ECONOMIC ANALYSIS: PROJECT 1

A. Background and Rationale

1. Project 1 of the Green Power Development and Energy Efficiency Improvement Investment Program involves construction of a 30-megawatt Moragolla hydropower plant; transmission system strengthening; medium-voltage network efficiency improvement; conduct of energy efficiency pilot subprojects, including smart grid, smart buildings, and cold thermal storage; and nonphysical components involving consultancy support for project supervision and capacity building for Ceylon Electricity Board (CEB). The second tranche for project 2 to be drawn in 2016 will focus on transmission system strengthening, medium-voltage network improvement, and energy-efficiency development. Project 1 will contribute to the expansion of Sri Lanka's transmission and distribution network by adding 10 kilometers (km) of 132-kilovolt (kV) transmission lines, 92.3 km of 33 kV distribution lines, 90 megavolt-amperes of 220/132/33 kV substation transformer capacity, and 320.5 megavolt-amperes to 132/33 kV substation transformer capacity. In addition, the project will contribute to about 100 gigawatt-hours of clean energy in the Sri Lankan system. The energy efficiency pilot subprojects will contribute to flattening of the overall demand curve and reduction in peak power demand. The main economic benefits from the subprojects will include (i) reduced transmission and distribution losses from strengthening the network, (ii) reduced coincident peak demand and energy consumption resulting from energy efficiency measures, and (iii) increased availability of power for additional customers to be served through the construction of new lines and the addition of a generation facility.

2. **Economic rationale**. The subprojects are elements of CEB's long-term generation expansion plan, long-term transmission plan, and distribution plans. The project will increase power system reliability and will also serve additional demand as a result of increased generation.

3. **Project alternatives and least-cost planning.** The CEB Transmission Planning Branch uses the power system simulator for engineering network analysis software to model and examine the transmission network under a range of generation and demand conditions and contingencies to ensure that the network provides acceptable quality and security of supply. CEB's standard substation and line designs are considered to be reasonable from a cost perspective, effectively balancing simplicity, reliability, and flexibility for future upgrading. CEB confirms that it has considered reasonable and practical alternatives to the proposed subprojects, and that the alternatives selected for implementation represent the least-cost means of achieving the desired network performance in terms of voltage, stability, reliability, and required flexibility in network operations. CEB's Long-Term Transmission Development Plan covers 10 years, is updated at least once every 2 years, and must be approved by the Public Utilities Commission of Sri Lanka (PUCSL).

4. CEB distribution regions use the SynergyE model to analyze and plan the 33 kV distribution network, which forms the basis of the distribution system development plan developed for each region. This plan is updated every 2 years. The demand forecast for each area under each distribution region is developed using a bottom-up approach on the basis of trend analysis of past demand and knowledge of new spot loads expected during the next 5 years. The plan outlines the 33 kV network strengthening required over a 10-year planning period to ensure delivery of power to customers at the specified power quality, and provides the economic justification of the plan through the improvement of power quality and reduction of network losses. CEB approves the plan, which is then submitted to PUCSL for approval. Projects selected for implementation are elements of the plan for each distribution region.

5. **Demand assessment**. CEB's demand forecasting methodology follows internationally accepted norms and practices. It uses a top-down econometric approach to estimate national demand for electricity based on expected national income growth (measured by growth in gross domestic product) and population growth. It relates growth in these variables to electricity growth through multiple linear regression analysis of historical data. CEB translates its aggregate demand forecast to generation requirements by estimating the transmission and distribution losses, which in the long term meet the government policy target of 12%, and develops the Long-Term Generation Expansion Plan covering 20 years. CEB's Transmission Planning Branch then identifies the transmission network reinforcement and expansion requirements to accommodate the new generation in accordance with the generation expansion plan and to meet the forecast customer demand in the load centers. CEB derives forecast demand to be served at each grid substation using a bottom-up approach for distribution, using a trend extrapolation for existing loads and expected spot loads in the next 5 years.

B. Cost–Benefit Analysis

6. The economic impact of each component was evaluated from a national power system perspective in accordance with the *Guidelines for Economic Analysis of Projects* of the Asian Development Bank (ADB).[1] A 25-year period was used for the evaluation with no terminal value considered for the investment. All costs and benefits are expressed at a constant quarter 1 (Q1) 2014 price. A domestic price numeraire is used. Traded inputs are valued at their border price equivalent and then adjusted to the domestic price by multiplying by a shadow exchange rate factor of 1.06, calculated using a simple trade-weighted approach for the last 5 years. Nontraded inputs are valued at domestic prices. The economic internal rate of return (EIRR) is estimated and evaluated against the ADB hurdle rate of 12%.

7. Investments for each subproject are determined on the basis of the costs provided by CEB and reviewed during the study. Taxes and custom duty are not considered. Operation and maintenance costs for the subprojects range from 1.5% to 2% of subproject costs, based on historical benchmark data used in previous studies.

8. Benefits are evaluated on the basis of nonincremental and incremental benefits. The key nonincremental benefits comprise savings in energy losses in the network valued at the average generation cost of power in Sri Lanka. For transmission subprojects, reduced energy losses are calculated through a load-flow analysis to first calculate the system capacity loss savings at peak time, and then using the loss-load factor of 0.38 applicable for the Sri Lankan system to calculate the corresponding energy savings.[2] These savings in energy losses by the implementation of transmission and distribution subprojects are valued at the average generation cost for each year in the evaluation period, determined based on the fuel consumption figures stated in CEB's Long-Term Generation Expansion Plan for the recommended least-cost generation plan.

