Validation Report
December 2018

Bhutan: Green Power Development Project

Reference Number: PVR-552
Project Number: 37399-013
Loan Numbers: 2463, 2464, and 3034
Grant Numbers: 0119 and 0141

Independent Evaluation ADB

Raising development impact through evaluation

ABBREVIATIONS

ACEF	–	Asia Clean Energy Fund
ADB	–	Asian Development Bank
ADF	–	Asian Development Fund
BEA	–	Bhutan Electricity Authority
BPC	–	Bhutan Power Corporation
CER	–	Certified Emission Reduction
CDTA	–	capacity development technical assistance
CO_2	–	carbon dioxide
DGPC	–	Druk Green Power Corporation
DHPC	–	Dagachhu Hydro Power Corporation
DMF	–	design and monitoring framework
DOE	–	Department of Energy
EIRR	–	economic internal rate of return
EMP	–	environmental management plan
FIRR	–	financial internal rate of return
GDP	–	gross domestic product
km	–	kilometer
MW	–	megawatt
PPER	–	project performance evaluation report
PPP	–	public–private partnership
PCR	–	project completion report
WACC	–	weighted average cost of capital

NOTE

In this report, "$" refers to United States dollars.

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PROJECT BASIC DATA

Project Number	37399-013	**PCR Circulation Date**	12 September 2017	
Loan/Grant Numbers	2463, 2464, 3034, 0119, and 0141	**PCR Validation Date**	Dec 2018	
Project Name	**Green Power Development Project**			
Sector and subsector	Energy	Large hydropower generation and electricity transmission and distribution		
Strategic agenda	Environmentally sustainable growth and regional integration			
Safeguard categories	Environment		B	
	Involuntary resettlement		B	
	Indigenous peoples		C	
Country	Kingdom of Bhutan		**Approved** ($ million)	**Actual** ($ million)
ADB Financing ($ million)	**ADF:**	**Total Project Costs**	**234.50**	**266.30**
	29.00 (L2464, hard-term)	Dagachhu Hydropower	201.50	234.60
	25.28 (G0119)	Rural Electrification	33.00	31.70
	1.00 (G0141)			
	39.00 (L3034, hard-term)			
	OCR:	**Loans**	**80.00**	**115.50**
	51.00 (L2463)	2463	51.00	51.00
		2464	29.00	29.40
		3034	0.00	35.10
		Grants	**26.30**	**25.00**
		0119	25.30	24.10
		0141[a]	1.00	0.90
		Borrower[b]	51.70	50.20
		Tata Power Company	21.00	21.50
Cofinancier	Austrian Export Credit Agency	**Total Cofinancing**	55.50	54.10
Approval Dates		**Effectiveness Dates**		
2463, 2464, and 0019	29 Oct 2008	2463 and 2464	13 May 2009	4 May 2009
0141	26 Dec 2008	0119 and 0141	13 May 2009	21 Apr 2009
3034	30 Sep 2013	3034	30 Dec 2013	9 Oct 2013
Signing Dates		**Closing Dates**		
2463, 2464, 0119, and 0141	13 Feb 2009	2463, 2464, and 0141	31 Dec 2013	2 Apr 2014
3034	2 Oct 2013	0119	31 Dec 2013	28 Feb 2015
		3034	31 Dec 2014	28 Jul 2015
Project Officers		**Location**	**From**	**To**
	K. Ogino	ADB headquarters	Dec 2006	Feb 2011
			Aug 2017	Mar 2018
	H. Kobayashi	ADB headquarters	Feb 2011	Jul 2012
	T. Shiihara	ADB headquarters	Jul 2012	Sep 2016
	S. Kurimoto	ADB headquarters	Sep 2016	Aug 2017
IED Review				
Director	N. Subramaniam, IESP			
Team Leader	K. Thukral, Principal Evaluation Specialist, IESP*			

ADB = Asian Development Bank, ADF = Asian Development Fund, IED = Independent Evaluation Department, IESP = Sector and Project Division, OCR = ordinary capital resources, PCR = project completion report.

Notes:

[a] Fund source is the Asian Clean Energy Fund (ACEF) established by the Government of Japan and is under the Clean Energy Financing Partnership Facility (CEFPF) administered by ADB.

[b] The borrower is the Government of Bhutan, Druk Green Power Corporation, and the National Pension and Provident Fund.

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I. PROJECT DESCRIPTION

A. Rationale

1. Bhutan's mountainous terrain, with many rivers and streams, provide abundant potential for clean and renewable hydropower. The country exports about 80% of hydropower generated to the large market in neighboring India, thus, increasing the government's revenue through taxes and dividend. This revenue is used to cross-subsidize electricity tariff for rural households, and to support socioeconomic goals (health and education) and infrastructure development (rural roads and bridges), which are closely linked to poverty reduction and inclusive economic growth. However, the unfavorable terrain made it difficult to extend grid-based supply to remote, rural regions (where only 40% of the rural households in 2008 mainly used electricity for lighting), hence, off-grid solutions were needed to provide electricity for lighting, communication, and entertainment.

