People's Republic of Bangladesh

FY2020 Ex-Post Evaluation of Japanese ODA Loan

"The Renewable Energy Development Project"

External Evaluator: Hisae Takahashi, Ernst & Young ShinNihon LLC

0. Summary

The purpose of this project was to diversify the energy sources and increase the power supply as well as electrification by financing the installation of Renewable Energy (RE) facilities in rural areas of Bangladesh. The implementation of this project is consistent with Bangladesh's development strategy, which emphasizes the roles of the power and energy sectors in contributing to economic development, as well as sector plan and development needs of Bangladesh, which have specified the importance of increasing power generation capacity, diversifying energy sources, and furthering RE adoption. The project is also consistent with Japan's ODA policy. Therefore, the relevance of the project is high. Although the project cost was within the plan, the project period exceeded the plan due to the time required to select consultants and implement Sub Projects (SP) in new fields. Thus, efficiency of the project is fair. The installation of Solar Home Systems[1] (SHS), Solar Irrigation Pumps[2] (SIP), Solar Mini Grids[3] (SMG), etc., in non-electrified areas has contributed in generating a variety of impacts, which include increasing power generation volumes and installed generation capacity, reducing CO_2 levels, improving convenience for local residents and operations at factories due to electrification, expanding store hours and product offerings, increasing efficiency of work and production of crops due to the use of electric power pumps for irrigation, and raising income and employment rates. In addition, the success of SIPs and SMGs, which have had limited adoption in the country, contributed to the spread of solar power technology in the country. Therefore, effectiveness and impact of the project are high. While there are no issues in terms of technical aspects related to operation and maintenance, minor problems have been observed regarding institutional/organizational aspects, financial aspects and maintenance conditions. Therefore, sustainability of the project effects is fair.

In light of the above, this project is evaluated to be satisfactory.

[1] Compact solar panels with an output of 20 - 65 watts are installed on the roof. The power generated during the day is stored in batteries and used at night, such as for lighting and watching TV.

[2] Solar pumps for ground water irrigation use electricity generated by generators with a capacity of about 27 kW to drive the pumps.

[3] Solar mini-grid power generator is a device that recharges about 150kW of sunlight to storage batteries and supplies it to the community for lighting, ventilation, televisions, and other uses.

1. Project Description

Project Location

Installed Solar Panel for SHS

1.1 Background

The annual electricity usage per capita of Bangladesh was one of the lowest in the world, at 252 kWh (2009) at the time of the appraisal. However, the demand for electricity was on the rise due to strong economic growth in the country. The supply of electricity could not keep pace with the increase in demand, and in 2010, the available installed capacity of electricity was only 5,271 MW, or about 80% of the demand, compared to the peak electricity demand of 6,454 MW. As a result, about 1,500 hours of power outage was implemented in FY 2009/2010, which caused the major disruptions in the lives of the people and economic activities. In addition, the country's gas-fired power plants, which account for more than 80% of the country's total installed power generation capacity, were fully dependent on domestically produced natural gas. Therefore, the country needed to diversify its energy sources due to sluggish gas production growth. Furthermore, the national household electrification rate in Bangladesh as of 2012 was 50%. The rate was 35% in rural areas compared to 90% in urban areas, which implied that there was a significant need for electrification in rural areas. The Infrastructure Development Company Limited (IDCOL) has conducted SHS programs in the non-electrified areas in rural areas since 2003 and installed approximately 1.71 million SHS sets as of September 30, 2012. However, to respond to the enormous demand for electrification, the company set a target for installing additional 4 million SHS units in off-grid areas[4] with an estimated funding of $788 million required. Based on this, the project was implemented with the aim of diversifying power supply sources and increasing electricity supply by the installation of RE facilities, including SHS programs, through the provision of a two-step loan to IDCOL.

[4] An off-grid area is an area that is not connected to the power grid.

1.2 Project Outline

The objective of this project is to diversify the energy sources and increase the power supply as well as electrification by financing the installation of RE facilities such as SHS, biomass power generation and so on mainly in the rural area of Bangladesh, thereby contributing to the sustainable economic development, improvement of the people's living conditions and mitigation of climate change.

Loan Approved Amount/ Disbursed Amount	11,335 million yen/10,849 million yen	
Exchange of Notes Date/ Loan Agreement Signing Date	March 2013/March 2013	
Terms and Conditions	Interest Rate Repayment Period (Grace Period Conditions for Procurement	0.01 % 40 years 10 years) General untied
Borrower/ Executing Agency	Government of the People's Republic of Bangladesh/Infrastructure Development Company Limited	
Project Completion	March 2019	
Target Area	All of Bangladesh	
Main Contractors (Over 1 billion yen)	-	
Main Consultants (Over 100 million yen)	Unnayan Shamannay (Bangladesh)/Keystone Business Support Company LT. (Bangladesh) (JV)	
Related Studies (Feasibility Studies, etc.)	"People's Republic of Bangladesh Preparatory Survey on Renewable Energy Development Project" (JICA, 2012)	
Related Projects	[Area-Focused Training] ・ "Support for Introduction of Solar Power Generation" (2010, 2011, 2012) [ODA Loan Project] ・ "Energy Efficiency and Conservation Promotion Financing Project" (June 2016), Phase 2 (May 2019) ・ Dispatch of ODA loan assistance experts (2013) [Other Development Partners, International Organizations] ・ World Bank: As a major donor in the field of RE since 2002, provided support for establishing IDCOL, and for implementing and disseminating SHSs, SIPs, SMGs, and biomass gasification[5] power generation facilities ・ Asian Development Bank: Provided continuous support for biomass gasification and dissemination projects since 2008 ・ GIZ: Provided technical support for SHSs and biomass gasification since 2006 ・ KfW: Provided support for SHSs, SIPs, SMGs, etc., through loans and grants since 2007	

[5] In biomass gasification, raw materials such as rice husks are gasified using a gasifier, and the gas generated is used to generate electricity using a gas engine.

2. Outline of the Evaluation Study

2.1 External Evaluator

Hisae Takahashi, Ernst & Young ShinNihon LLC

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: October 2020 – January 2022

Duration of the Field Study: February－March and August 2021 (The field survey was conducted by the local assistant.)

2.3 Constraints during the Evaluation Study

Due to the COVID-19 pandemic, it was not possible to conduct the field surveys by the external evaluator in this ex-post evaluation. For this reason, the field surveys were carried out by the local assistant under the instruction of the external evaluator. The external evaluator conducted bench tests based on the information gathered and the results of beneficiary survey and site inspection conducted by the local assistant. Moreover, the lockdown to prevent the spread of COVID-19 continued for a long period, thus the number of sites where the local assistant could visit was limited while there were a large number of SPs that were spread throughout the country. Therefore, the information obtained during the site visit confirmed information for only a portion of the SPs and end users.

3. Results of the Evaluation (Overall Rating: B[6])

3.1 Relevance (Rating: ③[7])

3.1.1 Consistency with the Development Plan of Bangladesh

At the time of the appraisal, Bangladesh's development policy, the *6th Five-Year Plan* (FY2011 – FY2015), advocated the promotion of RE development to counter the depletion of fossil fuels and environmental considerations, and set a target of increasing the percentage that RE accounts as a share in power generation to 5% by 2015. In addition, the long-term vision for the power and energy sector at that time, the *Policy Statement on Power and Energy Sector Reforms* (2000), set targets of (a) ensuring available power supply for all people by 2020, (b) providing a highly reliable power supply, and (c) providing a power supply based on appropriate prices. The *Renewable Energy Policy*, formulated in 2008, also aimed to increase the share of RE accounting for power generation from the share of about 1% at the time the policy was formulated to 10% by 2020[8].

