ECONOMIC ANALYSIS

1. Bhutan has one of the fastest growing economies in Asia. Its annual growth rate averaged 8.7% of gross domestic product (GDP) during 2003–2012. Per capita GDP was estimated at $2,621 in fiscal year (FY) 2013, a threefold increase from $852 in FY2002.

2. Bhutan's high investment growth model focuses on hydropower. The government's development strategy gives the power sector a central role in efforts to achieve (i) economic development and poverty reduction by exploiting the country's abundant hydropower potential and increasing the government's fiscal revenues through power exports, (ii) balanced growth between regions by extending access to electricity to rural communities, and (iii) an environment for industrial investments based on cheap and reliable electricity supply. To meet these objectives, the government is planning investments in more export-oriented hydropower projects. The government has committed to ambitious targets of developing more than 10,000 megawatts (MW) of hydropower capacity by 2020 with assistance from the Government of India.

3. The Asian Development Bank (ADB) approved the Green Power Development Project in 2008 to support the Dagachhu hydropower development (126 MW) for power export to India. The Second Green Power Development Project moves the strategy forward with support for the 118 MW Nikachhu hydropower plant, intended to export clean renewable energy from Bhutan. The annual design energy is conservatively based on a 90% dependable year with 95% plant availability works out to 491.52 gigawatt-hours (GWh). The executing agencies for the project are Druk Green Power Corporation (DGPC) and its subsidiary, Tangsibji Hydro Energy (THyE).

A. Methodology and Major Assumptions

4. **Methodology.** The economic evaluation is in accordance with ADB guidelines for project economic analysis.[1] The evaluation is tested for sensitivity to changes in the basic parameters. When completed, the hydropower plant will generate 491.52 GWh of electricity each year on a standalone basis. Of this energy, 12% will be used for domestic consumption and provided free as an energy royalty to the Government of Bhutan until 2031. Thereafter the energy royalty will increase to 18% of generation. The remaining will be exported to India. Economic benefits will mainly accrue from the displacement of more expensive fuel sources and from the incremental electricity consumption. Environmental benefits will be achieved as hydropower displaces fossil fuels for generating electricity and reduces emissions. These environmental benefits are not considered in the present study.

5. **Supply and demand forecast.** Projected supply is estimated by adding the current generation with planned capacity creation under the 10,000 MW investment plan. The project is studied separately to estimate its impact. Base domestic demand in Bhutan is computed using historical monthly and hourly data. For future projections, demand is assumed to grow at the rate of growth of real GDP.

6. The assumptions for the project's monthly generation are taken from the technical studies. The monthly and seasonal supply patterns are assumed to be unchanged in the future. For all supply projections, a transmission loss of 2% is included. The demand and supply projections are divided into peak and off-peak periods for two seasons (summer and winter) given seasonal characteristics. The project's contribution is then analyzed (paras. 8 and 9).

[1] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila.

7. **Investment costs.** All costs and benefits are expressed at constant 2014 prices. The domestic price numeraire is used. Tradable inputs are converted into domestic equivalents using an estimated shadow exchange rate factor of 1.004 after factoring in the impact of trade taxes. Capital costs and operation and maintenance costs are taken from the financial data, with appropriate adjustments to remove taxes and price contingencies. Costs are divided into tradables, nontradables, fuel, skilled and unskilled domestic labor, and skilled and unskilled foreign labor based on reasonable assumptions about their proportion in total cost. A shadow wage rate factor of 0.75 is used for unskilled labor and 1.00 for skilled labor. For foreign labor, the shadow wage rate factor was multiplied by the shadow exchange rate factor to obtain the appropriate conversion factor. The residual value of investment is estimated as the same proportion to economic costs as the book value is to financial costs.