2. The Green Power Development Project comprised the following: (i) implementation of the Dagachhu project—a 126-megawatt (MW) run-of-river hydropower—mostly for export to India using existing transmission interconnections, and (ii) extension of the distribution network to connect 9,586 households to the grid and provision of off-grid solar power to 116 public institutions.[1] The Dagachhu project was recognized for being the first public–private partnership (PPP) in Bhutan's power sector and the world's first cross-border project that earned Certified Emission Reduction (CER) credits under the Clean Development Mechanism defined in the Kyoto Protocol. Further, the off-grid solar power subcomponent used emerging technologies, including super-bright light-emitting diodes, lithium-ion batteries, and super capacitors as storage.[2]

3. The ordinary capital resources of the Asian Development Bank (ADB) and additional hard-term Asian Development Fund (ADF) loan proceeds were onlent to the Dagachhu Hydro Power Corporation (DHPC) to meet the need for increasing hydropower generation capacity.

The hard-term ADF loan proceed constituted part of the government's equity, which increased the public share of DHPC to 74%. The rural electrification component was supported by the ADF grant and the off-grid supply by the Asia Clean Energy Fund (ACEF) grant.

4. Bhutan's gross domestic product (GDP) was less than $1 billion in 2007, so a debt sustainability assessment—based on the framework of the International Monetary Fund and International Development Association for low-income countries—was carried out at appraisal for the $234.5 million Dagachhu project. The borrowings for this and two other hydropower projects increased the stress on debt sustainability in the short term, but the debt indicators rapidly fell below the threshold. These hydropower projects had long-term, self-sustaining export contracts and could be excluded from the debt-sustainability analysis.

B. Expected Impact, Outcome, and Outputs

5. The project's expected impact was increased cross-border power trade and domestic electricity access that could sustain inclusive economic growth in Bhutan. The envisaged outcome was expanded coverage of sustainable clean power supply. The three expected outputs[3] were to

[1] ADB. 2008. *Report and Recommendations of the President to the Board of Directors: Proposed Loans, Asian Development Fund Grant, Technical Assistance Grant, and Administration of Grant to Bhutan for the Green Power Development Project.* Manila (Loans 2463/2464-BHU and Grants 0019- and 0141-BHU).

[2] ADB. 2017. *Completion Report: Green Power Development Project in Bhutan.* Manila (Loans 2463/2464-BHU and Grants 0019 and 0141-BHU).

[3] There are three versions of the design and monitoring framework (DMF). When the additional financing was approved in September 2013, the impact, outcome, and outputs remained significantly the same as the October 2008 version in the report and recommendations of the President (footnote 1). Changes in output targets were reflected in the

have (i) the Dagachhu hydropower plant constructed, (ii) the rural electricity supply system expanded, and (iii) the management system of the Druk Green Power Corporation (DGPC) improved. The DGPC is a state-owned enterprise created in 2008, which owned four operating hydropower stations with a combined capacity of 1,480 MW and was responsible for the development of hydropower projects in Bhutan. Under the government's PPP policy, the DGPC had a joint venture with the Tata Power Company—a major company in India—to establish the DHPC as the owners that will implement the Dagachhu project.

C. Provision of Inputs

6. The project was approved in October 2008 and the ACEF grant in December 2008 following the approval of the Government of Japan. The loan, project, and grant agreements were signed in February 2009 and made effective in April–May 2009. The Dagachhu project was initially scheduled for completion by December 2012. However, its implementation was delayed mainly because (i) a major shareholder of the first-ranked bidder for the civil works contract had financial irregularity and additional time was needed to renegotiate and sign the contract with the second-ranked bidder in July 2009, (ii) unforeseen geological conditions required extra reinforcement during headrace tunnel excavation, and (iii) the tailrace tunnel that was built initially limited the plant output to 100 MW and had to be enlarged to enable a full 126 MW capacity. The project cost increase—mainly due to unforeseen geotechnical reasons—required additional financing that was approved in September 2013 (para. 7).[4] It was signed in October 2013 and made effective a week later. The ordinary capital resources and ADF loans for the Dagachhu project and the ACEF grant for off-grid subcomponent were fully disbursed by November 2013 and closed without any extension in April 2014 (and allowing time for reconciliation of payments till the end of the year).

