



# Completion Report

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**PUBLIC**

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Loan Number: 3075  
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## People's Republic of China: Qinghai Delingha Concentrated Solar Thermal Power Project

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**Asian Development Bank**



## CURRENCY EQUIVALENTS

Currency unit – yuan (CNY)

		<b>At Appraisal</b> (28 October 2013)	<b>At Project Completion</b> (30 June 2018)
CNY1.00	=	\$0.1644	\$0.1510
\$1.00	=	CNY6.0829	CNY6.6225

## ABBREVIATIONS

ADB	–	Asian Development Bank
CGN	–	China General Nuclear Power Corporation
CGN-DSE	–	CGN Delingha Solar Energy Co., Ltd.
CEXIM	–	The Export-Import Bank of China
CO <sub>2</sub>	–	carbon dioxide
CSP	–	concentrated solar thermal power
EMP	–	environmental management plan
EPC	–	engineering, procurement, and construction
FIRR	–	financial internal rate of return
HTF	–	heat transfer fluid
ICB	–	international competitive bidding
LAEMDP	–	land acquisition and ethnic minority development plan
O&M	–	operation and maintenance
PRC	–	People's Republic of China
PV	–	photovoltaic
TES	–	thermal energy storage
WACC	–	weighted average cost of capital

## WEIGHTS AND MEASURES

GW	–	gigawatt
GWh	–	gigawatt-hour
kWh	–	kilowatt-hour
MW	–	megawatt

## NOTE

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

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## BASIC DATA

### A. Loan Identification

1.	Country	People's Republic of China
2.	Loan number and financing source	3075 (ordinary capital resources)
3.	Project title	Qinghai Delingha Concentrated Solar Thermal Power Project
4.	Borrower	People's Republic of China
5.	Executing agency	China General Nuclear Power Corporation
6.	Amount of loan	\$150 million
7.	Financing modality	Project loan

### B. Loan Data

1.	Appraisal	
	– Date started	6 May 2013
	– Date completed	17 May 2013
2.	Loan negotiations	
	– Date started	21 October 2013
	– Date completed	22 October 2013
3.	Date of Board approval	2 December 2013
4.	Date of loan agreement	23 January 2014
5.	Date of loan effectiveness	
	– In loan agreement	23 April 2014
	– Actual	21 April 2014
	– Number of extensions	0
6.	Project completion date	
	– Appraisal	30 November 2017
	– Actual	30 June 2018
7.	Loan closing date	
	– In loan agreement	31 May 2018
	– Actual	31 May 2020
	– Number of extensions	2
8.	Financial closing date	
	– Actual	16 March 2021
9.	Terms of loan	
	– Interest rate	London Inter-Bank Offered Rate + 0.5%
	– Maturity (number of years)	25
	– Grace period (number of years)	5
10.	Terms of relending (if any)	The Export-Import Bank of China to China General Nuclear Power Corporation
	– Interest rate	ADB loan term + 0.5% annual administration fee on outstanding loan
	– Maturity (number of years)	25
	– Grace period (number of years)	5
	– Second-step borrower	China General Nuclear Power Corporation

## 11. Disbursements

## a. Dates

<b>Initial Disbursement</b> 26 August 2016	<b>Final Disbursement</b> 14 May 2020	<b>Time Interval</b> 44 months
<b>Effective Date</b> 21 April 2014	<b>Actual Closing Date</b> 16 March 2021	<b>Time Interval</b> 82 months

## b. Amount (\$ million)

<b>Category</b>	<b>Original Allocation (1)</b>	<b>Increased during Implementation (2)</b>	<b>Canceled during Implementation (3)</b>	<b>Last Revised Allocation (4=1+2-3)</b>	<b>Amount Disbursed (5)</b>	<b>Undisbursed Balance<sup>a</sup> (6=4-5)</b>
1. Equipment and materials and EPC <sup>b</sup>	145.88	0.00	0.00	145.88	119.18	26.70
2. Interest and commitment charges	4.12	0.00	0.00	4.12	4.12	0.00
<b>Total</b>	<b>150.00</b>	<b>0.00</b>	<b>0.00</b>	<b>150.00</b>	<b>123.30</b>	<b>26.70</b>

EPC = engineering, procurement, and construction.

Note: Numbers may not add up due to rounding.

<sup>a</sup> Cancelled at loan closing.

<sup>b</sup> In the original allocation, only equipment and materials were envisaged. The EPC was proposed through a minor change approved on 5 February 2015.