The country's development plan at the time of the ex-post evaluation, the *8th Five-Year*

[6] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory
[7] ③: High, ②: Fair, ①: Low
[8] Source: Document provided by JICA

Plan (2021-2025), designates the power and energy sector as a sector that plays a central role in the country's economic growth. It also specifies a strategy that emphasizes RE, with a goal of increasing its share of total power generation by 2025[9]. The *Power System Master Plan 2016*, the energy and power development plan that is in effect until 2041, also states the necessity of diversifying energy sources due to the gradual decrease in the domestic gas supply, and presents policies supporting RE expansion while maintaining a stable power supply, taking into account issues such as limited land available for RE installation and high initial costs.[10]

As mentioned above, both at the time of the appraisal and ex-post evaluation, Bangladesh's development policy and directions in the power and energy sector emphasize securing power supply capacity, energy diversification, and promoting RE, thereby confirming the consistency with this project, which aims to diversify power supply sources and increase power supply by funding the installation of RE facilities.

3.1.2 Consistency with the Development Needs of Bangladesh

As described in "1.1 Background", in Bangladesh at the time of appraisal, the supply could not keep up with the increase in demand for electricity due to economic growth, and the supply capacity was only about 80% of the demand. As a result, about 1,500 hours of planned power outages were implemented annually, interfering with daily life and economic activities. In addition, the country's electrification rate was 90% in urban areas and low as 35% in rural areas, and the disparity was becoming more pronounced. Therefore, it was necessary to increase the supply of electricity by promoting rural electrification while diversifying energy sources, including the introduction of RE.

At the time of the ex-post evaluation, the maximum peak electricity generation was 12,738 MW against a peak electricity demand of 13,300 MW, and the country's supply capacity has improved significantly to 96% of demand (2019/2020)[11]. However, electricity demand is increasing by 9-10% per year, and it is estimated that about 21,977 MW of additional new generation will be needed by 2025 to narrow the possible supply-demand gap[12]. Domestic gas production has been declining in recent years[13], thus diversification of energy sources is still a priority. In addition, the electrification rates in urban areas and rural areas have improved significantly, especially in rural areas, to rates of 97% and 78% respectively, but the supply of electricity in rural areas is still unstable. Therefore, even at the time of ex-post

[9] Source: Questionnaire responses, The *8th Five-Year Plan* page(xlix)
[10] Source: Questionnaire responses from the executing agency, *Power System Master Plan 2016 Final Report* p.1-61, p.2-12
[11] Source: Questionnaire responses from the executing agency
[12] Source: BPDB *Annual Report 2019-20*
[13] The country's annual natural gas production has been declining year on year: 27,559 MMCM (million cubic meters) in 2015 - 16, 27,445 MMCM in 2016 - 17, 27430 MMCM in 2017 - 18, 27,233 MMCM in 2018 - 19 and 24,983 MMCM in 2019 - 20. (Source: Data provided by the executing agency)

evaluation, the needs for the development of electricity generation facilities in rural areas are high.

3.1.3 Consistency with Japan's ODA Policy

At the time of the appraisal, The *Country Assistance Program for Bangladesh* (2012) set "accelerating economic growth toward a middle-income country where all citizens can benefit" as a priority challenge and raised increasing the supply of electricity. In addition, the *Renewable Energy Initiative for the South Asian Association for Regional Cooperation (SAARC) Region* (2012) specified the sharing and support of knowledge and lessons learned from the comprehensive review of energy source diversification conducted in the wake of the Great East Japan Earthquake with SAARC countries, and called for the promotion of cooperation with the Japanese government in the field of RE. Furthermore, the *Japan Revitalization Strategy* (2012) stated that Japan would lead the world in tackling global warming issues and provided $3 billion in support for the RE sector, etc. This project financed the installation of RE facilities to diversify and increase power supply sources, which was in line with Japan's ODA policy. This project provided loans for the installation of RE facilities to diversify and increase the sources of power and power supply in Bangladesh, thus its objective is consistent with Japan's ODA policy.

3.1.4 Appropriateness of the Project Plan and Approach

In this project, among the outputs (SP) planned to be financed at the time of appraisal, financing for biomass gasification and biogas-based power generation[14]-related SPs was cancelled. This project supported the provision of financing to institutions responsible for the sale and maintenance of RE facilities through IDCOL by means of a two-step loan. At the time of the appraisal, the output of the project was planned based on a list of proposed candidate SPs and the SPs were selected for implementation through IDCOL's review. At that time, biomass gasification and biogas-based power generation-related SPs were excluded from the list of potential loan recipients due to technical, financial, and environmental concerns (see "3.2.1 Project Output" for details). This change was made as a result of IDCOL's screening of appropriate lenders; hence both the project plans and approaches were considered appropriate.

In light of the above, this project has been highly relevant to Bangladesh's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

[14] In biogas-based power generation, animal waste such as from poultry is stored in a fermenter to generate fermentation gas, which is then burned in a gas engine after removal of toxic gases to generate electricity.

3.2 Efficiency (Rating: ②)

3.2.1 Project Outputs

The planned major outputs of the project consist of the financing (two-step loan) for implementing SP on installation of the RE facilities, provision of implementing support and consulting services. The planned and actual performance are shown in Table 1. The planned and actual amounts for each component of SP implementation are shown in Figure 1.

Table1 Planned and Actual Output

	Plan		Actual	
1. Number of SP	Number of installation (set)	Generation capacity (MWh/year)	Number of installation (set)	Generation capacity (MWh/year)
1-1. SHS program	590,000	27,936	576,693	22,031
1-2. Others				
a) SIP	1,200	7,954	516	16,198
b) SMG	29	5,005	15	2,856
c) Biomass gasification	20	18,480	0	0
d) Biogas-based power generation	60	3,504	0	0
2. Implementing support	- Verification of O&M condition of SHS through IDCOL -Training outreach through POs to SHS end users		As planned (see below for details)	
3. Consulting services	- Assistance to screening SP, monitoring the progress, and environmental & social consideration reporting, technological and business environment advisory, etc.		As planned	
4. Assistance of the ODA loan expert	- To prepare appraisal manual for other RE components, which includes technical specification, to improve appraisal capacity of IDCOL - To provide technical and operational advice to IDCOL and sponsors		As planned (see below for details)	

Source: Documents provided by JICA, PCR and questionnaire responses from the executing agency

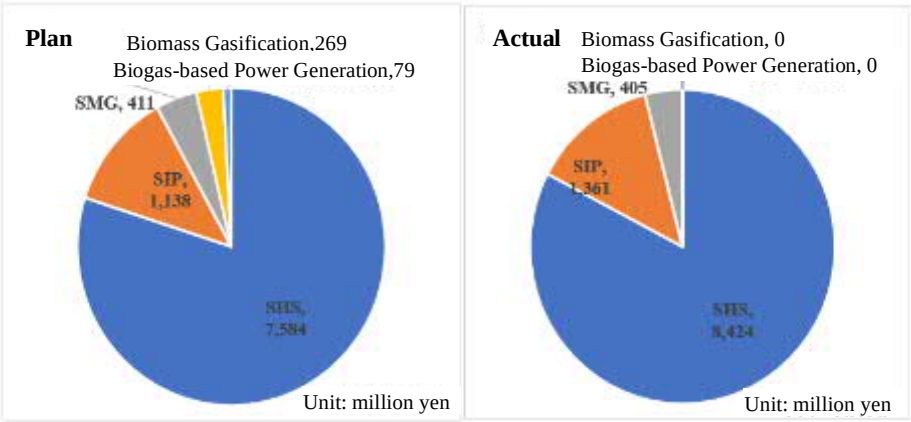

Figure 1 Amount of Each Component of SP (Planned and Actual)

Source: PCR

Note: The amount is for two-step loan.

(1) Financing for the implementation of SP which installed RE facilities

In this project, funding was provided to Partner Organizations (POs)[15], which were responsible for sales and maintenance of facilities through IDCOL, to implement SPs for the installation of RE facilities. An SP is classified as an SHS program and other components (SIP, SMG, biomass gasification, and biogas-based power generation). Under an SHS program, POs sell and install SHSs to end users (households). In SIPs and SMGs, POs, which have track records in SHS programs, provided services to end users, such as farmers and merchants. These services included water supply and electricity sales. For biomass gasification and biogas-based power generation, it was planned that electricity would be used by the Sponsor Organizations for air conditioning and lighting at poultry farms and for cooling systems at rice mills, and that fertilizer and fish food obtained as by-products would be sold at local stores and the like. (See Figure 2)

[15] The organizations responsible for selling and maintaining SHS facilities are mainly NGOs, known and referred to as Partner Organizations (POs).