7. The two hydraulic turbo-generators of the Dagachhu project were declared commercial in February and March 2015. However, the plant achieved full capacity in March 2016, after rectifying the tailrace tunnel at contractor's cost. Implementation took 7.5 years since loan approval compared to the envisaged 4 years at appraisal. Soon after the project's commercial operation date, the additional ADF loan, which was extended for 6 months, was closed in July 2015. The planned rural electrification subcomponent was implemented based on its original closing date. However, its closing date was extended by 14 months to allow for additional procurement, installation, and settlement of payments.

8. The estimated cost of the Dagachhu hydropower project was $201.5 million while the actual cost was $234.6 million. The 16.4% cost overrun resulted from the (i) extra reinforcement needed during the construction of the headrace tunnel, (ii) large escalation of labor and material costs, (iii) adverse change in foreign exchange rate, and (iv) higher interest during construction because of the longer implementation period.[5] The base tariff for the power sale to the offtaker from India was increased—from Rs2.4 per kilowatt-hour to Rs2.9 per kilowatt-hour[6]—to reflect the increased project cost. The additional ADF loan caused the debt-to-equity ratio of DHPC to

increased capacity of Dagachhu hydropower project and the 1-year delay in project implementation schedule. The project completion report (footnote 2) used the October 2008 DMF but changed the dates for achieving the results for the Dagachhu hydropower project by another year to reflect the actual completion date.

[4] ADB. 2013. *Report and Recommendation of the President to the Board of Directors: Proposed Loan for Additional Financing to Bhutan for the Green Power Development Project.* Manila (Loan 3043-BHU).

[5] The increase in capacity of Dagachhu hydropower project from 114 MW to 126 MW was achieved by design optimization and without an increase in cost. The cost of electro-mechanical equipment, procured under bilateral assistance, was 20% higher than the appraisal estimate.

[6] The tariff was $0.045 per kWh given the foreign exchange rate of Rs64 to Rs65 per $1 in 2017.

increase from 60:40 to 65:35. The actual cost of the rural electrification subcomponent was $31.7 million, which is about $1 million below the estimate.

9. The engineering consultant to monitor the design and construction was funded by the Government of Austria, together with the support for the main electro-mechanical package. The Bhutan Power Corporation (BPC) had adequate experience and capacity to implement on-grid rural electrification works; hence, no supervision consultant was needed. ADB approved a single-source selection of an individual international consultant to supervise the off-grid subcomponent for one that possessed the expertise on the new technologies and the experience in Bhutan. The value of the consulting services contract was $0.2 million.

10. The project's environment and involuntary resettlement were classified as category B and the indigenous people's as category C (footnotes 1 and 4). In March 2008, ADB reclassified the Dagachhu hydropower development component from environment category A to B. The main reasons were as follows: (i) it is a run-of-river design, with a dam that serves to divert the water flow, but not store it; (ii) it is located in a remote area that is not environmentally sensitive; (iii) water is returned to the river about 6 kilometers (km) downstream or to the powerhouse, and the river is not affected by variations in the water flow; and (iv) the environmental impact assessment includes an environmental management plan (EMP) through which all mitigation measures are provided and monitored. The project is a border case between categories A and B. A capacity development technical assistance (CDTA) of $1.5 million was approved for the Promotion of Clean Power Export Development.[7] The aim was to (i) enhance the capacity of DGPC and Druk Holding and Investment (holding company of DGPC) to consider the financing of hydropower projects using different options, (ii) modernize DGPC's business systems and prepare strategies for the development of hydropower projects, and (iii) assist the Department of Energy (DOE) in accelerating the development of hydropower. On completion, the technical assistance grant was rated highly satisfactory.

D. Implementation Arrangements

11. The DGPC was the executing agency and the DHPC was the implementing agency for the Dagachhu project. The commercial risk of the project was managed by selecting Tata Power Company as a strategic investor (holding 26% of the equity) and signing a long-term power purchase agreement with Tata Power Trading Corporation.[8] The main electro-mechanical equipment for the project was sourced using bilateral assistance from the Government of Austria.[9] The DOE, under the Ministry of Economic Affairs, was the executing agency for the rural electrification component while the BPC was the implementing agency for the on-grid subcomponent and the DOE for the off-grid subcomponent. The CDTA helped develop the financing strategy and action plan for hydropower development and staff from associated agencies received hands-on training in financial analysis and modeling skills. An analysis of domestic and India's power demand was carried to support the road map for hydropower development. A corporate strategic plan was developed for DHPC and a detailed operations manual that included risk management, accounting, procurement, and safeguard.

[7] This was funded by the Regional Cooperation and Integration Fund ($0.9 million) and the ADB TA funds ($0.6 million).

