Technical Assistance Report

PUBLIC

Project Number: 56163-001
Knowledge and Support Technical Assistance (KSTA)
December 2022

Kingdom of Bhutan: Promoting Energy Security and Transition Project

Asian Development Bank

CURRENCY EQUIVALENTS
(as of 15 November 2022)

Currency unit	=	ngultrum (Nu)
Nu1.00	=	$0.01235
$1.00	=	Nu80.9455

ABBREVIATIONS

ADB	–	Asian Development Bank
DGPC	–	Druk Green Power Corporation
MW	–	megawatt
TA	–	technical assistance

NOTE

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

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CONTENTS

KNOWLEDGE AND SUPPORT TECHNICAL ASSISTANCE AT A GLANCE

1. Basic Data — **Project Number:** 56163-001

Project Name	Promoting Energy Security and Transition Project	**Department/Division**	SARD/SAEN
Nature of Activity	Capacity Development	**Executing Agency**	Department of Energy, Ministry of Economic Affairs
Modality	Regular		
Country	Bhutan		

2. Sector	**Subsector(s)**	**ADB Financing ($ million)**
✓ Energy	Renewable energy generation - solar	1.000
	Total	**1.000**

3. Operational Priorities

- ✓ OP2: Accelerating progress in gender equality
- ✓ OP3: Tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability
- ✓ OP6: Strengthening governance and institutional capacity

Climate Change Information

GHG Reductions (tons per annum)	0
Climate Change impact on the Project	Low

ADB Financing

Adaptation ($ million)	0.200
Mitigation ($ million)	0.800

Cofinancing

Adaptation ($ million)	0.000
Mitigation ($ million)	0.000

Sustainable Development Goals

SDG 1.4
SDG 5.a
SDG 7.2, 7.b
SDG 9.b
SDG 10.3
SDG 13.a

Gender Equity and Mainstreaming

Some gender elements (SGE) ✓

Poverty Targeting

General Intervention on Poverty ✓

4. Risk Categorization Low

5. Safeguard Categorization Safeguard Policy Statement does not apply

6. Financing

Modality and Sources	Amount ($ million)
ADB	**1.000**
Knowledge and Support technical assistance: Technical Assistance Special Fund	1.000
Cofinancing	**0.000**
None	0.000
Counterpart	**0.000**
None	0.000
Total	**1.000**

Currency of ADB Financing: US Dollar

I. INTRODUCTION

1. The knowledge and support technical assistance (TA) aims to help Bhutan diversify renewable energy sources and promote energy transition to more resilient energy systems with novel technologies, new approaches, and concrete strategies. Bhutan's energy is dependent on a single resource—hydropower—export revenues of which sustain the national economy and the government's revenues. This suggests that Bhutan is vulnerable to any impacts of climate change on hydropower resources. To alleviate concerns on energy security and climate change, it is necessary to diversify energy resources and build resilience. Hence, the TA will support the development of new schemes for rooftop solar photovoltaic and floating solar photovoltaic systems, and the required knowledge enhancement among stakeholders. The studies will assess the resource and technical design requirements, financial and economic viability measurements, business models, safeguards, and regulation and policy formation on alternative energy resources. The TA is anchored in the country partnership strategy for Bhutan, 2019–2023,[1] in which the Asian Development Bank (ADB) will help the government to reform policies to promote the efficient use of renewable energy and invest more in alternative renewable energy sources, including solar power, biogas, and wind power.

II. ISSUES

2. **Climate and energy security.** Bhutan's key economic drivers are hydropower export, tourism, and agriculture. Although tourism was significantly affected by the coronavirus disease (COVID-19) pandemic, hydropower exports have remained relatively stable, and the resultant foreign currency earning has been sustained. During 2020–2021, hydropower exports represented about 50% of the total exports.[2] However, hydropower generation is dependent on the availability of water resources, which can vary by weather and climatic conditions. This means that Bhutan's high dependency on hydropower (99.7%) renders the country vulnerable to climate change impacts, thereby raising energy security concerns.