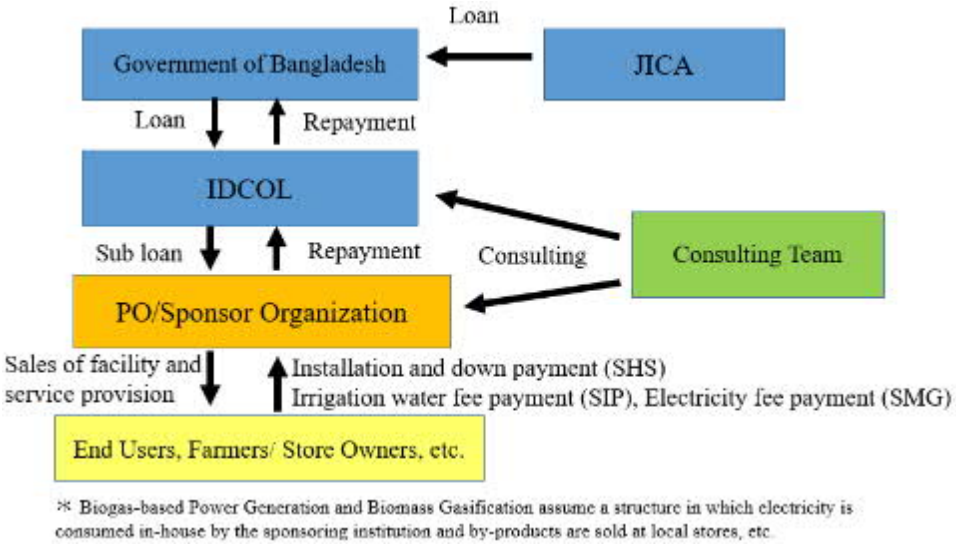

Figure 2 Scheme of This Project

Source: Modified based on documents provided by JICA

Home Solar Panel
(Kushtia District, Khulna Division)

Solar Panel for Irrigation
(Bogra District, Rajshahi Division)

Solar Power Mini-Grid
(Kushtia District, Khulna Division)

As shown in Table 1, SPs under the SHS program were mostly implemented as planned. However, the number of SPs for SIPs and SMGs was lower than planned, and SPs for biomass gasification and biogas-based power generation were not eligible for funding. Each change and the reason for the change are described below. The planned output, which was prepared at the time of the appraisal, was presented as a draft list of candidates, and the POs receiving the funding were subsequently selected and finalized after a review by IDCOL.

【Decrease in the number of SPs for SIPs】

The number of SIPs installed, which was planned to be 1,200 sets, was actually 516 sets, about 40% of the planned number. This was due to the increase of the generation capacity of solar panel 11 kW to 27 kW in response to the need of the increase of irrigation pump's output to cover more farmers. The cost per unit increased due to this

change, and in addition, demand decreased in some areas due to the on-grid[16] electrification, resulting in a decrease in the overall volume. This change was made based on user needs and had little impact on the project costs and volume of power generation, thus is considered as appropriate.

【Decrease in the number of SPs for SMGs】

The actual number of SMGs (15 sets) was about half of the planned number (29 sets). IDCOL was planning to provide funding for 29 SMG sets in remote and non-electrified areas where on-grid expansion would not be foreseeable in future, such as river and offshore islands, after gaining approval from Power Division. Later, however, following the government's policy for achieving electricity access by all households, on-grid areas have been expanded by the Bangladesh Rural Electrification Board (BREB). In response to this, it was decided that the project would no longer continue to implement SPs in on-grid areas designated by BREB, therefore, the number of SPs was half of the planned targets. This change was a result of coordination efforts to avoid overlapping of electricity services providers, and thus considered as a reasonable decision.

【Cancelation of providing funding for Biomass Gasification】

Although IDCOL had an extensive track record in providing support for the SHS program, their experience in supporting biomass gasification projects was limited to two projects prior to the implementation of this project. On the other hand, because of the rapid expansion of on-grid areas in response to government policy, the lack of a sufficiently successful track record in biomass gasification projects, as well as concerns[17] about uncertainty of the availability of biomass raw materials as well as market price volatility and so on, sponsors felt the project was less attractive. Accordingly the implementation of biomass gasification projects was determined to be commercially unfeasible. Therefore, funding for biomass gasification projects was not granted.

【Cancellation of funding biogas-based power generation】

IDCOL had financed a few biogas-based power generation projects, however, several sponsors of these projects as well as other sponsors that implemented such projects with their own financing subsequently conveyed environmental concerns related to the management of slurry, a by-product of biogas-based projects. After investigating the site, IDCOL, including the project's consultants, discussed the problem and decided not to

[16] A power generation system that is connected to the transmission system (transmission network) with grid connection.

[17] When confirming with a JICA staff in charge whether those risks were discussed at the time of the appraisal, it was recognized that Bangladesh is an agricultural country and that raw materials such as rice husks were secured based on the data, thus recognized that there was less price change influence in the region.

finance any new projects until a solution was found, accordingly it was decided not to provide the fund in this project as well.

It was expected that loan terms (sub-loan interest rate and tenor) from IDCOL to POs would not be uniform but be handled flexibly and flexible loan terms were duly followed for as long as the program continued.

Table 2 Lending Term to PO for SHS

Cumulative loan amount (Taka)	Annual interest rate	Tenure	Grace period
200 million or less	6%	7 years	1 year
250 million – 500 million	7%	6 years	1 year
500 million – 1 billion	8%	6 years	1 year
1 billion or more	9%	5 years	0.5 year

Source: Documents provided by JICA

Table 3 Lending Term to PO for other RE Components

Components	Annual Interest rate	Tenure	Grace period
SIP	6%	10 years	1 year
SMG	6%	10 years	2 years
Biomass gasification	6-10%	7 years	1 year
Biogas-based power generation	6-9%	5 years	1 year

Source: Documents provided by JICA

(2) Implementation Support

The quality inspections of the facilities and training for POs and end users were conducted as planned during the implementation of the SPs. The quality inspections were conducted by about 200 inspectors contracted by IDCOL to ensure whether (1) end users have received the products that comply with required standards and been properly trained to use them; (2) POs' loan collection and their procedures were in compliance with rules set forth, and (3) products were delivered that met required levels of service and reliability at the end user level. In addition, all POs contracted with IDCOL, conducted training and awareness-raising activities for SHS end users (customers), conducted training for PO staff, as well as conducted training and technical accreditation activities for PO staff assigned to install SHS equipment. The training content for each component is shown in Table 4.

Table 4 Contents of the Trainings

Components	Name of trainings (number of trainings)
SHS	Trainings for customer (end user) (92,597), trainings for trainers (10), trainings for staff (1,345), technical trainings (6), management trainings for PO officials (45), IT trainings (7), collection efficiency trainings (19), procurement management trainings (3), microcredit management trainings (2), trainings for project implementation officers (18)

SIP	Farmer's training (565), training of trainers (7), demonstration of high yield variety for farmers (283), training of pump supervisors (28), training for pump operators (55), technical training for suppliers (2)
SMG	Customer (user user) training (283), technical training for PO and suppliers (5)

Source: Questionnaire responses from the executing agency
Note: The number in parentheses indicates the number of implemented trainings.

(3) Implementation of the technical support related to the projects

Follow-up on the progress of the project by ODA loan experts was conducted as planned. Technical support was provided to non-SHS SPs, in which IDCOL has little track record, including the preparation of appraisal manuals and providing advice on conducting appraisals. Training on management and maintenance of the facility was also provided during the implementation of the project in consideration of long-term maintenance.