[8] Tata Power Trading Company traded 14.5 terawatt-hour in 2017 (and 17.3 terawatt-hour in 2016). India's power system is now fully integrated. Traders can sell electricity to customers in any part of the country or on a day-ahead basis in two power exchanges. The company also co-owned a power transmission interconnection from the southern border of Bhutan to New Delhi, where Tata Power Delhi Distribution Limited retailed electricity to consumers in Delhi region.

[9] The Government of Austria gave bilateral funds for the construction of the Basochhu hydropower project (64 MW).

Of the 84 covenants for the Dagachhu project, 59 were for the rural electrification component. All covenants were complied with.

12. The CER credits from the Dagachhu hydropower project had a duration of 7 years from April 2014. These were held by the Swedish Energy Agency under the Future Carbon Fund, a trust managed by ADB. It was a special feature of the project, however, the price and revenue from the sale of the credits are uncertain at the time of this validation as the Kyoto Protocol has not been renewed under the UN Framework Convention on Climate Change. When the power purchase agreement was renegotiated to reflect the higher project cost, it was also agreed that the Tata Power Trading Company would not purchase the CERs. Instead, it agreed to share the profit in case it sold the power at a higher price than the agreed tariff.

II. EVALUATION OF PERFORMANCE AND RATINGS

A. Relevance of Design and Formulation

13. The project completion report (PCR) rated the project highly relevant (footnote 2). It indicated that the project was fully aligned with the government's strategic priorities for accelerating hydropower development for export and providing access to electricity to rural communities to improve their lives. The PCR noted that the project was also in line with ADB's country partnership strategy, which aimed to support government priorities and to enhance cross-border energy trade in the region.[10] This would enhance inclusive economic growth in an environmentally sustainable manner and enhance energy security. The project was consistent with the Ninth Five-Year Plan of Bhutan, which aims to facilitate the export of power and provide electricity to about 15,000 rural households.[11]

14. The project has some transformative characteristics. The introduction of the PPP model improved the governance structure and brought commercial principles into the DHPC functions. The off-grid rural electrification subcomponent used emerging technologies (including super-bright light emitting diodes, lithium-ion batteries, and super capacitors for energy storage) that extended the life and increased the efficiency of the lighting service. The project demonstrated the effective use of these emerging technologies, which have since then been widely used in several countries across the globe. The project was implemented as envisaged, including the increase in hydropower capacity by 10% during design optimization. The attached CDTA was implemented well and the staff in the DOE, DGPC, and other related agencies were able to increase their knowledge and relevant skills. This validation rates the project highly relevant.

B. Effectiveness in Achieving Project Outcome and Outputs

15. Following minor changes in the design and monitoring framework (DMF) when additional financing was approved in 2013, the final project outcome indicators and targets were (i) the national electrification ratio for rural and urban households increased from 60% (2007) to 84% (2012); (ii) the hydropower export revenue as share of total government revenue increased from 40% (2007) to 45% (2013); (iii) the size of PPP hydropower increased by 1,314 MW by 2014; (iv) annual carbon dioxide (CO_2) emission reduced through power export of 0.5 million tons from 2013 onwards; and (v) power system losses maintained below 10%, and the financial health of power company stabilized as indicated by debt-service coverage ratio (minimum 1.2) and net profit.

[10] ADB. 2005. *Country Strategy and Program: Bhutan, 2006–2010*. Manila.
[11] Royal Government of Bhutan, Planning Commission. 2002. *Ninth Five-Year Plan (2002–2007)*. Thimphu.

16. The final output indicators and targets had three components—the Dagachhu project, rural electrification, and DHPC management improvement. The Dagachhu project had the following targets: (i) project (126 MW) constructed by 2013, (ii) construction of the 19 km transmission line for evacuating the power from the project to the existing power grid completed by 2012, and (iii) export of clean and renewable energy to India increased by 500 gigawatt-hour after 2013. The rural electrification target was to have the grid supply extended to 8,767 additional rural households and to have off-grid electrification of 119 public institutions (schools, health clinics, and other community facilities) undertaken. The DHPC management targets were to have (i) corporate policy adopted by 2009 and management information system by 2011, (ii) hydropower development policy implemented by 2012 through two projects with public and/or private investments, and (iii) financial and engineering assessment done for Nikachhu (210 MW) and Khomachhu (326 MW) hydropower projects and completed before 2011.

17. According to the PCR, all targets were achieved or exceeded, and the project was rated highly effective. Together with activities under other parallel projects, 99% of households had access to electricity by December 2016. Over 3,000 MW of hydropower capacity was under construction in 2017. The level of CO_2 avoided due to power export was almost 0.5 million tons in 2015. Although revenues from hydropower export did not increase by as much as the increase in total government revenue (178%), the hydropower export revenue still increased by almost 130% between 2007 and 2015. Physical outputs were also achieved in the (i) Dagachhu project with 126 MW capacity completed, (ii) power export to India increased by 497 gigawatt-hour in 2015 (0.6% below target), (iii) number of households connected through the rural electrification subcomponent at 9,586 (or 9% higher than the target), and (iv) 162 sets of solar system provided for the electrification of 116 public institutions under the off-grid electrification subcomponent.