8. **Investment benefits.** Total benefits from the project to Bhutan accrue through the (i) nonincremental benefits from direct resource cost savings in the domestic economy,[2] (ii) incremental benefits to new customers and additional domestic consumption demand by existing customers due to supply availability in certain periods, and (iii) incremental benefits from exports of energy from the project to India. As the electricity demand within Bhutan increases over time, the share of nonincremental domestic benefits will increase and that of incremental domestic benefits will decrease until it becomes zero after 2037. For a small project producing export goods, the output for export is considered incremental.[3]

9. The valuation of the incremental benefits for domestic consumers is in accordance with the methodology outlined in an ADB technical note on measuring willingness to pay for electricity.[4] The coefficients of the demand equation are based on relative energy consumption data in rural electrified and electrified households in Bhutan,[5] with suitable per unit cost assumptions for the key alternate fuel sources. For other consumer categories, incremental benefit is computed by estimating the area under the demand curve by assuming a price elasticity of minus 0.43, which is the average for Asian developing countries.[6] To compute the benefits accruing to only Bhutan (without considering subregional benefits), export energy is treated as incremental and the value determined through competitive bidding.

10. If reviewed from a Bhutan–India subregion perspective, given the significant power deficit in India, the entire export output from the project can be assumed to be utilized to meet unsatisfied electricity demand in India and to replace a similar quantum of imported coal-based generation in India. Thus, the benefit in this case will be entirely nonincremental for the quantum of export from Bhutan to India and resource cost savings are accordingly estimated.[7]

B. Calculation of Economic Internal Rate of Return

11. The economic evaluation is based on a plant economic life of 30 years, in consistency with the financial analysis. Detailed cost–benefit calculations show that the project can be expected to deliver reasonable economic benefits, with an estimated economic internal rate of

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[2] Independent Evaluation Department. 2010. *Sector Assistance Program Evaluation: Energy Sector in Bhutan. Manila: ADB*.

[3] ADB. 1997. *Guidelines for the Economic Analysis of Projects.* Manila. p. 56, para. 15.

[4] ADB. 2002. Measuring Willingness to Pay for Electricity. *ADB Economic and Research Department Technical Note Series.* No. 3. Manila.

[5] The Energy and Research Institute (TERI). 2010. *Energy Consumption in the Residential Sector in the Himalayan Kingdom of Bhutan*. Delhi.

[6] ADB. 2013. *Cost−Benefit Analysis for Development: A Practical Guide*. Manila.

[7] Institute for Energy Economics and Financial Analysis. 2014. *Briefing Note: Indian Power Prices.* The cost of coal-fired generation in 2018 is adjusted for price escalation from 2014 to 2018.

return (EIRR) of 17.31% (Table 1). When project benefits to the Bhutan–India subregion are considered, the EIRR rises to 21.70%.

Table 1: Economic Internal Rate of Return

	Benefits				Costs			
Year	Incremental Benefits, Bhutan Consumption	Incremental Benefits, Energy Exports	Non incremental Benefits, Bhutan Consumption	Total Benefits	Capital	O&M	Total Cost	Net Benefits
2014	0	0	0	0	0	0	0	0
2015	0	0	0	0	1,130	0	1,130	(1130)
2016	0	0	0	0	1,622	0	1,622	(1622)
2017	0	0	0	0	2,220	0	2,220	(2220)
2018	0	0	0	0	2,196	0	2,196	(2196)
2019	93	852	84	1,028	1,154	44	1,198	(169)
2020	140	1,303	126	1,569	0	88	88	1,481
2021	140	1,297	126	1,562	0	87	87	1,475
2022	140	1,312	126	1,578	0	87	87	1,491
2023	140	1,364	126	1,630	0	87	87	1,542
2024	140	1,395	126	1,661	0	88	88	1,574
2025	135	1,425	151	1,711	0	87	87	1,623
2026	33	1,474	651	2,157	0	87	87	2,070
2027	22	1,521	703	2,246	0	87	87	2,159
2028	22	1,566	703	2,291	0	88	88	2,204
2029	22	1,609	703	2,334	0	87	87	2,247
2030	22	1,649	703	2,373	0	87	87	2,286
2031	33	1,589	1,054	2,676	0	87	87	2,589
2032	33	1,641	1,054	2,728	0	88	88	2,640
2033	33	1,691	1,054	2,778	0	87	87	2,691
2034	33	1,612	1,054	2,699	0	87	87	2,612
2035	33	1,557	1,054	2,644	0	87	87	2,557
2036	33	1,565	1,054	2,652	0	88	88	2,565
2037	33	1,574	1,054	2,661	0	87	87	2,574
2038	0	1,582	1,219	2,802	0	87	87	2,714
2039	0	1,591	1,219	2,810	0	87	87	2,723
2040	0	1,600	1,219	2,819	0	88	88	2,732
2041	0	1,608	1,219	2,828	0	87	87	2,741
2042	0	1,617	1,219	2,837	0	87	87	2,749
2043	0	1,626	1,219	2,846	0	87	87	2,758
2044	0	1,635	1,219	2,855	0	88	88	2,767
2045	0	1,643	1,219	2,862	0	87	87	2,775
2046	0	1,650	1,219	2,870	0	87	87	2,783
2047	0	1,660	1,219	2,879	0	87	87	2,792
2048	0	1,669	1,219	2,889	0	88	88	2,801
2049	0	561	610	1,170	(94)	22	(73)	1,243
EIRR								**17.31%**