9. The methodology provided in ADB's *Cost Benefit Analysis for Development: A Practical Guide* is used to calculate the incremental benefits.[3] According to the guide, incremental benefits are valued as the relevant area under the demand curve, which comprises sales revenue plus consumer surplus. Sales revenue is estimated using incremental output of the

---

[1] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila.
[2] Load-loss factor is the ratio of average load loss to the peak load loss. It is the factor which, when multiplied by peak system loss, gives the average energy lost.
[3] ADB. 2013. *Cost Benefit Analysis for Development: A Practical Guide.* Manila (Chapter 8: Appraising Electricity Projects).

project and average consumer price. The price elasticity of 0.75 in Sri Lanka is used to calculate the consumer surplus based on the following formula:

$$Consumer\ surplus = 0.5[P_1\ (\Delta Q)^2] / [e_d\ Q_1] = 0.5\ [\Delta Q.\ \Delta P]$$

In the formula, P_1 is the prevailing electricity price, and Q_1 is electricity consumption without the project. With the project, the electricity consumption increases to Q_2 with ΔQ being the additional consumption from reduced losses. Finally, e_d is the absolute value of the price elasticity of demand.

10. Table 1 summarizes the results of the economic evaluation of each subproject. The EIRRs of all project components are above the benchmark of 12.00%, while the estimated EIRR of the aggregate project is 15.17%.

Table 1: Results of the Economic Evaluation

Component	EIRR
Generation	17.86%
Transmission	13.25%
Distribution	17.16%
Energy efficiency	16.82%
Consolidated Result	**15.17%**

Source: Asian Development Bank estimates.

11. Table 2 presents the cost and benefit flows of the combined project.

Table 2: Cost Benefit Streams: Combined Investment

	Benefit (SLRs million)			**Cost** (SLRs million)		
Year	**Incremental**	**Nonincremental**	**Total Benefits**	**Capital**	**O&M**	**Net Benefit**
2014				500		(500)
2015				3,847		(3,847)
2016				4,365		(4,365)
2017	83		83	7,691	7	(7,614)
2018	788	1,221	2,009	7,666	195	(5,853)
2019	779	1,004	1,783	3,644	195	(2,056)
2020	3,909	1,867	5,779		437	5,213
2021	3,909	1,787	5,697		437	5,213
2022	3,909	1,741	5,650		437	5,213
2023	3,909	1,741	5,650		437	5,213
2024	3,909	1,741	5,650		437	5,213
2025	3,909	1,741	5,650		437	5,213
2026	3,909	1,741	5,650		437	5,213
2027	3,909	1,741	5,650		437	5,213
2028	3,909	1,741	5,650		437	5,213
2029	3,909	1,741	5,650		437	5,213
2030	3,909	1,741	5,650		437	5,213
2031	3,909	1,741	5,650		437	5,213
2032	3,909	1,741	5,650		437	5,213
2033	3,909	1,741	5,650		437	5,213
2034	3,909	1,741	5,650		437	5,213
2035	3,909	1,741	5,650		437	5,213

Year	Benefit (SLRs million)			Cost (SLRs million)		
	Incremental	**Nonincremental**	**Total Benefits**	**Capital**	**O&M**	**Net Benefit**
2036	3,909	1,741	5,650		437	5,213
2037	3,909	1,741	5,650		437	5,213
2038	3,909	1,741	5,650		437	5,213
2039	3,909	1,741	5,650		437	5,213
2040	3,909	1,741	5,650		437	5,213
2041	3,909	1,741	5,650		437	5,213
2042	3,909	1,741	5,650		437	5,213
2043	3,909	1,741	5,650		437	5,213
Economic Internal Rate of Return						**15.17%**

( ) = negative value, O&M = operation and maintenance, SLRs = Sri Lanka rupees.
Source: Asian Development Bank estimates.

C. Sensitivity Analysis

12. The risks that the subprojects may not achieve satisfactory economic returns were identified and the sensitivity of the EIRR for each risk is tested (Table 3).

Table 3: Sensitivity Analysis for Combined Components

Sensitivity Parameter	Variation	EIRR
Base case		**15.17%**
1. Project capital costs	10%	13.87%
2. Reduction in willingness to pay	–10%	14.14%
3. Operation and maintenance	10%	15.05%
Combined impacts: 1+2+3		**12.76%**

EIRR = economic internal rate of return.
Source: Asian Development Bank estimates.

13. The proposed investments are critical to the sector's overall investment need and will make a substantial difference to the quality of electricity supply received by consumers. Economic benefits are expected to be sustainable as the sector is already supported by a transparent tariff-setting methodology that proposes full recovery of efficient costs and allows an acceptable rate of return to be earned on capital investments, enabling the assets built to be maintained throughout their economic life.

14. The subprojects are elements of the country's long-term generation, transmission, and distribution plans to meet the forecast demand for electricity at the required quality and reliability. The economic analysis confirms that the proposed investments are economically viable. The analysis yields an overall EIRR of 15.17%. Sensitivity and risk analyses demonstrate that the expected economic performance is robust.