18. The project safeguard performance is rated satisfactory for environment and involuntary resettlement.[12] The mitigation measures identified in the EMP were adequate and implemented well during the construction of the Dagachhu project.[13] Local authorities regularly monitored the implementation and monitoring reports were submitted biannually to ADB. The Summary of Initial Environment Examination identified relevant regulatory requirements and potential direct, indirect, cumulative, and induced environmental impacts in consultation with stakeholders. Pollution prevention and abatement was deemed satisfactory in terms of air emissions, while effluents and waste management were also deemed overall satisfactory. As a renewable energy clean development mechanism project, the Green Power Development Project exceeded ADB's benchmarks in the power sector with the CO_2 emission reduction estimated at 0.5 million tons annually.

19. A fish ladder was constructed for the migration of one fish species and environmental flows are being maintained, but the monitoring of information on upstream migrant fish population was not evident. Site restoration works were mostly completed; the contractor was expected to complete the works at the last site by March 2018, which was within the warranty period and covered by adequate security deposit. The DHPC also initiated a tree plantation program as part of compensatory afforestation program every year. At the end of civil works, the environmental restoration for the dumping yards and stabilization works took place.

20. The project complied with ADB standards and with host country laws and regulations. The Short Resettlement Plan was adequate and ensured affected persons' entitlements to compensation and rehabilitation measures. Compensation, assistance, and benefits for affected

[12] ADB (Independent Evaluation Department). 2018. Safeguard Performance and ADB's Safeguard Work Quality: Green Power Development Project in Bhutan. 9 April (internal).

[13] The project included an adequate Environmental Impacts and Mitigation Matrix and Monitoring Plan. Biodiversity conservation and sustainable natural resource management materially met ADB's safeguard requirements.

persons were satisfactory, but there were serious information gaps on indicators and project performance 2 years after the resettlement activities. The project areas and surroundings had no settlement records of ethnic groups or indigenous peoples. The concerned ministry monitored the felling of trees, the use of manual labor for construction in forests minimized the impact of rural electrification, while encroachment into the wildlife was restricted and adverse impacts were reported. All 25 affected landowners chose to accept alternate government land of equal value. Local jobs were created, bus service was provided for schoolchildren traveling 16 km, and awareness was raised for common health issues. The local community expressed satisfaction and support for the project.

21. The achievement of some targets was not elaborated in the PCR, such as the (i) power system losses, (ii) financial health of the power sector, (iii) adoption of corporate policy and management information system, (iv) assessment of two hydropower projects with aggregate capacity of 536 MW, and (v) basic information of two further sample hydropower projects to be developed with public and/or private investments. According to a 2017 tariff report of Bhutan Electricity Authority (BEA),[14] the allowable transmission losses was 4.5% and the actual losses are expected to be about the same—well below the DMF target of 10%. Nothing adverse is indicated in the annual report of BPC, it has declared dividends as expected in 2015 and 2016 and the debt service coverage ratio was 6.45 in 2016.[15] Nikachhu and Kholongchhu hydropower projects are being implemented under the PPP model, and a Norwegian consultant carried out the pre-feasibility study of Khomachhu hydropower project.

22. Other than the 9% overachievement of the rural household electrification target, there is little to unequivocally support the highly effective rating for the project.[16] The BEA report (footnote 14) indicates that five hydropower projects with 3,658 MW capacity were under construction, however, only 718 MW of this (or 55% of DMF target) were being implemented using the PPP model while the remaining were following the bilateral route. The increase in capacity of the hydropower project from 114 MW to 126 MW cannot be considered an overachievement as the DMF was revised when additional financing was approved in 2013. Without clear evidence of overachievement, this validation the rates the project effective.

C. Efficiency of Resource Use

23. The economic internal rates of return (EIRRs) for the hydropower subcomponent were determined separately. It was 19.5% in 2013 during the approval for additional financing and 24.8% at project completion in 2017. The EIRRs for the rural electrification component at appraisal was 13%–26% for different feeders, and 14.3% when recalculated at project completion. There was a delay of 1–2 years in achieving the targets.[17] The PCR rated the project efficient.