3.2.2 Project Inputs

3.2.2.1 Project Cost

The actual project cost was 21,572 million yen, which was compared the total project cost (26,669 million yen) planned at the time of the appraisal, and was within the plan amount (81% of the original). Under this project, biomass gasification and biogas-based power generation were not implemented from funding for SP implementation as already mentioned. Thus, the actual project cost was compared with the project cost at the time of the appraisal (25,832 million yen), which excludes the amount planned for those relevant components, and, as a result, the project cost was 84% of the plan, which was still within the plan.

Table 5 Planned and Actual Project Cost

(Unit: mil yen)

	Plan			Actual		
	JICA	Other	Total	JICA	Other	Total
SP implementation	9,480	9,338	18,818	10,525	9,873	20,398
Implementation support	196	0	196	196	47	243
Price escalation	904	1,012	1,915	0	0	0
Physical contingency	529	517	1,046	0	0	0
Consulting service	226	0	226	129	63	192
Administrative cost	0	1,100	1,100	0	734	734
VAT, Tax import	0	3,353	3,353	0	0	0
Interest during construction	0	4	4	0	4	4
Total	11,335	15,334	26,669	10,850	10,722	21,572

Source: Document provided by JICA and PCR, questionnaire responses from the executing agency
Note 1: Exchange rate plan: 1 taka = 0.97 yen (as of December 2012), actual: 1 taka = 1.35 yen (average rate by International Financial Statistics during the project implementing period.)
Note 2: Totals may not match due to rounding.

The cost for the implementation of SP was higher than planned because the unit price increased in response to the increase in power generation capacity per facility. On the other hand, the reasons why the actual cost was lower than planned were due to the decrease in RE prices[18], the decrease in the number of SPs and the resulting decrease in administrative costs, as well as the reduction in local costs such as Value Added Tax (VAT) exemptions and the elimination of the need to pay contingencies

3.2.2.2 Project Period[19]

The project period was planned to be 46 months as opposed to an actual period of 73 months, from March 2013 to March 2019, which was longer than planned (159% of the plan) (See Table 6). One of the reasons for exceeding the plan was that it was necessary to open re-bidding because there were no consultant firms who participated in the first bidding that fulfilled the technical requirements of the proposal. Upon implementation of the SPs, an SHS program was successfully completed by December 2016, the planned period for the entire SP implementation[20]. However, since there were few cases around the world of support for SIPs and SMGs based on business models led by private companies, and there were no reference cases for IDCOL, the project was delayed due to continuous trial and error. For instance, it was necessary to reach out to potential sponsors through awareness-raising activities in different parts of the country and to conduct repeated awareness-raising events for farmers to deepen their understanding of RE. In addition, to strengthen the supply chain side, events needed to be organized to encourage suppliers to enter the market and the like. These series of activities required a lot of time.

[18] The average selling price of SHSs in 2017, which was the most widely and commonly used system at the time of the appraisal (50Wp), dropped to about 60% of 2013. (Source: Documents provided by the executing agency)
[19] The project period is defined as the period from the month in which the L/A is signed to the month in which the disbursement is completed.
[20] As already mentioned, in the bidding process for the selection of consultants, the project had to be re-bid due to the absence of bidders that satisfied the technical requirements, which caused a delay in the implementation of the SP. Considering the limited experience of the executing agency in non-SHS SPs, it was pointed by JICA related department that JICA and others involved in the project should have been more careful in setting technical requirements.

Table 6 Project Period of This Project

	Plan	Actual
L/A	March 2013	March 2013
Selection of consultant	April 2013 – October 2013	June 2013 – January 2015
Consulting service	November 2013 – December 2016	February 2015 – September 2018
SP implementation	July 2013 – December 2016	April 2013 – March 2019
SHS	July 2013 – December 2015	April 2013 – December 2016
SIP	July 2013 – December 2016	January 2014 – December 2018
SMG	July 2013 – December 2016	January 2017 – March 2019
Biomass gasification	July 2013 – December 2016	–
Biogas-based power generation	July 2013 – December 2016	–
Implementation support	July 2013 – December 2016	April 2013 – December 2016
Project completion	December 2016	March 2019
Project periods	46 months	73 months

Source: Document provided by JICA, questionnaire responses from the executing agency

3.2.3 Results of Calculations for Internal Rates of Return (Reference only)

Internal rate of return for this project was not calculated at the time of appraisal. EIRR only for the SHS program was calculated on a sample basis (per SHS system), thus EIRR at the time of ex-post evaluation was recalculated under the same conditions. As a result, the recalculated value at the time of ex-post evaluation was higher than the calculated value at the time of appraisal. The reason why the EIRR at the time of the ex-post evaluation was higher than that at the time of the appraisal is thought to be due to the fact that the SHS cost was lower than that at the time of the appraisal and the price of fuel increased.

Table 7 Internal Rate of Return (Sample) and Calculation Elements

	Economic Internal Rate of Return (EIRR)
Internal Rate of Return	At appraisal: 40.7%, At ex-post evaluation: 44.7%
Cost	SHS cost, interest on loan, replacing costs of battery, replacing cost of charge controller, cost for lamp
Benefit	Saving from purchasing alternative power, saving from reduction of CO^2
Project Life	20 years

Source: Prepared by the evaluator based on data provided by JICA and the executing agency, World Bank (2021) *Living in the Light: The Bangladesh Solar Home System Story*

In light of the above, although the project cost was within the plan, the project period exceeded the plan. Therefore, efficiency of the project is fair.

3.3 Effectiveness and Impacts[21] (Rating: ③)

3.3.1 Effectiveness

3.3.1.1 Quantitative Effects (Operation and Effect Indicators)

In this project, the target was estimated based on the candidate SPs at the time of appraisal (refer to "3.2.1 Project Outputs" for the changes in the outputs). The baseline and target for each operational and effect indicator set at the time of the appraisal are shown in Table 8. In practice, however, funds were provided to SPs that passed the IDCOL appraisal, thus the targets were revised based on the actual outputs, and performance was then confirmed based on the revised targets (see table 9). In addition, with regard to the annual reductions of CO_2, the fuel used in the calculation at the time of the appraisal was not the fuel actually used. Therefore, based on consultations with the executing agency, the target was revised using the fuel actually used to show the actual results (see the note in the table for details).

Table 8 Baseline and Target for Indicators Set at the Time of Appraisal

Indicators	Baseline	Target
	2012	2018
		2 Years After Completion
(1) Yearly power generation volume (MWh)	0	63,162
(2) Installed generation capacity (MW)	0	46.6
(3) Effect of the reduction of CO_2 (CO_2 conversion tons/year)	0	40,422

Source: Documents provided by JICA

Table 9 Revised Target and Actual Data for Indicators

Indi-cators	Revised target	Actual				Achievement rate (%)
	2021	2017	2018	2019	2020	
	2 Years After Completion			Completion Year	1 Year After Completion	
(1)	41,178 Note 1	22,449	23,793	33,230	41,085	99%
(2)	41.4 Note 1	26.0	28.0	36.0	41.0	99%
(3)	27,782 Note 2	12,987	14,040	21,795	28,001	101%

Source: Documents provided by JICA, questionnaire responses from the executing agency

Note 1: The proportion of biomass gasification and biogas-based power generation in the total components at the time of the appraisal was excluded from the target and targets were revised.

Note 2: The emissions reduction targets by the SHSs at the time of appraisal were calculated by emissions reduction related to the replacement of natural gas consumption. However, IDCOL pointed out that the fuel used before project implementation was not natural gas, thus the emissions reduction factors should be calculated based on kerosene oil and diesel oil, which were actually used. Accordingly, the target was revised.

[21] Sub-rating for Effectiveness is to be put with consideration of Impacts.

As described above, the yearly power generation volume, the installed generation capacity, and effect of the reduction of CO_2 of the target SPs for funding of this project have all met the revised targets. In rural areas where access to electricity is difficult, the installation of SHS, SIP, and SMG facilities has directly led to an increase in electricity supply, and RE power generation has led to a reduction in CO_2 emissions by reducing the use of kerosene oil, which has traditionally been used.