3. In 2021, Bhutan's peak demand was 487 megawatts (MW) against the total installed capacity of 2,342 MW. However, all the existing plants are run-of-the-river schemes, which have a limited amount of the water storage capacity. As a result, the total generation drops to about 400 MW during the dry season (December–March) because of low river inflows, resulting in a power deficit that has to be supplemented through import from India. The seasonal power shortages are expected to increase significantly over the upcoming lean seasons. This is because (i) domestic demand continues to increase at around 9% annually and industry sector demand growth has outpaced the generation capacity addition,[3] (ii) it takes time to install additional hydropower plants, and (iii) there are no other power sources that can be developed quickly

[1] Asian Development Bank (ADB). 2019. *Country Partnership Strategy: Bhutan, 2019–2023—Fostering Diversification and Reducing Disparities.* Manila. The TA is expected to contribute to the ADB Strategy 2030 operational priorities, including (i) operational priority 2: accelerating progress in gender equality; (ii) operational priority 3: tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability; and (iii) operational priority 6: strengthening governance and institutional capacity. The TA first appeared in the business opportunities section of ADB's website on 21 September 2022.

[2] Ministry of finance, Government of Bhutan. 2022. *National Budget Financial Year 2022-2023, Budget Report for FY2022-23*. Thimphu. In 2019, hydropower exports represented 33% of the total exports.

[3] Since Bhutan's electricity prices are cheaper than in neighboring countries, energy-intensive industries such as ferro-silicon and cement have been established in Bhutan. This demand growth was anticipated but the supply side capacity addition has not taken place, mainly because of unexpected delays of two mega run-of-the-river hydropower projects—the Punatsangtsu-I (1,200 MW) and the Punatsangtsu-II (1,020 MW). Bhutan is likely to experience continued seasonal power shortages against the winter peak demand given the existing plans for increased power supply requirements from industry customers.

domestically besides electricity import from the Indian short-term power trading market. In the winter of 2021–2022, Bhutan recorded the highest power shortage, which was met by power import from India (with a daily import average of 150–200 MW equivalent). The power import prices have already been more expensive than the power export tariffs. Bhutan envisages power import from India of more than 400–600 MW for December 2022–April 2023 and the import quantum and price will continue to increase to 2030 and beyond. To mitigate the climate and resultant energy security risks, Bhutan will be required to rapidly develop alternative clean energy sources that can be developed and installed quickly while exploring hydropower investments to ensure long-term energy self-reliance.

4. **Energy diversification.** Being concerned about climate and energy security, the government intends to diversify energy sources to improve energy independence. Bhutan's Sustainable Hydropower Development Policy, 2021 aims to enhance energy security and develop value chains based on alternative clean energy.[4] The global costs of renewable energy technologies such as solar and wind power have fallen steadily over the decade. Their gestation and construction periods are much shorter than that of hydropower. Further, solar and wind power often have different generation profiles and patterns during the year and daytime, which can complement hydropower (e.g., in the dry seasons the river water flows reduce while sunny days continue). Thus, government plans to fast-track solar development up to 400 MW over the next 3 years, and the Druk Green Power Corporation (DGPC) has been directed to take a lead in adding such capacity as the state-owned generation company.[5] For this purpose, ADB decided to finance Bhutan's first utility-scale solar photovoltaic power plant (17.38 MW) at Sephu in central Bhutan in 2022,[6] and intends to support subsequent similar ground-mounted solar power projects in other locations. Solar power will compensate for power deficits in the lean seasons and increase hydropower export in the wet seasons when the additional solar power generation can be used for domestic consumption. Given the comparative advantage of the complementarity between solar power and hydropower generation, solar power development can be promoted faster and diversified further from just ground-mounted solar photovoltaic power to floating solar and rooftop solar power generation.