24. For the economic analysis of the Dagachhu project, the cost was based on the actual project cost. The benefits were from the (i) incremental sale to consumers in Bhutan (12% of the generation), which were valued at the willingness-to-pay of various consumer categories; and (ii) non-incremental benefit from the resource cost savings. The power exported to India (88% of the generation) was also an incremental benefit that was valued at the agreed

[14] Bhutan Electricity Authority. 2017. *Bhutan Power Corporation, 2016–2019, Tariff Review Report.* Thimpu.
[15] Bhutan Power Corporation. 2017. *Annual Report 2016.* Thimpu.
[16] Based on the information provided in a March 2013 loan review mission report, the access to electricity of 9,586 households has been attributed to the project. Yet, the *Bhutan Statistical Yearbook* 2017 mentions that the power generation from Dagachhu hydropower project was 350 GWh in 2015, and the export in 2014 was unusually low (478 GWh less than 2013), so the increase in export by 497 GWh claimed in 2015 cannot be attributed solely to the project.
[17] Footnote 2, para. 38.

tariff in the power purchase agreement. A review of the Excel file with EIRR calculation during validation revealed that the incremental benefit from the sale of power to consumers in the domestic category has been considerably overestimated.

25. To obtain a ballpark estimate of the EIRR, the calculation was revised with simplified assumptions—only the incremental benefits from the sale within Bhutan and the export to India were considered. The willingness-to-pay within Bhutan was estimated according to the possible alternate means for obtaining power such as a solar and battery system in the domestic category and diesel-based power generation for others. The benefit from exporting power to India was valued at the agreed tariff in the power purchase agreement.[18] Thus, the EIRR was conservatively estimated as 17.7%. However, the combined EIRR for all project components (hydropower project with grid interconnection, providing electricity access to households by extending the grid, and providing off-grid solutions to public institutions) should have been computed. Nonetheless, given that each component shows an EIRR comfortably above the 12% threshold, this validation rates the project efficient.

D. Preliminary Assessment of Sustainability

26. The financial internal rate of return (FIRR) for the hydropower component was determined in 2013 and recalculated at project completion. The methodology was the same. It was recalculated, in real terms, as 3.8% compared to the weighted average cost of capital (WACC) of 2.4%. The value was better than what was projected in 2013—which were an FIRR of 2.6% and a WACC of 1.6%. The DHPC's return on equity was recalculated as 14.9% (after-tax basis) compared to 12% at project appraisal. The debt-service coverage ratio was above 1.3 in 2016 and will remain at the level till the debt is repaid, which indicated that the company would have sufficient cash flow for operating expenses and debt-service payments. The PCR rated the project most likely sustainable. A review of the FIRR calculations revealed that the estimate was conservative as only the revenue from power export was considered.[19] Although DHPC provided 12% of the output from the Dagachhu project free and at no cost to Bhutan as royalty, it is sold to consumers by the BPC so the revenue needs to be reflected in the benefits. Using simplified assumptions for share of power sold and average tariff for various consumer categories, the inclusion of revenue from the sale of power within Bhutan increased the FIRR to 4.9%.

27. At appraisal, the FIRR of the rural electrification component was calculated as –5.99% with WACC as 0.2%, which made it financially unviable. However, it was clarified that BPC was compensated for the loss in rural electrification by a cross-subsidy from the royalty energy.[20] The cost-recovery tariff approach was confirmed during project completion. The rural electrification component remained unsustainable but the tariff for power consumed within Bhutan and the wheeling charges for power exported to India were maintained at a level that ensured BPC's good financial health. Thus, BPC consistently declared dividends and its debt-service coverage ratio was 7.32 in 2015 and 6.45 in 2016. This validation holds the view that the tariff regime will enable BPC operations to be sustainable. However, given the subsidy in rural electrification component, and the absence of any discussion in the PCR on institutional sustainability aspects, this validation rates the project likely sustainable.

[18] If the willingness-to-pay for India's consumers was used instead of the PPA tariff, the result will be an EIRR on a regional basis. Information about India's consumers are not available in the PCR.

[19] In the Excel file, the export tariff was reduced annually by 3% without explanation; this further lowered the FIRR.

[20] In 2016 (footnote 14), for its power sale to consumers in Bhutan, BPC purchased 2,085 GWh, of which 1,122 GWh (54%) was royalty energy. This indicates that the government has room to adjust BPC's cost of electricity purchase, which accounts for 15% of the total expenditure. In fact, if the expenditure for construction contracts was removed (it is not a regular function of the company), power purchase cost amounts to 35% of the total expenditure.

III. OTHER PERFORMANCE ASSESSMENTS

A. Preliminary Assessment of Development Impact

28. The PCR rated the development impact of the project highly satisfactory based on the completion of the hydropower project and the high electrification ratio achieved. The clean hydropower exported to India displaced hydrocarbon-based power generation and the use of electricity in Bhutan displaced the use of firewood and kerosene in households. Revenues from power export will be available to the government for allocation to socioeconomic causes long after the project loans have been repaid. The PPP model demonstrated by the project has been replicated in two other hydropower projects, the more recent one being the Kholongchhu hydropower project with 600 MW capacity estimated to cost over $630 million. Similarly, the impact of expanding rural electrification lowered indoor pollution, helped improve the quality of life, and provided economic opportunities.