3.3.1.2 Qualitative Effects (Other Effects)

Enhancement of IDCOL's capacity on appraisal and implementation of SPs other than SHSs

IDCOL did not have much of a track record implementing components other than the SHS program, such as SIPs and SMGs since there were few actual cases in the country. Therefore, the project provided assistance to prepare the appraisal manual and to improve the appraisal capacity through the dispatch of ODA loan experts. Specifically, technical support was provided for reviewing the technical standards and designs of facilities, preparation of Bill of Quantity[22] for use in bidding, development of operation and maintenance guidelines, site selection, and verification of proposals. According to the staff of IDCOL who received support, in addition to the enhancement of IDCOL's appraisal capacity for evaluating SIPs and SMGs, it has become possible to maintain cost-effectiveness of the project, contribute to technical sustainability, provide higher quality services to end users, and collect field-based information through those support. The provision of technical assistance not only allowed IDCOL staff to gain experience in the formation and evaluation stages of SPs, but also served to facilitate the implementation of the project.

3.3.2 Impacts

3.3.2.1 Intended Impacts

The project was expected to contribute to improving the living standards of the residents, sustainable economic development, and climate change mitigation by supporting the installation of RE facilities. The impact of the establishment of SHSs, SIPs, and SMGs is summarized below based on the information provided by the executing agency, and POs and end users interviews [23] conducted during the field site inspections[24].

(1) Impact generated by the installation of SHSs

IDCOL supported the installation of 4.13 million sets of SHSs by 2018 and about 20

[22] Refers to quantity calculation documents, bills of quantities, and statement of quantities used in bidding.

[23] Site inspections were conducted by the local assistant at six POs (three SHSs, one SMG, and two SIPs) in the Bogra and Kushtia districts to check the facilities, interview each PO staff, and conduct interviews with 14 SHSs (11 males and 3 females), 12 SIPs (12 males), and 6 SMGs (4 males and 2 females) end users. Due to the Covid-19 pandemic during the site survey, domestic travel was severely restricted, and the number of PO visits were limited. Later, additional interviews via telephone and e-mail were conducted with staff at four POs (two SHSs, one SIP, and one SMG) in Gazipur district and near Dhaka.

[24] The qualitative information is based on the results of interviews conducted with a limited sample.

million people[25] in Bangladesh, or about 12% of Bangladesh's population (about 164.69 million[26]) have access to electricity through the SHS program. The project has installed 576,593 sets of SHSs, which also contributed to the access to electricity for about 2.79 million people, or about 1.4% of the country's population[27]. The installation of SHSs in households was found to contribute to increased study time, improved safety, better quality of life, and health and cost benefits due to the discontinuance of use of kerosene oil[28], which is considered harmful to human health and the environment.

- Increase in children's study time

  Installation of SHSs made possible the use of solar lumps at home, and as a result, study times increased in the evening or during electricity outage periods[29]. 13 of the 14 interviewees cited an increase in children's study time (about 2-3 hours on average) as the impact of the project.

- Improved safety at night

  Keep lighting in areas can act as measures for security and improve safety in the community at night.

- Improvement of quality of life

  The use of cooking appliances including the electric stove, electric fans, TVs, and other electrical appliances has improved the quality of life of residents. For women in particular, the use of electrical appliances reduces the time spent on housework and daily tasks, and they can now utilize more time for leisure and spending with their families.

- Effects of discontinuing the use of kerosene lamps

  The installation of SHSs has eliminated the needs of using kerosene lamps, which has reduced the risk of asthma and other health hazards caused by smoke. As a result of the discontinued use of it, on average, each household saves about 1-5 litters (ℓ) of kerosene oil (about 50 taka/ℓ = about 65 yen/ℓ) and many end users use the savings to pay off SHSs. In addition, the reduction of smoke from the kerosene lamp also helps to keep wallpaper, clothes, and other household items clean.

[25] Based on Census on 2011 (Source: World Bank (2021) *Living in The Light: The Bangladesh Solar Home System Story*)
[26] Source: UN data, http://data.un.org/en/iso/bd.html (Confirmed on October 10, 2021)
[27] Source: Questionnaire responses from the executing agency
[28] Lamps that use inexpensive petroleum-based fuel. The black smoke produced by these lamps is a health hazard.
[29] The target areas of this project include areas that were electrified with on-grid after the SHSs were installed. Even in such areas, electricity supply is not stable in many sections, and SHSs have continued to be used as a backup.

【BOX】Changes in life after purchasing SHSs

Mr. and Mrs. A, who live in Bogura District, purchased an SHS in 2013 because they needed an environment where they could use electric lights and fans on a daily basis to raise their newborn baby. After the SHS was installed, their needs were fully met, moreover they no longer needed to use kerosene lamps, which could have a negative impact on their family's health, thus eliminating their concerns about the health effects on their family. In addition, Mrs. A can now use an electric stove for cooking, which reduces her household workload. Their second son, who was preparing for his high school graduation exams, was able to spend an hour or two more studying at night using the solar light. Their oldest son also had the opportunity to participate in the training held by the PO on the operation and maintenance of the SHS and has been able to use the system without any problems since its installation.

(2) Impact generated by the installation of SIPs

With the installation of SIPs, by using electric pumps to get irrigation water farmers no longer need to use rented diesel pumps. As a result, benefits have been realized such as more efficient transport operations, less labour for irrigation water management, reduced pumping costs, increased crop yields, as well as increased income and local employment.

・ <u>More efficient operations, increased yields and improved farmers livelihoods</u>

Before the installation of SIPs, diesel pumps for irrigation were rented from the market and transported to the farms, but after the installation of the facilities, transporting the pumps became unnecessary, and led to reducing tasks of farmers. In addition, the fact that the farmers themselves no longer need to adjust irrigation water because an operator is assigned[30] to manage water has also contributed to the reduction of farming time. Furthermore, due to the availability of sufficient irrigation water throughout the year, it is possible to grow crops in three seasons, as opposed to two seasons in the past, resulting in increased yields (for example, farmers in Kushtia district increased rice yields by about 100-300 kg (about two to three times higher than before the project) and tobacco yield increased by about 25%). Accordingly, farmer's revenue has also increased in proportion to the increase in the production.

・ <u>Pump cost reduction</u>

Before the project, an average of about 3,000 taka (about 3,900 yen) per season for the diesel pump fuel and about 80 kg of rice (equivalent to about 4,000 taka = about 5,200 yen) for the use of the pump were paid[31]. After the installation of the SIPs, fuel and pump usage fees are no longer required by paying a water fee of about 3,000 taka to POs, thus the introduction of the SIPs has contributed to cost reduction.

[30] Operator's fee is paid by the POs based on the water fee covered by farmers.
[31] Since payment differs by farmer and area, averages figures are used.

・ Job creation and stimulating local economies

One operator and one supervisor are required to be assigned per SIP installation. Since 516 sets of SIPs have been installed under this project, at least 1,032 jobs have been created. In addition, with the increase in yields, farm laborers, workers at rice mills, and logistic jobs have been created in the target areas. Moreover, the installation of the SIPs has increased the number of suppliers of electric pumps in the installation area.

【BOX】Success story of SIP installation in rice cultivation

Mr. B, a young farmer, was engaged in rice cultivation in Boro Boaliya village. Though timely irrigation is vital for rice cultivation, Mr. B and other farmers in Boro Boaliya village depended on natural rainfall and expensive diesel pumps for irrigation. To obtain adequate water with the rented pumps at the market, transportation costs and the diesel fuel were needed on top of the rent. Diesel prices were often raised in the local market and the farmers had to stay in the field day and night to manage the pumps. To resolve this situation, Mr. B and some other farmers received the assistance of IDCOL and POs to install SIPs. Currently, they are getting adequate and uninterrupted water supply with an electric pump by utilizing SIPs installed near the farms, and the harvest season can be increased from two to three cropping seasons. The pumps require less time and effort to operate, leading to increased production and productivity. It also saves time and labour cost for transporting the pumps, and reduces rental fees and fuel costs. Farmers have also had the opportunity to be trained in agricultural technology, which has had a significant impact on improving agricultural production and living standards in the region.

