ECONOMIC ANALYSIS

1. The economic analysis undertaken for the South Asia Subregional Economic Cooperation Power System Expansion Project examines the economic viability of the project from the national perspective. The project is expected to result in enhanced electricity transmission and distribution capacity in Nepal's national grid and improved access to energy in off-grid areas. Economic benefits will accrue from incremental and nonincremental electricity consumption and from displacement of more expensive sources of energy.

A. Economic Rationale for the Project

2. The project comprises electricity transmission system expansion, grid substation reinforcement, distribution system augmentation, and the mini-grid-based renewable energy development subprojects of the Alternative Energy Promotion Centre (AEPC).

3. Nepal is experiencing a severe energy crisis. Annual peak power demand of the integrated Nepal power system in 2013 was estimated to be 1,095 megawatts (MW), the system was unable to meet about 375 MW needed during the winter peak. Energy demand was estimated at 5,446 gigawatt-hours, out of which only 4,218 gigawatt-hours were supplied.[1] This gap between demand and supply cannot be reduced without addition of significant generation capacity and augmentation of transmission capacity in the integrated power system.

4. About 93% of urban areas have access to electricity; in rural areas access is about 49%.[2] About 33% of households in the country still depend largely on kerosene for lighting. Renewable energy is a government priority, with a goal for the next 20 years to increase the share of renewable energy from less than 1% in 2012 to 10% of the total energy supply, and to increase access to electricity from alternative energy sources from 10% to 30%.[3]

5. As it has no commercial indigenous fossil fuel reserves, the country is 100% reliant on imported petroleum fuels for transport and other applications. Recently, use of stand-alone generator sets has increased, especially during periods of load shedding, resulting in a significant increase in diesel consumption and import. Almost 33,000 generator sets are reported to be imported; the average age of the operating generator sets is 3.5 years.[4] Two-thirds of all households use firewood as a main fuel for cooking; just more than one-fifth use liquefied petroleum gas. An uninterrupted supply of electricity has tremendous potential to replace and or reduce the use of imported petroleum fuels; the resulting foreign exchange savings could be used for other useful imports. The supply of electricity to users does not meet basic energy needs for current economic activity or to promote economic growth. Development of the electricity subsector is essential to national development and the transmission system is the backbone of electricity system development.

B. Electric Power Demand Analysis

6. The demand-forecasting methodology adopted by the Nepal Electricity Authority (NEA) was developed during a power system master planning exercise financed by the Asian

[1] Nepal Electrical Authority. 2013. *A Year In Review: Fiscal Year 2012/2013*. Kathmandu.
[2] Government of Nepal, Central Bureau of Statistics. 2008. *Nepal Labour Force Survey 2008*. Kathmandu.
[3] Presentation by AEPC on Scaling-Up Renewable Energy Program in Nepal, 6 February 2011.
[4] Formulation of Low Carbon Economic Development Strategy for Nepal, Phase 1: Data Collection and Analysis (draft).

Development Bank (ADB) in 1998. NEA has since updated key model assumptions periodically. The demand-forecasting model broadly follows an econometric approach, incorporating assessments of price and income elasticity of demand. Overall, NEA forecasts electricity demand to grow by an average of 8.3% per annum from 2013 to 2028, and peak demand to grow by an average of 8.1% per annum, with losses declining from 25.5% to 15.05%.

7. The actual average per capita electricity consumption was 108 kilowatt-hours (kWh) in 2012. The Government plans to achieve average consumption of 140 kWh per capita by the end of Thirteenth Plan (2013–2016).[5]

C. Least-Cost Analysis of the Project

8. NEA no longer prepares a least-cost system expansion plan in the conventional sense. Following the opening of the energy sector to private developers, NEA is responsible for only a portion of generation expansion. Further, while licenses have been issued for thousands of MW of new hydropower capacity, experience has taught NEA system planners that such licenses are not a reliable indicator of project development. Obstacles range from environmental permitting to financing, resulting in a small fraction of potential projects being realized, and typically not according to the original schedule. In this context, the subject transmission projects have been prioritized due to the hydropower potential in the Kali Gandaki and Marsyangdi valleys and on the basis of power purchase agreements signed with independent power producers. Analysis of options for voltage levels and conductor type has been undertaken to determine that the least-cost solution has been selected, taking into account uncertainties regarding future independent power producers and export of electricity to India. NEA adopts an “n-1” criterion for transmission planning, i.e., network expansion is planned so that any single component outage can be sustained without loss of load. Distribution augmentation has been prioritized in areas with high losses and significant overloading of substation transformers, and NEA’s standard planning principles and designs have been adopted for those areas.