29. The project's development impacts cut across all three of ADB's strategic agenda—inclusive economic growth, environmentally sustainable growth, and regional integration. First, the impact indicator in the DMF, which was to increase the energy sector's share to GDP from 25% in 2007 to 40% by 2017, remained virtually unchanged until 2015 as the 90% increase in the energy sector's GDP was overshadowed by the 156% increase in overall GDP. Second, by the time the PCR was finalized, it was not clear whether the energy share in government revenue, which was targeted to increase from 45% (2007) to 75% (2020) through clean power export to India will be achieved. This will depend on the progress of large hydropower projects being implemented under bilateral agreements with India. Third, the planned increase in the use of electric lighting from 40% (2007) to 100% (2013) among rural households was achieved, with over 99% of the households having access to electricity through grid extension and off-grid solar home system. Based on these achievements, this validation rates the development impact satisfactory.

B. Performance of the Borrower and Executing Agency

30. The PCR rated the borrower and executing agency performance highly satisfactory. The loans and grants became effective in a timely manner and disbursement was generally according to schedule. The DGPC and DHPC provided appropriate support to resolve issues—such as negotiating the civil works contract with the second-ranked bidder, obtaining additional financing for the extra works related to the headrace tunnel, and rectifying the tailrace tunnel without extra cost. The inputs of the CDTA were incorporated in the business systems of the companies. Tata Power Company, the joint-venture partner, provided advice and support when needed. Both the DOE and BPC have adequate capacity to design and implement rural electrification plans. This validation rates the borrower performance highly satisfactory.

C. Performance of the Asian Development Bank and Cofinanciers

31. The PCR considered the performance of ADB and the cofinancer—the Austrian Export Credit Agency—highly satisfactory. Designing four ADB loans and grants and the timely approval of the additional financing helped to successfully complete the construction of the hydropower project. ADB's safeguard work quality at approval was satisfactory. It complied with ADB's Environment Policy (2002) and Environmental Assessment Guidelines (2003) at appraisal. It reclassified the run-of-river design hydropower development component from environment category A to B due to environmental impacts associated with hydropower development, and being located in a remote area that is not environment sensitive. Key loan covenants included requirements aimed to comply with relevant ADB policies and applicable Bhutan laws and

regulations. Additional covenants addressed biodiversity, occupational health and safety, and cultural heritage aspects.

32. ADB's safeguard work quality at supervision was satisfactory at the lower range [21] but materially met ADB requirements and kept itself sufficiently informed. A survey was planned in the Short Resettlement Plan, but this was not found among the project documentation. The safeguards monitoring report adequately addressed EMP requirements and provided ADB sufficient information on project progress and compliance with regulatory requirements regarding ADB's environment safeguards. However, ADB should have urged better reporting on the resettlement activities and ensured that the post-resettlement survey was disclosed (footnote 12). This validation considers ADB's performance satisfactory.

IV. OVERALL ASSESSMENT, LESSONS, AND RECOMMENDATIONS

A. Overall Assessment and Ratings

33. The PCR gave the project an overall rating of highly successful; the table below summarizes the performance ratings. It was highly relevant to the strategies and priorities of ADB and to the government for accelerating hydropower development for power export, the almost 100% electrification of all households, and the transformative use of technology. As the PCR noted, although it achieved or exceeded the outcome and output targets, there is lack of evidence that it exceeded the targets. The project was efficient as it was implemented as designed, and the EIRR for the hydropower project was 19.5% and the rural electrification component was 14.5%. Sound arrangements are in place for power export from the Dagachhu project. The FIRR was also well above the WACC. The rural electrification component was unsustainable but the cross-subsidy and BEA's tariffs and wheeling charges ensured BPC's financial health.

Overall Ratings

Validation Criteria	PCR	IED Review	Reason for Disagreement and/or Comments
Relevance	Highly relevant	Highly relevant	
Effectiveness	Highly effective	Effective	There is lack of evidence for overachievement of targets.
Efficiency	Efficient	Efficient	
Sustainability	Most likely sustainable	Likely sustainable	Institutional sustainability was not discussed despite subsidies.
Overall assessment	**Highly successful**	**Successful**	
Preliminary assessment of impact	Highly satisfactory	Satisfactory	Of the three impact indicators, the targets for two could not be achieved or could not be determined at the time of project completion.
Borrower and executing agency	Highly satisfactory	Highly satisfactory	
Performance of ADB	Highly satisfactory	Satisfactory	ADB should have urged better reporting on the resettlement activities.
Quality of PCR		Satisfactory	Para. 39.