## C. Project Data

## 1. Project cost (\$ million)

<b>Cost</b>	<b>Appraisal Estimate</b>	<b>Actual</b>
Foreign exchange cost	163.04	118.79
Local currency cost	159.22	139.98
<b>Total</b>	<b>322.26</b>	<b>258.77</b>

## 2. Financing plan (\$ million)

<b>Cost</b>	<b>Appraisal Estimate</b>	<b>Actual</b>
Implementation cost		
Borrower financed	95.58	78.47
ADB financed	145.88	119.18
Other external financing	69.49	54.61
<b>Total implementation cost</b>	<b>310.95</b>	<b>252.26</b>
Interest during construction costs		
Borrower financed	1.10	0.00
ADB financed	4.12	4.12
Other external financing	6.09	2.39
<b>Total interest during construction cost</b>	<b>11.31</b>	<b>6.51</b>



## 3. Cost breakdown by project component (\$ million)

Component	Appraisal Estimate	Actual
<b>A. Investment Cost</b>		
Civil works	11.80	8.10
Solar field	132.81	95.01
Heat transfer fluid system	13.62	10.35
Thermal energy storage system	38.68	71.50
Power generation system	24.09	28.63
Auxiliaries	18.03	5.41
Other costs	27.53	20.91
Engineering service	7.68	12.35
<b>Subtotal (A)</b>	<b>274.24</b>	<b>252.26</b>
<b>B. Contingencies</b>		
1. Physical	13.71	0.00
2. Price	23.01	0.00
<b>Subtotal (B)</b>	<b>36.72</b>	<b>0.00</b>
<b>C. Financial Charges during Implementation</b>		
1. Interest during implementation	11.02	6.18
2. Commitment charges	0.29	0.33
<b>Subtotal (C)</b>	<b>11.31</b>	<b>6.51</b>
<b>Total Project Cost (A+B+C)</b>	<b>322.26</b>	<b>258.77</b>

Note: Numbers may not add up due to rounding.

## 4. Project schedule

Item	Appraisal Estimate	Actual
Date of contract with consultant	Q4 2013	Q3 2014
Civil works/EPC contract		
Date of award	Q2 2014	Q3 2016
Completion of work	Q2 2016	Q2 2018
Equipment and supplies		
Dates		
First procurement	Q2 2014	Q1 2016
Last procurement		Q1 2016
Completion of equipment installation	Q2 2016	Q2 2018
Start of operations		
Completion of tests and commissioning	Q4 2016	Q3 2018
Beginning of start-up	Q4 2016	Q4 2018

EPC = engineering, procurement, and construction, Q = quarter.

## 5. Project performance report ratings

Implementation Period	Single Project Rating
From 21 April 2014 to 30 June 2015	On track
From 1 July 2015 to 31 December 2015	Potential problem
From 1 January 2016 to 31 March 2016	On track
From 1 April 2016 to 30 June 2016	Actual problem
From 1 July 2016 to 30 September 2017	Potential problem
From 1 October 2017 to 31 December 2019	On track
From 1 January 2019 to 31 March 2019	Potential problem
From 1 April 2019 to 30 June 2019	Actual problem
From 1 July 2019 to 31 December 2019	On track
From 1 January 2020 to 31 December 2020	For attention
From 1 January 2021 to 16 March 2021	On track

**D. Data on Asian Development Bank Missions**

<b>Name of Mission</b>	<b>Date</b>	<b>No. of Persons</b>	<b>No. of Person-Days</b>	<b>Specialization of Members</b>
Fact-finding	6–17 May 2013	9	90	a, b, c, d, e, f, g, h, i
Inception	3–4 June 2014	1	2	a
Loan review 1	18–19 September 2014	2	4	a, e
Loan review 2	2–3 February 2015	1	2	a
Loan review 3	27 March 2015	2	2	d, g
Midterm review	8–13 May 2016	3	14	a, d, g
Loan review 4	1–6 May 2017	1	6	a
Loan review 5	4–7 September 2017	3	8	a, d, j
Loan review 6	23–24 November 2017	1	2	a
Loan review 7	21–23 October 2018	4	12	a, d, j, k
Project completion review	13–17 September 2021	3	12	l, d, m

a = energy specialist or senior energy specialist or principal energy specialist/mission leader; b = project officer; c = senior counsel; d = environment specialist or senior environment specialist; e = energy specialist; f = senior project officer (energy); g = senior energy specialist; h = senior operations assistant; i = financial specialist (energy); j = director; k = senior project officer; l = unit head, project administration/mission leader; m = social development specialist (safeguards).