9. Renewable energy is a priority for providing least-cost, clean, and safe solutions for commercial energy to remote and sparsely populated areas that are unviable for grid extension. Identification of least-cost renewable energy solutions are made on a case-by-case basis according to an evaluation framework developed by AEPC; no specific projects have been identified at this stage.

D. Detailed Project Economic Cost–Benefit Analysis

1. Project Economic Costs

10. All costs and benefits are expressed at a constant 2014 price. The world price numeraire is used. Traded inputs are valued at their border price equivalent values, and nontraded inputs are valued at domestic prices and then adjusted to the world price numeraire by multiplying by the estimated standard conversion factor of 0.93, calculated using a simple trade-weighted approach. No significant distortions are assumed for the wage rates for skilled labor. In the case of unskilled labor, underemployment exists in the economy, resulting in the opportunity costs of unskilled labor being less than the promulgated minimum wage rates. Based on an assessment of underemployment in the unskilled sector, average wage rate, and expected wage rates paid by the project to unskilled labor, a shadow wage rate of 0.75 was adopted. The fuel conversion factor is estimated at 0.98 based on current fuel prices in the domestic market.

[5] Government of Nepal, National Planning Commission. 2013. *Approach Paper Thirteenth Plan.* Kathmandu.

11. Project financial costs are categorized as investment costs (including taxes and duties), other costs (i.e., environmental and social mitigation, project management, and construction supervision), and contingencies (both physical and price). Where adequate and reliable information is available, land is valued at its opportunity cost; otherwise it is valued at assumed market value.[6] Capital costs include physical contingencies but exclude price contingencies as well as taxes and duties.

12. The total economic cost of the project is estimated to be $360.39 million (Table 1).

Table 1: Economic Cost ($ million)

Subproject	Economic Cost
Kali Gandaki corridor transmission line and substation augmentation	150.45
Marsyangdi corridor including Marsyangdi–Kathmandu and substation augmentation	149.42
Samundratar–Trishuli 3B to transmission and substation augmentation	13.64
Grid service substations	8.03
Distribution system augmentation	39.41
AEPC's mini-grid based renewable energy development	26.71
Total	**387.67**

AEPC = .
Source: Asian Development Bank staff estimates.

13. Based on international experience, the operating costs are estimated at 1.5% of capital costs for transmission subprojects, 2.5% for distribution system reinforcement, and 4% for renewable energy projects.

14. The proposed project investments are only part of the total cost of delivering electricity to consumers; the total cost of supply must be included. Incremental transmission investments require continued investment in generation, other transmission, and distribution. While a detailed marginal cost study is beyond the scope of the present analysis, an approximation is based on proxy units. The capital cost breakdown of a selection of hydropower plants is used to arrive at the specific conversion factor and is used in conjunction with the power purchase agreement wet and dry season buy rates for independent power producer plant supported by the project.

2. Project Economic Benefits

15. Project benefits include a reduction in energy not served; an increase in capacity for meeting growth in demand; and, in the case of the grid service substation and distribution components, a reduction in losses. Use of diesel for power generation is prevalent; captive generator sets are assumed generate about 500 MW equivalent of electricity diesel, drawing a huge amount of national resources for the import of diesel. The cost of electricity generation by diesel, in the absence of sufficient generation in the integrated Nepal power system, is exorbitantly high. The opportunity cost of electricity given the high demand for electricity.

16. The resource cost saving is estimated with diesel for small and medium-sized generator sets and kerosene for lighting (the fuels most likely to be displaced by the project). For willingness to pay, a semi-log interpolation between the resource cost-saving value and the appropriate NEA realization rate is used. For the transmission and distribution components and

[6] This assumption is not material in overall economic internal rate of return (EIRR) calculations; a full opportunity cost valuation of land is expected to be lower than its market value resulting in a higher overall EIRR.

on the basis of an assessment of the expected demand and supply balance, half of the electricity transmitted by the project during the dry winter months is assumed to be incremental output (valued at willingness to pay) and that the other half will be nonincremental (valued at resource cost saving). For the rest of the year, an expectation of a surplus of hydropower supports an assumption that that all output is incremental. For the renewable energy components, all electricity used in excess of the kWh equivalent of current kerosene consumption is assumed to be incremental output. The renewable energy projects also avoid carbon emissions; this is valued using an emissions factor of 0.0025 tons of carbon dioxide/kWh and a unit value of $10/ton of carbon dioxide. The improvement in incomes of electrified consumers vis-à-vis nonelectrified consumers is also likely to improve the health and education of rural households, however these benefits are not quantified in this analysis.