(3) Impact generated by installation of SMGs

Similar benefits to SHSs have been identified in the areas which were mainly supplied with electricity by diesel generators and have been electrified with the installation of SMGs. In addition, it was observed that the installation of SMGs has contributed to benefits such as extended operation hours of markets and stores as well as improving their service offerings.

・ Increase in student study time and improved quality of life

As with the SHS, all interviewees described the impact of the project as an increase in children's learning time (about 3-4 hours on average) due to the availability of electricity at home after the installation of the SMGs. They also reported that the use of photocopiers, welding machines, electric sewing machines, storage of vaccines and medicines in pharmacies, and pumping and irrigation using electric pumps made their daily lives more convenient.

・ Increase in service improvement and harvest

The installation of SMGs has stabilized the electricity supply, expanded and extended the content and hours of service provided in the region, and improved convenience. For example, there has been an increase in the number of products sold by the installation of refrigerators in stores, an improvement in work efficiency by the use of electric tools in carpentry work, an improvement in farming efficiency, and an increase in yields by using

electric pumps for irrigation.

・ Job creation

The expansion of various services and extension of business hours due to electrification have created jobs in establishments such as restaurants, coffee shops, welding shops, rice mills, poultry farms, and computer centers.

【BOX】Contributing to health care at the non-electrified areas with installation of SMGs

Dr. C is a doctor in Chilmari sub-district and a beneficiary of 210 kWp size of solar mini grid systems. Chilmari, an island within Paddma river, is a very remote area and has very poor access to hospitals that provide healthcare that match the level of care in Upazila. Dr. C owns a pharmacy in a bazaar and runs a private practice for local residents in the pharmacy. In 2017, after the bazaar area of Chilmari became electrified by the installation of SMGs, Dr. C purchased a refrigerator for vaccine and medical supply storage. Thanks to this, local residents do not go to Upazila hospitals to obtain medicine and vaccines which are now available locally. In addition, the pharmacy can now install suction equipment that requires electricity, which is useful for treating children and elderly people with respiratory diseases and other conditions. Local residents can now access this pharmacy and medical facility until midnight, and the increase in patients has led to a 2.5-fold increase in remuneration what it used to be at the pharmacy, contributing to the stabilization of the pharmacy business.

In line with the government's policy, on-grid electronification has been promoted rapidly in many areas since 2015. In some areas where SHSs and SMGs have been installed, it has been also observed that end users returned the SHSs[32]. However, even after being connected to the transmission network (on-grid), the project facilities are used as a backup during planned and unplanned power outages and when the power supply becomes unstable. It is also believed that end users continue to enjoy the benefits of the project even in on-grid areas.

3.3.2.2 Other Positive and Negative Impacts

(1) Impacts on the Natural Environment

In this project, SPs could not be specified prior to JICA's approval for funding, and they might have environmental impacts under the *Japan International Cooperation Agency guidelines for environmental and social considerations* (April 2010), thus the project falls into Environmental Category FI. The executing agency was required to classify the categories of SPs based on the *Environmental and Social Management Framework (ESMF)* which conforms with national laws and above-mentioned Guideline, and to take necessary

[32] After the SHS is returned to the POs by end users, it can be sold again to anyone who wishes to purchase it. However, used SHSs are often discarded because there are few people who wish to purchase them. (Source: Interview with POs)

measures for the relevant categories, and specified not to implement those SPs which were categorized A. In practice, IDCOL has prepared the harmonized EMSF and has adhered to the framework since 2013, since it has implemented similar RE projects with the support of the World Bank, Asian Development Bank and many other donors[33]. Moreover, when selecting SPs, IDCOL classified the categories for each SP, and confirmed that SPs that categorized as A were not included. During the implementation of the project, regular monitoring by inspectors contracted by IDCOL had been conducted, and no environmental problems were reported. Therefore, it has been determined that the project implementation has not caused any negative impact on the natural environment.

Notably, IDCOL has sold about 1 million Certified Emission Reductions (CER)[34] based on reduction in kerosene used under their SHS installation. At the time of ex-post evaluation, they are in discussion through the World Bank to sell another 2.5 million CERs[35]. It includes the amount reduced by the SHS installed in this project, which is a noteworthy impact in terms of contribution to climate change.

(2) Resettlement and Land Acquisition

No resettlement and land acquisition along with implementation of this project occurred[36].

(3) Other impacts

Contribution to the development of the solar PV industry through the implementation of this project

In addition to the installation of SHSs, which had been deployed in the country prior to the implementation of this project, this project contributed to the dissemination of solar PV technology in Bangladesh by introducing and implementing SIPs and SMGs, which could be serve as future case examples. In addition to generating electricity from solar power, this project has demonstrated the importance and advantages of solar power in rural areas, as it provides a stable source of water for irrigation even during the dry season. Moreover, the results of the project have been recognized as a success and have led to the introduction and implementation of large rooftop solar PVs and other advanced initiatives that IDCOL has supported following the implementation of the project. According to IDCOL, had these projects not been implemented, the successful demonstration of larger scale solar PV projects

[33] Prior to the start of the project, IDCOL, together with the Asian Development Bank, signed an agreement that the EMSF would be a framework that encompasses and complies with the guidelines of both donors.

[34] IDCOL's SHS program is registered as a Clean Development Mechanism (CDM) project under the United Nations Framework Convention on Climate Change (UNFCCC). The CDM quantifies the carbon dioxide reduced by the program adoption and technology and issues Certified Emission Reduction (CER) credits periodically after verifying the performance and operational status of a particular program. One credit is equivalent to the reduction of approximately one ton of CO_2.

[35] Source: Documents provided by the executing agency

[36] Source: Questionnaire responses from the executing agency

would not have been possible.

The successful implementation of SIPs and SMGs and the introduction of these success examples in the country demonstrated that such systems can be effective solutions for remote rural areas, islands and areas which have limited access to power grids. Furthermore, IDCOL was awarded the Financial Innovation Award by the London Institute of Banking & Finance for its work on efficient water management using SIPs[37].

This project has mostly achieved its objectives. Therefore, effectiveness and impacts of the project are high.

3.4 Sustainability (Rating: ②)

3.4.1 Institutional/Organizational Aspects of Operation and Maintenance

IDCOL is a government-owned financial institution established to fund, invest, and provide subsidies for infrastructure and RE (see Figure 3 for organizational chart). After project completion, IDCOL oversees program operations, mainly fund management, and monitoring maintenance carried out by POs. The RE Department, which is in charge of SHS and RE-related projects, had 101 staff members at the time of the appraisal, and later increased to 224 at the time of the ex-post evaluation (2020) due to business expansion. After the implementation of a project, repayment is made by the PO or sponsoring agency to IDCOL as scheduled at the time of the appraisal, and the principal and interest are used for secondary lending and principal and interest payments to the government under IDCOL management.

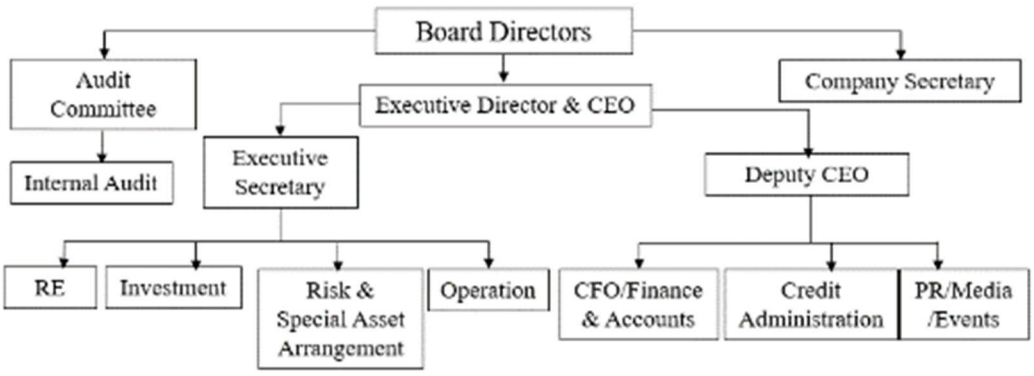

Figure 3 Organization Chart of IDCOL

Source: Documents provided by the executing agency

[37] Source: Interview with the executing agency, The London Institute of Banking & Finance Web Site https://www.libf.ac.uk/news-and-insights/our-events/financial-innovation-awards-2019/previous-winners (Confirmed on September 3, 2021)

For the repayment conditions set at the time of the appraisal, the interest rate of the SHS program was reduced by 1-2% taking into account the fluctuations in market interest rates[38] and increasing delays in repayment, and further reduced to 0% in 2018. IDCOL has considered taking steps to ease the burden of repayment by revising the repayment schedule of POs as well. With regard to the SIPs, IDCOL has taken measures such as changing the grace period to two years because it took longer than expected for farmers to install irrigation pumps and complete replacement of diesel pumps.