## I. PROJECT DESCRIPTION

1. The power sector in the People's Republic of China (PRC) grew rapidly between 2008 and 2012, with installed power capacity increasing by about 70%. With coal-fired generation supplying more than 75% of electricity in the PRC in 2012, the rapid capacity expansion also caused a large rise in emissions of carbon dioxide (CO<sub>2</sub>), the key greenhouse gas responsible for climate change.<sup>1</sup> The PRC also was promoting a more diversified energy mix with a greater share of renewable energy to reduce growth of greenhouse gas emissions in the power sector. As a result, the PRC also achieved rapid growth in wind power and solar photovoltaic (PV) capacity from 2008 to 2012. Wind power and solar PV capacities surged to 5.6 gigawatts (GW) and 3.2 GW, respectively, by 2012. The large wind and solar PV capacity gains posed new challenges of integrating the variable output from wind and solar power plants into the grid. The grid company was finding it extremely difficult to schedule its output dispatch economically, and this caused significant curtailment from renewable energy generators.<sup>2</sup>

2. Concentrated solar thermal power (CSP) is a state-of-the-art renewable energy technology that converts direct normal irradiation into usable heat, generating medium- to high-temperature saturated steam that runs steam turbines for power generation. Because of this thermal cycle, CSP plants can easily be combined with low-cost thermal energy storage (TES), allowing them to generate electricity even at night. Thus, CSP plants produce reliable, predictable, and dispatchable electricity at any time of day to allow the grid company to schedule their dispatch economically. This unique feature enables them to avoid grid integration issues posed by the variability of wind and solar PV plants.

3. With its rich solar irradiation resource, Qinghai Province, located in the northeastern part of the Qinghai-Xizang plateau in western PRC, is the country's fastest growing region for solar power. Its installed solar PV capacity reached 2 GW in 2012, which was 62.5% of all solar PV capacity installed in the PRC. The project site in Qinghai had an estimated solar resource of 2,187 kilowatt-hours (kWh) per square meter of annual direct normal irradiation. The project design adopted a parabolic trough CSP system,<sup>3</sup> one of the four major CSP technologies, with 50 megawatt (MW) of generating capacity and a 7-hour thermal storage system.<sup>4</sup> At appraisal, the project was estimated to avoid 154,446 tons of CO<sub>2</sub> emissions annually. The electricity generated by the project was to be fed into the existing 110-kilovolt substation in Delingha.

4. At appraisal, the project's expected impact was expanded share of CSP in the PRC's renewable energy mix. The outcome would be demonstrated feasibility and reliability of the utility-scale CSP plant with thermal storage system in Qinghai Province.<sup>5</sup> The project included two outputs: (i) construction of a first-of-its-kind utility-scale CSP plant with thermal storage in Qinghai

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<sup>1</sup> According to the International Energy Agency (2012), the power sector accounted for about 50% of CO<sub>2</sub> emissions in the PRC.

<sup>2</sup> Grid curtailment refers to non-absorption of electricity generated from power plants by the power grid.

<sup>3</sup> ADB. 2013. *Report and Recommendation of the President to the Board of Directors: Proposed Loan to the People's Republic of China for the Qinghai Delingha Concentrated Solar Thermal Power Project*. Manila. Parabolic trough CSP is the most mature and commercially proven technology used in 95% of the world's utility-scale CSP plants. The CSP consists of (i) a solar field system that concentrates direct normal irradiation to generate around 400°C of thermal energy; (ii) a heat transfer system; (iii) a TES system that stores excess heat from the solar field system for power production during nights or cloudy days; and (iv) a power block that generates electricity using saturated steam produced by thermal energy from the solar field and TES system to drive a turbine generator.

<sup>4</sup> Thermal storage hours for parabolic trough CSP plants in operation or under construction with similar system configuration have a maximum 7.5 hours of thermal storage.

<sup>5</sup> Utility-scale refers to grid-connected CSP plants with installed capacity of 10 MW or higher.

Province; and (ii) capacity development and training in CSP design, construction, and operation and management. The project design and monitoring framework is in Appendix 1.

## II. DESIGN AND IMPLEMENTATION

### A. Project Design and Formulation

5. The project design aligned fully with government development priorities and the 2011-2015 country partnership strategy of Asian Development Bank (ADB). At project appraisal, the design fully aligned with: (i) the Twelfth Five-Year Plan 2011–2015, targeting to increase the share of renewable energy from 8.9% in 2010 to 11.4% in 2015 and decrease carbon intensity (the amount of greenhouse gas emission per unit of gross domestic product) by 17% by 2015 compared with 2010 levels; (ii) the Medium and Long-Term Development Plan for Renewable Energy in the PRC issued in 2007, which aimed to increase the share of renewable energy in total primary energy consumption to 15% by 2020; (iii) implementation of the PRC's Renewable Energy Law issued in 2005, which led large-scale renewable energy development in the country, provided a set of incentives to promote some non-hydro renewable technologies, and specified grid feed-in requirements and standard procedures, as well as supervisory measures; and (iv) the Qinghai Provincial Government's solar energy development plan targeting installed capacity of 4.3 GW (including 300 MW of CSP) by 2015 and of 10 GW (including 2 GW of CSP) by 2020. After project approval, the National Energy Administration nominated it to be in the first batch (20 projects in total) of national-level solar energy pilot and demonstration projects in 2015.