5. Floating solar power generation is particularly suited to Bhutan's existing hydropower reservoir areas, which keep the river water running in all seasons. The advantages include: (i) it has higher generation efficiency than ground-mounted solar generation because of the cooling effect of the water surface, (ii) it makes use of the limited available flat space in this mountainous country, (iii) there is no land acquisition requirement or conflict with fishing purposes, (iv) there is close access to grid systems within the premises of the hydropower stations, and (v) operations are complementary to hydropower generation. Rooftop solar can also be expanded in urban areas to buildings and houses for various applications such as electricity and water heating. Given the nascent stage of solar power development in Bhutan, this new technological and business area can be demonstrated by the public sector to gradually boost private sector mobilization and create new job opportunities, particularly for women for operation and maintenance activities. Thus, the alternative domestic energy resources will help Bhutan increase opportunities for investments and employments while promoting energy transition.

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[4] Government of Bhutan, Ministry of Economic Affairs. 2021. *Bhutan Sustainable Hydropower Development Policy, 2021*. Thimphu.

[5] There are two power utilities in Bhutan. The DGPC is responsible for power generation, and the Bhutan Power Corporation is responsible for power supply as the state-owned transmission and distribution company. While the Bhutan Power Corporation has its own generation assets, including small and mini hydropower and wind power plants, these assets were transferred to the DGPC in 2022 to demarcate clear functions between these two utilities.

[6] ADB. 2022. *Proposed Loan and Grant to the Kingdom of Bhutan: Renewable Energy for Climate Resilience Project*. Manila.

III. THE TECHNICAL ASSISTANCE

A. Impact and Outcome

6. The TA is aligned with the following impact: Bhutan's diversification of clean energy sources promoted.[7] The TA will have the following outcome: readiness for project development in clean energy resources enhanced.[8]

B. Outputs, Methods, and Activities

7. **Output 1: Floating solar development plans prepared.** The surface area of the existing hydropower plant reservoirs is around 140 hectares. In Bhutan, the reservoirs are owned by the DGPC but have been used only for power generation rather than irrigation, drinking water, recreation, or fishing. The surface of the reservoirs is open and available for floating solar to generate 28–42 MW of power. Thus, the TA will examine the technological feasibility, financial viability, and safeguard impacts of existing reservoirs to assess the appropriate design of floating solar facilities and related grid connections.[9] The TA will also assess disaster risk resilience and climate-adaptative design against flood, drought, and glacial lake outburst flood. The studies will prepare an investment plan of floating solar development in the reservoirs of the existing hydropower stations as well as three hydropower plants under construction to maximize the use of these reservoirs in a phased approach.[10] The TA will also prepare the technical guidelines for installation, operation, and maintenance of the floating solar facilities.[11]

8. **Output 2: Rooftop solar business and financing models developed.** The TA will assess rooftop solar resources and its business potential and develop a phased investment plan based on the resource assessment and development plan. For example, about 1,500 government buildings in Thimphu can be the first target for the rooftop solar to demonstrate initial development.[12] Subsequently, it can be extended to other cities, and commercial and industrial segments as well as residential houses in a phased manner. Energy efficiency opportunities will also be identified in building designs for lighting and space and water heating equipment. While the TA studies various business models, the DGPC will implement the first schemes through the feasibility assessment, commercial contract, bulk procurement, installation, and operation and maintenance support. Opportunities for women to operate and maintain the rooftop solar installations will be assessed through a gender equality and social inclusion approach, and gender action plans will be prepared. The rooftop solar pricing and incentive mechanisms as well as regulations will be studied with the Bhutan Electricity Authority and the Department of Energy of

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7 Footnote 3; and Government of Bhutan, Ministry of Economic Affairs. 2013. *Alternative Renewable Energy Policy, 2013. Thimphu.*

8 The design and monitoring framework is in Appendix 1.

9 In designing floating solar installations, the reservoir scouring, and daily peaking operations will be taken into account.

10 The existing hydropower plants are Basochhu (64 MW), Chhukha (336 MW), Dagachhu (126 MW), Kurichhu (60 MW), Tala (1,020 MW), and Mangdechhu (720 MW). The hydropower plants under construction are Punatsangchhu-I (1,200 MW), Punatsangchhu-II (1,020 MW), and Nikachhu (118 MW).

11 The guideline will include a lifespan operation and maintenance of solar photovoltaic panels and their waste recycling and disposal systems. This will also apply for rooftop solar photovoltaic panels and their waste.