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

12. **Sensitivity analysis.** The evaluation tests the EIRR's sensitivity to a series of identified risks, including (i) a 5% increase in project costs (ii) a 10% increase in operation and maintenance costs, (iii) a 5% reduction in energy generation, (iv) a delay of 6 months in commissioning, and (v) a combination of these risk scenarios (Table 2). In each of the scenarios, the EIRR remains above the threshold of 12% for variations in the underlying

parameters. The EIRR is most sensitive to a delay in commissioning.

Table 2: Sensitivity Analysis

Scenario	**Variation** (%)	**EIRR** (%)
Base Case		17.31
Increase in project cost	5	16.70
Increase in O&M cost	10	17.25
Reduction in generation	(5)	17.15
Delay in commissioning	6 months	15.96
Combined effect (2 to 5)		15.22

O&M = operation and maintenance.
Source: Asian Development Bank.

13. **Distribution analysis.** Table 3 summarizes the distribution of costs and benefits among stakeholders, assessed by comparing constant price financial costs and benefits with economic costs and benefits, with both discounted at 12%. Consumer benefits from resource cost savings are expected as electricity from the Nikachhu plant replaces consumption of expensive alternative sources, like fuelwood, diesel, and kerosene. The overall economy will benefit as the economic net present value exceeds the estimated financial net present value by Nu5,526 million.

Table 3: Distribution Effects Analysis (Nu million)

	NPVs at 12%			**Distribution to Affected Groups**			
Item	**Economic**	**Financial**	**Difference**	**Sector Companies**	**Labor**	**Government, Economy**	**Electricity Consumers**
Benefits							
Incremental consumption	7,565	0	7,565	0	0	0	7,565
Resource cost saving	2,394	0	2,394	0	0	0	2,394
Revenue	0	8,594	(8,594)	0	0	0	(8,594)
Costs							
Investment							
Tradable	1,474	1,469	5	0	0	(5)	0
Nontradable	2,537	2,537	0	0	0	0	0
Local skilled labor	1,094	1,094	0	0	0	0	0
Local unskilled labor	32	42	(11)	0	11	0	0
Foreign skilled labor	339	338	1	0	(1)		
Foreign unskilled labor	218	290	(72)	0	72		
Fuel	237	236	1	0	0	(1)	0
Taxes and transfers	0	2,973	(2,973)	0	0	2,973	0
O&M							
Tradable	105	105	0	0	0	0	0
Nontradable	181	181	0	0	0	0	0
Local skilled labor	78	78	0	0	0	0	0
Local unskilled labor	2	3	(1)	0	1	0	0
Foreign skilled labor	24	24	0	1	0	0	0
Foreign unskilled labor	16	21	(5)	0	5	0	0
Fuel	17	17	0	0	0	0	0
Taxes and transfers	0	1,108	(1,108)	0	0	1,108	0
Net Benefits	3,604	(1,921)	5,526	(1,921)	87	4,074	1,365

() =negative, NPV = net present value, O&M = operation and maintenance.
Source: Asian Development Bank.

C. Conclusion

14. Cost–benefit calculations under the given assumptions show that the Nikachhu hydropower plant is expected to deliver significant economic benefits. The EIRR is estimated to be 17.31% when subregional benefits are excluded from consideration. The EIRR is much higher at 21.70% when subregional benefits are included. Thus, the EIRR is above the threshold in both cases. It is also resilient to significant variations in underlying parameters. The results show that the investment is economically viable and sustainable.