6. The project also reflected ADB's operational priorities as outlined in the PRC's country partnership strategy, 2011–2015 and country operations business plan, 2011–2013 because it would (i) contribute to environmentally sustainable growth, (ii) support the government's efforts to foster a cleaner and more sustainable growth process by strengthening capacity for environmental management and pilot testing cutting-edge clean energy and energy efficiency technologies, and (iii) encourage diversity in the energy mix and promote low carbon technology utilization.<sup>6</sup> The project has provided valuable hands-on experience and mitigated some of the perceived and real technology risks associated with first-of-its-kind projects. That developed confidence in the technology and led to its wider development in line with ADB's energy policy.<sup>7</sup> The project also sought to contribute to the government's ability to formulate appropriate policy incentives for large-scale deployment of CSP in the PRC. ADB financing for the project provided comprehensive support, including low-cost financing, policy advice, and capacity development, all aimed at ensuring the project's sustainability in the short term and accelerating wider deployment of CSP plants in the PRC in the medium term.

7. The project design benefited significantly from capacity development technical assistance, which included development of a CSP roadmap and pre-feasibility studies and implemented a pilot CSP project in Beijing.<sup>8</sup> Successful implementation of the assistance and its pilot significantly lowered the barriers for demonstrating CSP in the PRC. In addition, the project strengthened institutional capacity of the executing agency, China General Nuclear Power Corporation (CGN), in CSP design, construction and operation, and management. During preparation, supported by ADB's technical assistance team, the project was designed with a holistic approach including solar field, heat transfer fluid (HTF) system, TES system, and power block. The design and layout

<sup>6</sup> ADB. 2012. *Country Partnership Strategy: People's Republic of China, 2011–2015*. Manila; ADB. 2012. *Country Operations Business Plan: People's Republic of China, 2011–2013*. Manila.

<sup>7</sup> ADB. 2009. *Energy Policy*. Manila.

<sup>8</sup> ADB. 2009. *Technical Assistance to the People's Republic of China for Concentrating Solar Thermal Power Development*. Manila.

were optimized based on technical needs and environmental and socioeconomic considerations, such as cold winter climate conditions. The project preparation gave special attention to technical design while considering the project's first-of-its-kind nature and to future performance-based operation and maintenance (O&M) mechanisms to ensure its readiness. Preliminary design was substantially completed prior to approval.

## **B. Project Outputs**

**8. Output 1: First-of-its-kind utility-scale CSP plant with thermal storage in Qinghai Province constructed.** This project output accounted for approximately 85% of the total project cost and 99% of ADB's financing at appraisal. CGN Delingha Solar Energy Co., Ltd. (CGN-DSE), under the leadership of CGN and with management support of CGN Solar Energy Development Co., Ltd., implemented the plant as implementing agency. Preparatory works financed by the government started in December 2013. In 2015, to mitigate engineering risks and as a minor change of the project, an engineering, procurement, and construction (EPC) contract for the solar field subsystem was proposed instead of equipment procurement. With the minor change and updated procurement plan approved by ADB, two ADB-financed goods contracts for a total value of \$26.87 million were awarded on 4 January 2016 for HTF and molten salt for TES.<sup>9</sup> The EPC contract was advertised in Q2 2015 and awarded on 20 September 2016 with a contract value of \$98.40 million. All other civil works and equipment under counterpart financing or domestic commercial loan were procured by April 2016, including the power generation system, auxiliary equipment, distributed control system, and power block equipment. Civil works started in August 2015. The major structure was completed in June 2018 with successful start-up of the generators. The CSP plant started commissioning in September 2018 and operation on 10 October 2018. It was officially connected to the grid on 11 November 2018 with generation capacity of 50 MW. At completion, this plant was the first utility-scale CSP plant in commercial operation in the PRC and the first CSP plant in the world operating at high altitude and extreme cold. The project successfully achieved the output target envisaged at appraisal. O&M of the plant is now ongoing under CGN-DSE.

**9. Output 2: Capacity development and training in CSP construction and operation and management.** At appraisal, the project planned to strengthen executing and implementing agencies' capacity in CSP design, construction, and O&M by providing trainings on plant design and preparing O&M manuals. In addition to the support for increased technology expertise, the project sought to enhance the ability of CGN and PRC government officials to formulate appropriate policy incentives for large-scale CSP deployment in the future.