17. The on-grid transmission and distribution components will support delivery of at a minimum of 200 MW of new clean energy supplies to electricity consumers in Nepal, sufficient for the minimum needs of at least 2 million people. The transmission component will facilitate a minimum of 1,200 MW of power exchange with India. The off-grid component will help about 30,500 households to access clean renewable energy. Around 20,000 ton of carbon dioxide will be reduced annually mainly due to displacement of fossil fuel and kerosene-based lighting systems in off-grid areas.

E. Economic Internal Rate of Return

18. The economic evaluation by project component indicates that the project will deliver a positive economic return, with an aggregate economic internal rate of return (EIRR) of 22% (Table 2).[7] The details of the calculation are shown in Table 3.

Table 2: Summary of Economic Results by the Project

Subproject	**EIRR** (%)
Kali Gandaki corridor transmission line and substation augmentation	26
Marsyangdi corridor including Marsyangdi to Kathmandu and substation augmentation	17
Samundratar–Trishuli 3B to transmission and substation augmentation	32
Grid service substations	24
Distribution system augmentation	22
AEPC's mini-grid based renewable energy development	12
Combined	**22**

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

F. Sensitivity Analysis

19. Sensitivity analysis of the EIRR for the combined project indicates that returns remain very stable against adverse conditions. Sensitivity was tested for increased costs, decreased benefits, increased cost of supply, and increased operation and maintenance costs (Table 4). Even when all the adverse changes are considered, the project EIRR remains well above the assumed economic discount rate of 12%. Based on these results, the project appears to be economically viable.

[7] For the AEPC's renewable energy component, five sample projects (two mini-hydro grid, one solar grid, and two solar-wind hybrid grid) were aggregated and analyzed, and the result is considered to be representative to the whole component.

Table 3: Economic Internal Rate of Return Calculations for Combined Subprojects
($ million)[a]

Year	Benefits		Costs			Net Benefits
	Incremental Output	Nonincremental Output	Capital	Supply	Operating	
2014	0.0	0.0	0.4	0.0	0.0	(0.4)
2015	0.0	0.0	107.3	0.0	0.0	(107.3)
2016	0.0	0.0	228.5	0.0	0.0	(228.5)
2017	0.0	0.0	51.5	0.0	0.0	(51.5)
2018	23.1	35.8	0.0	18.3	6.2	40.6
2019	54.5	84.4	0.0	56.7	6.2	76.1
2020	68.6	100.9	0.0	63.5	6.2	99.8
2021	76.7	112.4	0.0	71.4	6.2	111.5
2022	84.8	124.3	0.0	79.4	6.2	123.5
2023	89.1	130.8	0.0	85.0	6.2	128.7
2028	119.3	169.9	0.0	105.0	6.2	178.0
2033	125.7	174.9	0.0	101.9	6.2	192.5
2038	132.2	181.1	0.0	102.5	6.2	204.7
				Economic Internal Rate of Return = 22.1%		

() = negative value.
[a] For brevity, only every 5th year is included in the table after 2023.
Source: Asian Development Bank staff estimates.

Table 4: Sensitivity Analysis for Combined Project Components

Sensitivity Parameter	**Variation** (%)	**EIRR** (%)	**Switching Value** (%)
Base Case		22	
1. Capital cost increase	+ 10	21	92
2. Benefit decrease	–10	20	48
3. Operation and maintenance increase	+ 20	22	>100
4. Cost of supply increase	+ 20	21	>100
5. Combined (1+2+3+4)		16	

Source: Asian Development Bank staff estimates

G. Distribution of Project Effects and Poverty Impact

20. Overall, the economic net present value of the project exceeds the financial net present value by $542 million. Government and consumers are the greatest beneficiaries ($192 million for government and $351 million for consumers). The main net loser is NEA ($202 million).

H. Conclusion

21. Economic evaluation of the project indicates that the planned investment is economically viable, with an overall estimated EIRR of 22% against an assumed hurdle rate of 12%. The overall project remains viable under all sensitivities examined, including a combined downside scenario.