The operation and maintenance system of the facilities after installation differs for each SP. The operation and maintenance of the SHSs installed in each household is done by the end user. POs are responsible for monitoring and battery collection as required for SHSs, as well as collecting payment for installation. For SIPs and SMGs, POs operate and maintain the installed facilities and provides irrigation water (SIPs) and electricity (SMGs) to end users, who pay water or electricity charges based on their usage. In addition, one operator and one supervisor are assigned per SIP installation. The monitoring team of IDCOL conducts monitoring annually for each SP, and if any problems are identified, they are reported to the PO's headquarters and local offices in order to look into responses. However, as described in (3.4.3 Financial Aspects of Operation and Maintenance & 3.4.4 Status of Operation and Maintenance), some local offices of POs, which were opened during the implementation of the project, have been closed after project completion. Technical support to end users can be provided by suppliers and regional offices of IDCOL, there are some areas where follow-up by POs for collection of repayment and the replacement of batteries have been hindered. This is a concern in terms of institutional/organizational aspects of operation and maintenance.

3.4.2 Technical Aspects of Operation and Maintenance

IDCOL has a long track record in donor supported projects and has continued the SHS program since 2003, so it has many staff with expertise. In addition, its loan appraisal capabilities for SIPs and SMGs were also strengthened by working with ODA loan experts and consulting services during project implementation. Training to improve the expertise of staff[39] has been conducted on a regular basis, and there are no technical concerns in the proper implementation of loan appraisal processes.

Generally, advanced technical skills are not required for the operation and maintenance of the SHS program. When installing SHSs, trainings on operation and maintenance of SHSs,

[38] The market interest rate, which was around 13-15% during the project implementation, fluctuated to around 8-9% at the time of the ex-post evaluation.

[39] For example, capacity development trainings including "Project Finance", "Financial Modeling", "Financing Power Project", etc. have been organized.

an overview of renewable energy technologies, basic knowledge of electricity and solar power generation, overviews of solar panels and batteries, and how to charge the lights and other equipment were also conducted for end users in each PO, led by POs which already have experience in implementing IDCOL's SHS program. Moreover, it is assumed that the registered suppliers will provide technical support in case technical issues arise. POs operate the electric pump and suppliers provide technical support as needed for SIPs. During the implementation of the project, IDCOL provided technical training for POs and suppliers, and will continue to provide agricultural training to those involved in SIPs. For SMGs, as with SIPs, the POs operate the facility and the suppliers provide technical support as needed. Based on interviews with IDCOL and site inspections, no technical issues related to operation and maintenance have been reported, thus there are no particular concerns.

3.4.3 Financial Aspects of Operation and Maintenance

IDCOL has continued to increase its revenue and profit, and its profits have been increasing steadily since 2016. Its capital adequacy ratio has also been stable since the time of the appraisal, thus there are no financial concerns in general.

Table 10 Major Financial Indicators of IDCOL

(Unit: million taka)

	2015	2016	2017	2018	2019
Operating income	2,950	2,970	3,065	3,153	4,550
Interest income	2,755	2,588	2,652	2,626	3,949
Profit/(Loss) before tax	2,516	1,539	1,577	1,843	2,368
Profit/(Loss) after tax	1,366	397	530	703	1,378
Total asset	66,980	73,025	76,636	82,293	90,876
Equity ratio (%)	8.5	8.2	8.2	8.3	9.2

Source: IDCOL *Annual Reports* each year's edition

While the financial status of each PO is different, some of the POs visited during the site inspections mentioned that repayment to IDCOL is currently a burden on their organizations. As described in "3.4.1 Institutional/Organizational Aspects of Operation and Maintenance," IDCOL has eased loan terms, including interest rates, in order to ease the burden of loan repayment on POs. In addition, according to IDCOL, all POs have been formally notified of the changes, although it was confirmed in the interviews with POs that some of them were not aware of the changes for a certain period of time and thought that the interest rates were fixed and unchanged. Thus, it was necessary to comprehensively disseminate information on the reduction of interest rate to all POs.

In addition, some POs have reported cases where repayment of installation costs from end users to POs has been delayed, and installation cost cannot be collected upon return of

SHSs under the SHS program. This is due to the fact that some areas have been on-grid after the installation of SHSs, and the government's free SHS program (TR/KABIKA) has been launched, which has delayed the willingness of some end users to repay, or return their SHSs. It is also cited that the end user is no longer obligated to pay for the installation costs with the return of SHSs, and the POs are now responsible for covering them. As a result, some POs have closed their local offices in relevant areas due to the burden of maintaining them caused by a decrease in the number of end users, while some POs have found it difficult to collect loan repayment from end users though it is a limited number of POs[40]. Under SIPs, the end users pay for irrigation water to PO and pay for electricity to POs on a prepaid basis under SMGs, so the collection rate is generally maintained at 100% and there are no problems with the status of payments to POs by end users.

As mentioned above, with regard to the financial conditions of operation and maintenance, while IDCOL has no problems, there are financial concerns given the fact that a part of POs have felt burdens with the repayments to IDCOL since a part of end users have issues for the payment to POs under the SHS program.

3.4.4 Status of Operation and Maintenance

(1) Status of fund operations

The principal and interest repaid by the POs to IDCOL were planned to be utilized for secondary loans and principal and interest payments to the government under the management of IDCOL. IDCOL explained that they have not provided the fund for the SHS program since 2018 due to the current rapid on-grid development. Thus, IDCOL is planning to use the secondary loans effectively by financing rooftop solar projects and other projects.

Table 11 Fund Managed by IDCOL

(Unit: million taka)

	2016	2017	2018	2019	2020
Opening principal outstanding	25,143	23,482	21,266	19,103	16,714
Principal prepaid	3,650	2,735	2,665	3,055	955
Loans disbursed	1,973	502	484	650	286
Closing balance	23,482	21,266	19,103	16,714	16,063
Interest earned					
Interest received	1,706	1,409	741	133	91

Source: Documents provided by the executing agency

[40] It was noted that the situation of repayment from POs to IDCOL had deteriorated in the entire SHS program supported by the executing agency (including this project). For example, the debt collection efficiency ratio from end users to POs, which was 88% in 2015, declined to 38% in 2017. There was a concern that the impact of this would affect the financial condition of IDCOL. Later, it has been improving since 2018 due to IDCOL's efforts to reduce the interest rate and extend the repayment period and so on. (Source: World Bank (2021) *Living in The Light: The Bangladesh Solar Home System Story*)

(2) Operational status of equipment by component

At the time of the ex-post evaluation, the operational status of each component was 81% for SHSs, 99% for SIPs, and 33% for SMGs[41]. Almost all the SIPs are operating without issues and are being used effectively by farmers in respective areas. For SHSs and SMGs, although facilities are partially not in use in some areas due to grid electrification, as already mentioned, even in on-grid areas, electricity supply still has time restrictions or is unstable in rural areas, thus they are used as backup supply and as more stable power source in many cases. The fact that tariffs for SMGs are higher than those of the National Grid is a factor in their low utilization. IDCOL and the government are discussing the price setting and purchase of electricity from SMGs at the time of the ex-post evaluation, and the utilization rate of SMGs is expected to improve once the agreement is in place.