ADB = Asian Development Bank, IED = Independent Evaluation Department, PCR = project completion report.
Source: ADB (IED).

[21] The safeguard specialist rated it as weak satisfactory, which is deemed to be the equivalent of "satisfactory," but at the lower end." Hence, the rating of "satisfactory."

B. Lessons

34. **Project-level lessons.** The PCR identified these two, as follows: (i) the cost of construction of hydropower projects depend greatly on the actual geotechnical conditions, which in this case were very difficult and expensive to assess during appraisal; and (ii) mid-scale hydropower projects required thorough risk assessment and monitoring of environmental impacts during implementation. This validation agrees with these lessons. The PCR also identified additional lessons found below.

35. **Country-level lesson**. The PPP model can help finance relatively large infrastructure projects that directly increase export and government revenue. This approach is particularly relevant in developing countries with weak private sector participation in infrastructure and which lack the capacity for commercial borrowing because of debt sustainability considerations. Some examples of countries in a similar situation are the Kyrgyz Republic, the Lao People's Democratic Republic, Nepal, and Tajikistan where large hydropower potential can be developed to increase their power exports using the PPP model.

36. **Sector-level lessons.** First, the use of cross-subsidy and innovative technologies for renewable energy and electricity storage are effective in rapidly expanding electricity access for remote communities. This is critical in countries having mountainous terrain and archipelagos that require large investment to expand the distribution network.[22] Second, the DMF targets need to be project related. It used a target for impact indicator that linked project output to government revenue. While it is possible to reasonably forecast results, the government revenue may change for reasons unrelated to the project or the sector, as seen in this case.[23]

C. Recommendations for Follow-Up

37. The PCR recommended that ADB should (i) monitor the policy and implementation of cross-border power trade to ensure that access to the large market is not curtailed, (ii) consider the risks related to geotechnical uncertainties in the design and cost estimate of hydropower projects, and (iii) identify suitable mitigation strategies. The project performance evaluation report (PPER) also needs to be delayed till the Dagachhu project has completed at least 3 years of operation. This validation agrees with the recommendations but notes that the project needs to be in operation for 5–7 years to get reasonable assessment of the mean annual and seasonal water discharge, and to forecast the power generation levels and export revenue that depended on the hydrology and seasonal electricity prices in the power exchanges with India.

V. OTHER CONSIDERATIONS AND FOLLOW-UP

A. Monitoring and Reporting

38. The DHPC closely monitored the implementation of the hydropower project. The monitoring was effective as issues with procurement and civil works were flagged in time and appropriately resolved without unduly delaying project implementation. A specially created environment unit in the DHPC ensured that all contractors implemented the environmental action and resettlement plans. The BPC monitored the implementation of the on-grid rural electrification subcomponent, which was implemented ahead of schedule, and loan savings were diverted to

[22] Super capacitors were used for electricity storage in remote communities for the off-grid subcomponent of the project. It is an internationally innovative approach and it significantly increases the efficiency, cost, and life of energy storage for lighting, i.e., when the power requirement is nominal. This helps in obtaining feedback on the technology especially when its use is being considered in other off-grid electrification projects.

[23] The relevance of this lesson is low as impact indicator has been eliminated in the 2016 ADB Guidelines for Preparing a Design and Monitoring Framework.

extend electrification in other remote areas. According to the PCR, the quarterly progress, project midterm, and completion reports were submitted to ADB.

B. Comments on Project Completion Report Quality

39. The quality of the PCR is rated satisfactory. There was a good description of project outcome, outputs, and achievement of targets. Project implementation issues were explained, particularly the geotechnical problem, which needed the construction of the headrace tunnel that required additional financing. The contributions of the executing and implementing agencies, cofinancer, suppliers, contractors, and consultants were recognized. Improvement of the EIRR and FIRR recalculation was possible and it would have helped to include summaries as appendixes to support the ratings.

C. Data Sources for Validation

40. Data sources for this validation include the report and recommendation of the President, the PCR, loan review mission reports, project safeguard assessment, national and country strategies, and some external reports that have been cited.

D. Recommendation for Independent Evaluation Department Follow-Up

41. A full appreciation of project impacts will be possible by preparing the PPER by 2022. It will provide an opportunity to confirm the estimates of annual power production and revenues earned from power export. Discussions with the government and information on the country's budgets will reveal how the export proceeds helped improve economic and social indicators. Similarly, household survey data will reveal how rural electrification touched the lives of the common people. The PPER will also reveal if there were any negative environment or social impacts during the regular operation of the hydropower project.