10. During project implementation, CGN-DSE and consultants provided training on international best practices in CSP design, construction, and O&M; ADB's requirements for project management, especially on disbursement; and ADB safeguard policies and requirements. The trainings improved capacity of CGN's and CGN-DSE's engineers and management staff. Some of those trained are now already leaders in the CSP field working on new CSP projects in the PRC. This has contributed greatly to achieving the project's proposed objectives. At completion, CGN and CGN-DSE had prepared 29 manuals or industry standards at international (4), national (4), sectoral (7), cluster (4), and corporate (10) levels on design, construction, and O&M. They had submitted to the government in November 2015 a policy recommendation on feed-in tariff, piloting, and regulatory assistance to further support CSP demonstration and

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<sup>9</sup> Package 5: Molten salt for thermal energy storage includes two lots: potassium nitrate and sodium nitrate.

deployment. This was approved and adopted in September 2016.<sup>10</sup> These are all valuable knowledge products of the project.

11. At appraisal, domestic and overseas study tours were planned to better understand the international experience on CSP development. Due to the government's tightening restrictions on overseas travel, however, at completion no overseas study tour had been carried out. Along with other market players, CGN and CGN-DSE organized 62 workshops with 1,692 person-days of training on various topics of CSP plant O&M since project operation.

12. As a risk mitigation measure and part of capacity development, a performance-based O&M contract engaging international experts during the first 2 years of commercial operation (2018–2020) was included in the project design. No O&M contractor was successfully engaged even after re-advertising in 2018, however, because (i) no experienced international O&M contractor showed interest due to remoteness of project site and difficulties in operating CSP given the site's specific harsh climatic condition; and (ii) this is the first CSP plant in the PRC and no national consultants could provide the required services or meet the qualifications (para. 8). Therefore, CGN-DSE had to conduct the O&M by itself.

13. Overall, the project was implemented as originally designed. There was no major change in scope or implementation arrangements.

### C. Project Costs and Financing

14. The project cost at appraisal was estimated at \$322.26 million. The cost at completion was \$258.77 million, a 19.70% decrease. In local currency, the cost was 13.76% lower, as shown in Table 1. Detailed costs at appraisal versus completion are in Appendix 2.

**Table 1: Project Cost Estimates at Appraisal vs. Completion**

Items	Costs at Appraisal		Costs at Completion	
	Total (CNY million)	Total (\$ million)	Total (CNY million)	Total (\$ million)
<b>A. Base Costs</b>				
1. Civil works	73.15	11.80	53.90	8.10
2. Solar field	823.45	132.81	632.39	95.01
3. Heat transfer fluid system	84.45	13.62	68.58	10.35
4. Thermal energy storage system	239.79	38.68	475.88	71.50
5. Power generation system	149.33	24.09	190.56	28.63
6. Auxiliaries	111.80	18.03	35.98	5.41
7. Other costs	170.66	27.53	139.19	20.91
8. Engineering service	47.62	7.68	82.22	12.35
<b>Subtotal (A)</b>	<b>1,700.26</b>	<b>274.24</b>	<b>1,678.70</b>	<b>252.26</b>
<b>B. Contingencies</b>	<b>227.68</b>	<b>36.72</b>	<b>0.00</b>	<b>0.00</b>
<b>C. Financing Changes during Construction</b>	<b>70.10</b>	<b>11.31</b>	<b>44.44</b>	<b>6.51</b>
<b>Total Project Cost (A+B+C)</b>	<b>1,998.03</b>	<b>322.26</b>	<b>1,723.14</b>	<b>258.77</b>

Note: Numbers may not add precisely due to rounding.

Sources: Asian Development Bank and China General Nuclear Power Corporation.

15. The cost of civil works for the plant at contract award was lower than the engineer's cost estimates. The savings were mainly due to (i) sound design and no major design changes or unfavorable geological conditions encountered during construction; (ii) about 20% cost savings after international competitive bidding (ICB) of the EPC package as a result of market competition

<sup>10</sup> The National Energy Administration issued the *Notice for Piloting the CSP Demonstration Project Construction* on 13 September 2016.

at the bidding stage; (iii) prudent contract management by contractors and supervising engineers such that no contingency was utilized; (iv) improved capacity of CGN and CGN-DSE in project management; and (v) optimized engineering design and cost control during implementation.

16. At completion, two goods packages and one EPC package were procured under ADB financing with total contract value of \$119.18 million. That was \$26.70 million lower than the original ADB allocation. The bid prices for equipment funded by counterpart finance were also lower than cost estimates at appraisal. The main reasons for the savings were (i) optimized technical specifications; (ii) strong competition through ICB procurement; and (iii) tax and tariff rebate from the ICB on imported equipment that was not envisaged during project appraisal.

17. The financing plan included an ADB loan of \$150.00 million at appraisal and \$123.30 million at completion, as shown in Table 2. Appendix 3 details costs by financier.