(3) Collection of expired batteries

At the time of the appraisal, it was pointed out that the batteries used in SHSs may leak toxic lead-acid contained in the raw materials, causing environmental pollution and health hazards. At the time, IDCOL had developed the *Guidelines for Disposal of Expired Batteries* (2011), which required POs to collect batteries [42] from end users and manufacturers to recycle and dispose of them properly. Activities to raise awareness were also conducted for end users during implementation of the project. In addition, during the implementation of the project, IDCOL conducted an environmental audit in 2015, which confirmed that no relevant issues had occurred. However, during the site inspections conducted during the ex-post evaluation, it was not possible to confirm the actual collection of expired batteries. Regarding the lack of battery collection and recycling, based on interviews with end users, it was reported that there was a lack of awareness about battery replacements and that cheap batteries were purchased in the market. Since some POs closed their local offices after the project completion, it was confirmed that adequate follow-ups were not conducted in such areas. IDCOL states that it conducts annual monitoring[43], but since a large number of SPs have been included in the SHS program, it is very difficult to monitor and provide guidance to all of them. In the future, it needs to work with POs and suppliers to provide information on battery collection and correct disposal again.

In light of the above, some minor problems have been observed in terms of the institutional/ Organizational aspects, financial aspects and current status. Therefore, sustainability of the project effects is fair.

[41] Questionnaire responses from the executing agency
[42] According to the documents at the time of the appraisal, the battery has a usable life of about 5 years.
[43] According to IDCOL, no case of lead acid leakage from the battery has been reported through monitoring by the time of the ex-post evaluation.

4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The purpose of this project was to diversify the energy sources and increase the power supply as well as electrification by financing the installation of RE facilities in rural areas of Bangladesh. The implementation of this project is consistent with Bangladesh's development strategy, which emphasizes the roles of the power and energy sectors in contributing to economic development, as well as sector plan and development needs of Bangladesh, which have specified the importance of increasing power generation capacity, diversifying energy sources, and furthering RE adoption. The project is also consistent with Japan's ODA policy. Therefore, the relevance of the project is high. Although the project cost was within the plan, the project period exceeded the plan due to the time required to select consultants and implement SP in new fields. Thus, efficiency of the project is fair. The installation of SHS, SIP, SMG, etc., in non-electrified areas has contributed in generating a variety of impacts, which include increasing power generation volumes and installed generation capacity, reducing CO_2 levels, improving convenience for local residents and operations at factories due to electrification, expanding store hours and product offerings, increasing efficiency of work and production of crops due to the use of electric power pumps for irrigation, and raising income and employment rates. In addition, the success of SIPs and SMGs, which have had limited adoption in the country, contributed to the spread of solar power technology in the country. Therefore, effectiveness and impact of the project are high. While there are no issues in terms of technical aspects related to operation and maintenance, minor problems have been observed regarding institutional/organizational aspects, financial aspects and maintenance conditions. Therefore, sustainability of the project effects is fair.

In light of the above, this project is evaluated to be satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

・ Ensure that POs are informed of information on reduced interest rates

IDCOL changed the interest rate to 0% in 2018 to reduce the burden of repayment on POs following changes in market interest rates since the time of the appraisal. On the other hand, some POs interviewed during the site inspections were not fully aware of the changes for a certain period and felt that repayment was a burden on their organizations. It is advisable for IDCOL to send another formal written notice to all POs as soon as possible regarding the change in the interest rate and to set up a public awareness of the correct information.

・ Reinforce battery collection requirements

Since the batteries used in SHSs may cause environmental pollution and health hazards if not properly disposed, expired batteries have to be collected from end users by the PO and properly disposed of by the supplier. During the site inspection conducted as part of the ex-post evaluation, however, it was confirmed that there were no actual cases of batteries being collected, and some end users were not aware its necessity. Since some POs have closed their local offices, it is also necessary to examine a follow-up system. As more than 50,000 SHSs have been installed under this project, it is very difficult to know the collection status of all the batteries, however, it is recommended that IDCOL work with POs and suppliers to reiterate to end users the importance of battery collection and appropriate disposal.

4.2.2 Recommendations to JICA

None

4.3 Lessons Learned

Formulate project plans based on integrated on-grid and off-grid electrification

After the commencement of this project, grid expansion supported by the government in rural area increased rapidly from 2015 onward, and a free SHS distribution program was also launched. These movements have resulted in a situation in which SHSs have been returned by end users and the collection of the payments from end users has been delayed. The on-grid expansion also has a significant impact on the operational status of the RE facilities installed by the project. In a project such as this one, where the effectiveness and sustainability of the project can be greatly affected by the trends in the sector, it is necessary for the executing agency and other stakeholders involved in the project to keep in close communication with the government and the relevant authorities during the appraisal and implementation of the project, to discuss information on similar projects implemented in the target area and electrification plans, and to cooperate in the implementation of an integrated plan. It is also important to maintain the effectiveness and sustainability of the project through changes in a project's components, monitoring, and flexible operation in order to respond to changes in social needs in a timely and appropriate manner.

Establish a long-term follow-up system to ensure sustainability

In some areas, delays in loan payments by end users have also become a burden, and local offices of POs established in rural areas have been closed after the completion of projects, making it difficult to maintain adequate relationships and follow-up systems between end users and POs. Even after the project completion, it is necessary to have an entity that can support the end users in the regular replacement of SHS components such as batteries, spare parts for

equipment, and repayment of loans. On the other hand, the closure of local offices is a real possibility regardless of this project. Therefore, for projects that require follow-ups with end users even after the project completion, it is required that project stakeholders consider all the possible cases at the time of project formation, during implementation, and upon completion. In order to maintain the relationship between the end users and the organizations that conduct follow-ups, it is desirable to consider a system that is beneficial to the end user side as well, such as providing useful maintenance support and information when fees are collected, and to ensure sustainability by continuing communication, including monitoring using phone calls and short messages.

Contribution to the growth of solar PV industry through project implementation

Prior to the implementation of this project, there were very limited real world examples to support SIPs and SMGs based on business models led by the private sector, thus IDCOL reached out sponsors through awareness-raising activities in various parts of Bangladesh, held awareness-raising events to deepen understanding of RE, and organized events encouraging suppliers to enter the market in order to strengthen their supply chains. As a result, in addition to the SHSs that have been deployed in the country, SIPs and SMGs have been recognized for their achievements and have proven to be effective in remote rural areas, islands, and areas with limited access to on-grid electricity, contributing to the widespread adoption of Solar PV technology in the country. When introducing new schemes and technologies that have not been used in the past, such as this project, it is important to provide supports to each stakeholders involved in the industry, such as government agencies, companies in charge of the supply chain (suppliers), and end users, so that they can deepen understanding of the industry and improve their technological capacities.

Comparison of the Original and Actual Scope of the Project

Item	Plan	Actual
1. Project Outputs	Funding for SP implementation of RE (1) SHS 590,000 sets (2) Non-SHS 1) SIP 1,200 sets 2) SMG 29 sets 3) Biomass gasification 20 sets 4) Biogas-based power generation 60 sets	 (1) 576,693 sets (2) 1) 516 sets 2) 15 sets 3) 0 sets 4) 0 sets
	Implementing support Verification of O&M condition of SHS through IDCOL Training outreach through POs contracted with IDCOL to SHS end users	As planned
	Consulting services Assistance to screening SP, monitoring the progress, and environmental & social consideration reporting, technological and business environment advisory, etc.	As planned
	Assistance of the ODA loan expert - To prepare appraisal manual for other RE component, which includes technical specification, to improve appraisal capacity of IDCOL - To provide technical and operational advice to IDCOL and sponsors	As planned
2. Project Period	March 2013 – December 2016 (46 months)	March 2013 – March 2019 (73 months)
3. Project Cost Amount Paid in Foreign Currency Amount Paid in Local Currency Total ODA Loan Portion Exchange Rate	 155 million yen 26,514 million yen (27,344 million taka) 26,669 million yen 11,335 million yen 1 taka = 0.79 yen (As of Month year)	 133 million yen 21,439 million yen (15,880 million taka) 21,572 million yen 10,850 million yen 1taka = 1.35 yen (Average between March 2013 – March 2019)
4. Final Disbursement	March 2019	