the demand curves shift upward due to increasing incomes and that effect is not accounted for in the analysis.

[3] ADB. 2013. *Cost-Benefit Development for Analysis – A Practical Guide.* Manila.

16. Tranche 2 investments are not expected to produce any clear, measureable net environmental benefits.

17. **Estimated economic internal rate of return.** The economic internal rate of return (EIRR) was estimated with the conservative benefit assumptions discussed above. A valuation of the impact the improvement in the quality of supply would have on consumers' willingness to pay for incremental consumption was not incorporated in the analysis; only the conventional benefits of additional consumption owing to availability of electricity throughout the day were assessed. A period of 20 years was used for economic evaluation, with capital investment occurring during the first two years and benefits realized from year three. Detailed cost-benefit calculations (summarized in **Table 3**) show that Tranche 2 investments are economically viable overall, with an aggregated EIRR of approximately 21.5%, well above the assumed hurdle rate of 12%. The relatively high EIRR is a consequence of the value of loss reduction in network with persistent capacity and energy constraints.

Table 3: Tranche 2 EIRR Results
(INR million)

	Benefits	Costs		Net
Year		Capital	O & M	Benefits
2016	0.0	1,596.9	0.0	(1,596.9)
2017	0.0	1,596.9	0.0	(1,596.9)
2018	863.6	0.0	79.7	783.8
2019	863.6	0.0	79.7	783.8
2020	863.6	0.0	79.7	783.8
2021	863.6	0.0	79.7	783.8
2022	863.6	0.0	79.7	783.8
2023	863.6	0.0	79.7	783.8
2024	863.6	0.0	79.7	783.8
2034	863.6	0.0	79.7	783.8
				EIRR = 21.5%

EIRR = economic internal rate of return, INR = Indian Rupees, O&M = operations and maintenance.

Source: APDCL and ADB estimates

F. Sensitivity and Risk Analysis

18. The risks that the proposed Tranche 2 investment does not achieve satisfactory economic returns were identified from both cost and benefit side. For each of the risks identified, the sensitivity of the aggregate EIRR was tested and switching values were calculated. EIRR sensitivity results are shown in **Table 4**, with the EIRR exceeding 12% in all cases. The switching values are adequately separated from the values used in the base case, indicating that a change in any single key parameter beyond the value used in the sensitivity studies is unlikely to render the project non-viable. Based on these results, Tranche 2 investments appear to be economically viable.

Table 4: Tranche 2 Sensitivity Analysis

Sensitivity Parameter		Base Case Value	EIRR (%)	Switching Value (%)
	Base case		21.5	
1.	Project capital costs increased by 15%	$58.1 m	20.6	156.5
2.	Loss reduction scaled back by 15%	113.1 GWh	17.8	-38.8
3.	Price elasticity set at -0.6	-0.4	21.6	n.c.
4.	O&M costs increased by 15%	2% of capex	21.2	432.4
5.	Commissioning delayed by one year	-	17.9	
6.	Combined (1, 2, 3, 4, 5)	-	12.9	

EIRR = economic internal rate of return, GWh = gigawatt-hour, n.c. = not calculable, O&M = operations and maintenance.
Source: Asian Development Bank staff estimates.

19. **Distribution analysis.** The distribution of Tranche 2 costs and benefits among stakeholders was assessed by comparing financial costs and benefits to economic costs and benefits. Results are shown in **Table 5**. Overall, the economic net present value exceeds the financial net present value by INR155 million. In this analysis, APDCL is the greatest beneficiary because it earns an essentially unregulated return on loss reduction subprojects that far exceeds the 12% discount rate assumed in this analysis. The state economy benefits by approximately INR45 million, mostly due to the taxes and transfers that Tranche 2 investments would generate (although some of this surplus would accrue to the central government rather than the state government). Electricity consumers are modest beneficiaries (INR97 million) as a consequence of consumer surplus on incremental consumption.

Table 5: Tranche 2 Distribution of Benefits to Affected Groups
(INR million)

Item	NPV at 12%			Distribution to Affected Groups		
	Economic	Financial	Difference	Govt./ Economy	Labor	Consumers
Benefits						
Incremental consumption	4,991		4,991			4,991
Revenue		4,894	-54,894			-4,894
Costs	2,699	2,748	-49	36	13	
Investment	461	469	-8	8		
O&M	0	0	0			
Supply		0	0			
Income tax						
Net benefits	1,831	1,677	155	45	13	97

INR = Indian **Rupees,** NPV = net present value, O&M = operations and maintenance.
Source: Asian Development Bank staff estimates.

G. Conclusion

20. The economic analysis confirms that the Tranche 2 investment and the overall power system master plan investment are least cost and economically viable. Sensitivity and risk analysis demonstrates that the expected economic performance is robust. From an economic perspective the Tranche 2 investment and the overall investment program should proceed.