**Table 2: Financing Plan at Appraisal vs. Completion**

Item	Appraisal			Completion		
	Total Cost		% of Total	Total Cost		% of Total
	(CNY million)	(\$ million)		(CNY million)	(\$ million)	
Asian Development Bank	930.00	150.00	46.55	826.25	123.30	47.65
China General Nuclear Power Corporation	599.42	96.68	30.00	509.91	78.47	30.32
China Exim Bank	468.60	75.58	23.45	386.98	57.00	22.03
<b>Total</b>	<b>1,998.03</b>	<b>322.26</b>	<b>100.00</b>	<b>1,723.14</b>	<b>258.77</b>	<b>100.00</b>

Note: Numbers may not add precisely due to rounding.

Sources: Asian Development Bank and China General Nuclear Power Corporation.

18. In 2015, an EPC contract for the solar field subsystem was proposed instead of equipment procurement (para. 8). The procurement plan was adjusted accordingly. Equipment and materials excluded from the revised procurement plan were financed by counterpart financing. However, this minor change did not affect ADB's financing percentage for the project. Thus, no reallocation of loan proceeds took place.

#### D. Disbursements

19. By loan closure, \$123.30 million of the \$150.00 million loan was disbursed. Savings of \$26.70 million were canceled at loan closing. Withdrawal applications were prepared by the executing agency, jointly signed by The Export-Import Bank of China (CEXIM), in accordance with ADB's *Loan Disbursement Handbook* (2012, as amended from time to time). Overall disbursement was satisfactory. The project used direct payment modality for contractors and suppliers and reimbursement procedures for eligible expenditures initially funded by the executing agency. The first disbursement was in August 2016 and the final disbursement in May 2020. The loan closing date was extended twice, and the winding-up period also twice. The loan account was closed on 16 March 2021, nearly 3 years later than the original closing date. Projected and actual disbursements and contract awards are compared in Appendixes 4 and 5.

#### E. Project Schedule

20. At appraisal, the planned implementation period was 5 years, from October 2013 to November 2017, with loan closing on 31 May 2018. ADB twice approved extension of the loan closing date, from 31 May 2018 to 31 May 2020, to allow sufficient time to (i) complete the final acceptance test and commissioning approval for full commercial operation, and (ii) release outstanding payments. This was because of (i) prolonged basic design finalization and time-

consuming procurement, award, and signing of main packages; (ii) severe climactic conditions and challenging project site delaying construction and postponing overall implementation; and (iii) poor initial performance identified during the test run stage,<sup>11</sup> directly impacting the entire plant performance in power generation. The cause of (iii) was absence of the experienced O&M contractor as planned during project design (para. 12). The winding-up period was extended twice until 16 March 2021 because of prolonged negotiation between CGN-DSE and the EPC contractor over the punch-list of the solar field subsystem for final payment. The CSP plant nevertheless was fully completed and started commercial operation on 10 October 2018, only 1 year behind schedule. Construction began in August 2015, and the main structures were completed in June 2017. Energizing of the power system was launched on 31 August 2017, commencing the test run and commissioning of the plant. The HTF was successfully injected in January 2018, and the salt of the TES system started melting in June 2018. The plant was successfully connected to the grid on 30 June 2018. A chronology of events is in Appendix 6, and the planned versus actual implementation schedule is in Appendix 7.

## **F. Implementation Arrangements**

21. Implementation arrangements were appropriate and remained stable throughout project implementation. As envisaged at appraisal, CGN was the executing agency with overall responsibility for implementation. CGN-DSE, established in January 2012 in Delingha Qinghai Province, was the implementing agency responsible for day-to-day project management, including procurement and contract management, contractor payments, O&M, and social and environmental safeguard monitoring. CGN Solar Energy Development, the parent company fully owning the implementing agency, provided management support for procurement and contract management under CGN's guidance. The organizational structure is in Appendix 8.

22. The PRC was the borrower and relent the loan proceeds to CEXIM through the Ministry of Finance with the same terms and conditions as between it and ADB. CEXIM onlent the proceeds to CGN with the same terms plus an administration fee for onlending services. CGN then onlent the proceeds to CGN-DSE with the same terms and conditions as with CEXIM. CGN-DSE bore the risks of exchange rate and interest rate fluctuation. These arrangements were made through subsidiary onlending agreements. The implementation arrangements were adequate to deliver project outputs and achieve the project outcome.

## **G. Technical Assistance**

23. ADB financed technical assistance of \$750,000 on a grant basis from ADB's Technical Assistance Special Fund.<sup>12</sup> The assistance adopted a unique approach (two stages of consulting services) to efficiently use the limited loan processing time and effectively guide the executing and implementing agencies during project preparation. Part 1 included preliminary design review and technical guidance, initial financial viability assessment, and advance procurement support, while part 2 included detailed due diligence, technical guidance, and capacity development. Part 1 was implemented while selection of consulting services for part 2 was underway. Early engagement of consultants for part 1 was essential to ensure quality of design, financial viability gap assessment, and advance procurement support. The assistance was approved on 22 June 2012 and completed in September 2014. It produced the expected outcome, along with a

<sup>11</sup> Automatic and systematic control of heating transfer and thermal storage subsystems were insufficient and the solar field flow balance scheme was configured ineffectively.