12 The rooftop solar facilities can include ground-mounted solar schemes within the premises of some specific facilities. The project's scope can be extended to pilot ground-mounted solar power and rooftop solar schemes, which have been planned by His Majesty's Secretariat Office's Royal Society for Science Technology Engineering and Mathematics. The main scope will cover government buildings in Thimphu and Paro as well as the DGPC's own buildings.

the Ministry of Economic Affairs. The TA will also prepare the technical guidelines for installation, operation, and maintenance of rooftop solar facilities.

9. **Output 3: Floating and rooftop solar development knowledge sharing and awareness improvement among stakeholders promoted.** Various capacity building and knowledge sharing activities will be integrated to increase awareness of stakeholders on development and promotion of new types of solar power. The stakeholders will include potential public and private solar power producers and consumers, as well as "prosumers", who produce and consume electricity generated by rooftop solar photovoltaic systems. Through solar power development, the TA will disseminate the benefits of prosumers on the demand side.[13] The awareness improvements will focus on learning opportunities from other countries on technologies, markets, business models, stakeholder coordination, policies, and regulations. The TA will also introduce the use of solar power photovoltaic panels with other business activities for multiple purposes.[14] The workshops and/or physical site visit will be programmed to share lessons learned from TA findings and applications, build stakeholder knowledge and awareness, and explore how to implement and scale up innovative schemes of floating and rooftop solar power development.[15] In the knowledge sharing and awareness improvement workshops, female participants will be encouraged. Knowledge products will also be prepared.

10. As ADB's value addition, the TA will look into advanced technologies, appropriate business modeling, and future private sector development. Technical guidelines can also be provided to standardize technical specifications and safety requirements for any public and/or private investors. Knowledge sharing and capacity development will be conducted to improve awareness in government organizations, private parties, local communities, and civil society organizations based on similar practices in other countries.[16]

C. Cost and Financing

11. The TA financing amount is $1,000,000, which will be financed on a grant basis by ADB's Technical Assistance Special Fund (TASF 7). The key expenditure items are listed in Appendix 2. The government will provide counterpart support in the form of counterpart staff and other in-kind contributions.

D. Implementation Arrangements

12. ADB will administer the TA. ADB South Asia Department's Energy Division will select, supervise, and evaluate consultants, and organize workshops.

13. The executing agency will be the Department of Energy of the Ministry of Economic Affairs. The implementing agency will be the DGPC. Other relevant agencies will be the regulator (the Bhutan Electricity Authority), the distribution and transmission utility (the Bhutan Power Corporation), Druk Holding Investment, and His Majesty's Secretariat Office.

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[13] As prosumers, the solar rooftop's owners may get earnings from excess solar power sales to power utilities on a gross metering basis, or on a net metering basis where electricity produced is deducted from the total electricity consumed. Bhutan is drafting the metering policy where the feed-in tariffs will play a crucial incentive role in attracting investments in rooftop solar.

[14] For example, the solar photovoltaic panels have been placed on carports, which are the shelters of car parking areas, to use vacant space more effectively. They can also be used on agricultural land (so-called solar farms), where crops are grown underneath the solar panels.

[15] Since there are no existing floating solar facilities in Bhutan, a site visit can be considered to learn any lessons from the recent practices of other countries (e.g., the Republic of Korea may be considered for this purpose).

[16] ADB's guidelines and guidance notes will be referred to when required.

14. Implementation arrangements are summarized in the table.

Implementation Arrangements

Aspects	Arrangements		
Indicative implementation period	February 2023–January 2026		
Executing agency	Department of Energy, Ministry of Economic Affairs		
Implementing agency	Druk Green Power Corporation		
Consultants	To be selected and engaged by ADB		
	Firm: QCBS (90:10)	International and national consultants (29 person-months)	$950,000[a]
Disbursement	Disbursement of TA resources will follow ADB's *Technical Assistance Disbursement Handbook* (2020, as amended from time to time).		

ADB = Asian Development Bank, QCBS = quality- and cost-based selection, TA = technical assistance.
[a] Includes a contingency of 4%.
Source: ADB.