<sup>12</sup> ADB. 2012. *Technical Assistance to the People's Republic of China for Preparing Qinghai Delingha Concentrated Solar Thermal Plant Project*. Manila.



workshop on tariff setting held in September 2013, and the subsequent loan processing was based on the technical assistance findings and recommendations.

## H. Consultant Recruitment and Procurement

24. Financed by counterpart funds, a Spanish engineering firm, INGETEAM, was engaged for the basic engineering design for the CSP plant. As one of the enhanced risk mitigation measures in the project administration manual, the owner's engineer, ARIES INGENIERIA Y SISTEM, S.A. (Aries S.A.), another Spanish company, was engaged since 2014 from counterpart financing to assist in engineering design review, tendering, construction supervision, commissioning, acceptance, and capacity building support in EPC and project O&M. Various consulting service assignments—including materials testing, ground leveling design, terrain survey, design review, risk assessment, geotechnical drilling, and testing and commissioning—were outsourced to national design institutes, consultants, and relevant institutes during implementation. Consultant engagement was timely and followed national procedures.

25. The performance of the consultants was *satisfactory*. The design and supervision consultants performed well, established good working relationships with the executing and implementing agencies, and delivered high-quality outputs on time. The national consultants provided significant support in project implementation, ensuring the quality of the project. The monitoring teams provided regular monitoring reports on the performance indicators and safeguard aspects. During project implementation, the contract of the owner's engineer, Aries S.A., was closed early in 2017 (original planned closing date was in 2018), mainly due to tight control over foreigners' access to Delingha City.

26. All ADB-financed procurement followed ADB's Procurement Guidelines (2013, as amended from time to time). ADB financed two goods contracts and one EPC contract (solar field subsystem) using ICB procedure (para. 8). The solar field subsystem was deemed the most critical component affecting the entire CSP plant performance, and complexity and technical risks during construction were expected to be effectively managed under the EPC contract. As residual risks for remaining equipment were deemed low, the power block equipment, HTF and the auxiliary equipment, and TES in the original procurement plan remained as goods supply contract but changed to counterpart financing, except that HTF and the molten salt were procured under ADB financing. All other civil works were financed by counterpart funds. All bids were processed on time within the project implementation schedule. There were no other issues relating to project procurement.

27. The performance of contractors and suppliers was *satisfactory*. The equipment was delivered and installed on time and with good quality. The EPC and other civil works were completed according to specifications and applicable quality standards and in compliance with environmental and social safeguard requirements. Some defects in the automatic and systematic control of heating transfer and thermal storage subsystems and solar field flow balance scheme were identified during the test runs. This delayed loan closing. This issue will be settled along with implementation of the Technical Improvement Action Plan (Appendix 9).

## I. Gender Equity

28. The project was classified at project appraisal as no gender elements. The project had no gender action plan, but it included gender and development measures to promote equal access to job opportunities and training in the land acquisition and ethnic minority development plan (LAEMDP). Key achievements include that (i) 800 unskilled job opportunities during construction

were provided to local residents, of which 300 (37.5%) are women; (ii) 37 local residents worked in CGN-DSE as permanent employees, of which 10 low-skilled positions are provided to women, accounting for 27%; and (iii) among the participants in training on grassland management and household financial management, 45% and 56% were women, respectively.

## **J. Safeguards**

29. The project was classified as category B for environment, involuntary resettlement, and indigenous people.

30. **Environment.** An initial environmental examination, including an environmental management plan (EMP), was prepared in accordance with ADB's Safeguard Policy Statement (2009) and disclosed on ADB's website in May 2013.

31. During implementation, CGN-DSE established an environmental management unit with three designated staff. During construction, detailed and site-specific plans to mitigate potential impacts on water, soil, air quality, acoustic environment, and occupational and community health and safety were developed and implemented effectively. Temporary impacts, such as dust, noise disturbance, and damage to landscapes, were controlled and minimized through a range of good engineering practices, implementation of the EMP, and adherence to national regulations. Contractors also designated staff responsible for mitigating potential environmental impacts. Xi'an Jingcheng Monitoring Technology Co., Ltd. (Jingcheng) was engaged to conduct environmental management activities and noise, air quality, and water quality monitoring. Jingcheng also supported the environmental management unit in preparing environmental monitoring reports. During the operation phase, Qinghai Lanbo Monitoring Science and Technology Co., Ltd. was hired for quarterly monitoring of sulfur dioxide (SO<sub>2</sub>) and particulate matters and monthly monitoring of nitrogen oxides (NO<sub>x</sub>). The monitoring unit regularly monitors noise at the site boundary. Golmud Environmental Protection Science and Technology Co., Ltd. was engaged as the licensed third party for hazardous waste treatment and disposal.