15. **Consulting services.** ADB will engage consultants following the ADB Procurement Policy (2017, as amended from time to time) and its project administration instructions and/or staff instructions. The TA will require a consultancy contract with a firm, association, or joint venture,[17] recruited through a simplified technical proposal and quality- and cost-based selection method with a quality–cost ratio of 90:10. An output-based contract will be considered.

IV. THE PRESIDENT'S DECISION

16. The President, acting under the authority delegated by the Board, has approved the provision of technical assistance not exceeding the equivalent of $1,000,000 on a grant basis to the Kingdom of Bhutan for Promoting Energy Security and Transition Project, and hereby reports this action to the Board.

[17] Terms of Reference for Consultants (accessible from the list of linked documents in Appendix 3).

DESIGN AND MONITORING FRAMEWORK

Impacts the TA is Aligned with Bhutan's diversification of clean energy sources promoted [a]			
Results Chain	**Performance Indicators**	**Data Sources and Reporting Mechanisms**	**Risks and Critical Assumptions**
Outcome Readiness for project development in clean energy resources enhanced	By 2025: Phased investment schemes including at least two pilot project types prepared on floating solar and rooftop solar development (2022 baseline: 0) (OP 3.1.5)	TA progress and completion reports	R: Technological changes lead to adverse shift to other energy types
Outputs 1. Floating solar development plans prepared	By 2025: 1a. At least six pilot scheme feasibility studies for the existing hydropower plants completed (2022 baseline: 0) (OP 3.1.5, OP 3.2.5) 1b. A development plan on floating solar development which includes nine investment plans completed (for six existing and three ongoing construction reservoir areas) (2022 baseline: 0) (OP 3.1.5) 1c. Technical guidelines for installation, operation, and maintenance of floating solar facilities prepared (2022 baseline: not applicable) (OP 6.2.1)	1a–1c. TA consultant reports	R: Prolonged consensus building among stakeholders may delay finalization of project direction and design R: Due diligence studies may assess the pilot schemes as unfeasible and unviable for investments because of exogenous factors (e.g., sharp cost reduction in alternative energy sources)
2. Rooftop solar business and financing models developed	By 2024: 2a. Pilot scheme feasibility studies completed for public sector buildings in at least two cities—Thimphu and Paro (2020 baseline: not applicable) (OP 3.1.5) 2b. At least one resource assessment, investment plan, and development plan on rooftop solar business completed (2022 baseline: not applicable) (OP 3.1.5)	2a–2d. TA consultant reports	

Results Chain	Performance Indicators	Data Sources and Reporting Mechanisms	Risks and Critical Assumptions
	2c. Technical guidelines for installation, operation, and maintenance of rooftop solar facilities prepared (2022 baseline: not applicable) (OP 6.2.1) 2d. Gender equality and social inclusion assessed and gender action plan prepared for each pilot scheme (2022 baseline: not applicable) (OP 2.3.2, 3.2.2)		
3. Floating and rooftop solar development knowledge sharing and awareness improvement among stakeholders promoted	By 2025: 3a. At least 30 participants from relevant government agencies (of which 40% are women) reported increased knowledge on alternative energy development through four knowledge sharing workshops (2022 baseline: 0) (OP 6.1.1) 3b. At least two knowledge products on alternative energy development published (i.e., TA consultant reports and project briefs) (2022 baseline: not applicable)	3a–3b. TA consultant reports (including participants' evaluation on the knowledge workshops and knowledge products)	

Key Activities with Milestones

1. Floating solar development plans prepared

1.1 Assess floating solar resources potential (Q1 2023)
1.2 Examine and assess technical specification of floating solar photovoltaic systems and associated facilities including grid connection and energy battery storage systems using least-cost and disaster-resilient design (Q4 2023)
1.3 Develop an initial and long-term investment plan in a phased manner for private investment opportunities and select pilot schemes (Q2 2024)
1.4 Assess pilot scheme financial and economic feasibility and environmental and social safeguard impacts including water quality, impacts on aquatic ecosystems, and effect on greenhouse gas emissions (Q3 2024)
1.5 Prepare social and environmental impact studies and any mitigation measures including solar battery disposal management (Q4 2024)
1.6 Prepare technical guidelines for system installation, operation, and maintenance (Q4 2024)

2. Rooftop solar business and financing models developed

2.1 Assess rooftop solar resource potential and business modeling including private participation (Q1 2023)
2.2 Prepare a phased development plan for each geographical location and rooftop solar customer type (Q2 2023)
2.3 Estimate costs for pilot rooftop solar schemes for government buildings (Q2 2023)
2.4 Assess pilot schemes' financial and economic feasibility (Q2 2023)
2.5 Prepare rooftop solar pricing and incentive mechanisms and regulations (Q2 2023)
2.6 Arrange business modeling suitable for pilot schemes for Thimphu in terms of contracts and procurement (Q3 2023)
2.7 Assess pilot schemes' gender action plan (Q3 2023)
2.8 Prepare social and environmental impact studies and any mitigation measures including solar battery disposal management (Q3 2023)
2.9 Prepare technical guidelines for installation, operation, and maintenance (Q1 2024)

3. Floating and rooftop solar knowledge sharing and awareness improvement among stakeholders promoted

3.1 Organize the inception knowledge sharing workshops to introduce the work plans and approaches and publish a resultant consultant report (Q1 2023)
3.2 Conduct a thorough stakeholder mapping and analysis, including civil society (Q2 2023)
3.3 Develop a comprehensive stakeholder engagement plan, and facilitate early engagement with key stakeholders including civil society organizations (Q3 2023)
3.4 Organize the second knowledge sharing workshops to introduce rooftop solar and floating solar systems in other countries and publish a resultant consultant report (Q3 2023)
3.5 Undertake a site visit in other country when required (Q4 2023)
3.6 Conduct the third workshop for knowledge sharing and awareness improvement with stakeholders of rooftop solar development and publish a resultant consultant report (Q2 2024)
3.7 Conduct the fourth workshop for knowledge sharing and awareness improvement with stakeholders of floating solar development and publish a resultant consultant report (Q2 2025)
3.8 Publish project briefs (Q4 2025)

TA Management Activities

ADB is to conduct the TA administration and manage consulting contracts. Monitoring and review activities will follow ADB requirements.

Inputs

TASF 7: $1,000,000

ADB = Asian Development Bank, OP = operational priority, Q = quarter, R = risk, TA = technical assistance, TASF = Technical Assistance Special Fund.

[a] Government of Bhutan, Ministry of Economic Affairs. 2021. *Bhutan Sustainable Hydropower Development Policy, 2021*. Thimphu; and Government of Bhutan, Ministry of Economic Affairs. 2013. *Alternative Renewable Energy Policy, 2013*. Thimphu.

Contribution to Strategy 2030 Operational Priorities:

The expected values and methodological details for all OP indicators to which this TA will contribute results are detailed in Contribution to Strategy 2030 Operational Priorities (accessible from the list of linked documents in Appendix 3). Source: ADB.

COST ESTIMATES AND FINANCING PLAN
($'000)

Item	Amount
Asian Development Bank[a]	
1. Consultants	
a. Remuneration and per diem	
i. International consultants	630.0
ii. National consultants	67.5
b. Out-of-pocket expenditures	
i. International and local travel	100.0
ii. Surveys	40.0
iii. Training, seminars, and conferences	73.0
iv. Reports and communications	2.0
2. Contingencies	87.5
Total	**1,000.0**

Note: The technical assistance (TA) is estimated to cost $1,050,000, of which contributions from the Asian Development Bank are presented in the table. The government will provide counterpart support in the form of counterpart staff and other in-kind contributions. The value of the government contribution is estimated to account for 5% of the total TA cost.
[a] Financed by the ADB's Technical Assistance Special Fund (TASF 7).
Source: ADB estimates.

LIST OF LINKED DOCUMENTS

http://www.adb.org/Documents/LinkedDocs/?id=56163-001-TAReport

1. Terms of Reference for Consultants
2. Contribution to Strategy 2030 Operational Priorities