32. No unexpected adverse environmental impacts were identified other than those predicted in the original EMP. No environmental safeguard-related complaints were received during project construction and operation. Eight environmental monitoring reports have been prepared and disclosed on the ADB website. Overall implementation of the EMP appears satisfactory based upon ADB's review mission and the monitoring results. At the time of the project completion review mission, there were no pending environmental safeguard-related noncompliance issues. The detailed environmental impact analysis is in Appendix 10.

33. **Resettlement and indigenous peoples.** A combined LAEMDP was prepared in December 2012 in accordance with the PRC's laws and regulations and ADB's Safeguard Policy Statement (2009). During implementation, there was no change in project scope and land acquisition impact.

34. The project permanently acquired 246 hectares of jointly contracted grassland with 50 years land use rights since 1984 belonging to 153 people of 31 ethnic minority households in Taositu Village, Xuji Township, Delingha City, Qinghai Province. The acquired land was unused semi-arid land constituting 0.7% of the total grazing land area owned by the affected households. The 31 households included 30 Mongolian households of 148 persons and one Tuzu household of 5 members. No vulnerable household was affected.

35. All affected households received cash compensation for loss of land and in-kind assistance, including (i) employment opportunities during project construction and operation, (ii) portable PV power generation sets and highly insulated yurts, and (iii) livelihood skills development training. In addition, an amount equivalent to 50% of total land compensation paid to farmers (CNY2.60 million) was also paid to Delingha Land Resource Bureau in June 2014 for the endowment insurance fund pool. All entitled affected farmers have enrolled in the social endowment insurance system and are eligible to receive pensions from 60 years of age.

36. There was a well-organized institutional structure for management and implementation of the LAEMDP. Stakeholder participation and consultations took place throughout the project cycle. The grievance redress mechanism was well established and disclosed to affected people prior to land acquisition implementation. No grievance issues arose during implementation.

37. The actual cost for LAEMDP implementation was CNY8.70 million. Due to payment into the endowment insurance fund pool for affected farmers, that was 1.31 times the CNY6.63 million estimated in the LAEMDP. Four social monitoring reports have been prepared by CGN-DSE and disclosed on ADB's website. Appendix 11 details LAEMDP implementation.

## K. Monitoring and Reporting

38. Of the 41 loan covenants, 37 were complied with, 2 were partly complied with,<sup>13</sup> 1 was not complied with,<sup>14</sup> and 1 was not applicable.<sup>15</sup> The status of compliance with the covenants in the loan and project agreements is in Appendix 12.

39. The progress reports, including quarterly and annual reports, environmental and LAEMDP monitoring reports, due diligence reports, audited financial statements and audited project accounts, and auditor's reports (including opinions) were submitted to ADB as required, with only occasional delays. The executing and implementing agencies have implemented the project unremittingly and provided sufficient funds for its construction, O&M, and management.

## III. EVALUATION OF PERFORMANCE

### A. Relevance

40. The project is rated *highly relevant*. It has contributed to the expanded share of CSP in the PRC's renewable energy mix as the first-of-its-kind pioneer. At appraisal, the project was fully aligned with the government's Renewable Energy Law, Twelfth Five-Year Plan, and the Medium and Long-Term Development Plan for Renewable Energy in the PRC, as well as ADB's operational priorities. This first utility-scale CSP project in the PRC demonstrated ADB's commitment to focus future energy sector support on clean energy development, improving energy efficiency, reducing emissions, and encouraging diversity in the energy mix, in line with ADB's Energy Policy 2009 (footnote 7). At completion, the project is still highly relevant. It is aligned with priorities of the ADB-PRC country partnership strategy 2021-2025 and ADB's operational priorities under its strategy 2030, improving energy efficiency and environmental

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<sup>13</sup> The covenant refers to financial management. Records were maintained according to sound accounting principles, but CGN-DSE has not achieved the required debt service coverage and long-term debt to equity ratios because the project has not yet achieved full operation capacity. The company's financial performance and debt repayment capacity will improve significantly upon full operation of the plant. CGN-DSE is taking measures to improve the plant's technical performance, aiming to reach designed full capacity in 2023 (para. 43 and Appendix 14).

<sup>14</sup> The covenants are (i) performance-based O&M in the first 2 years of operation (para. 12), and (ii) completion date.

<sup>15</sup> The covenant refers to the change in ownership.

conservation and mitigating climate change impact through reduced CO<sub>2</sub> emission and greater share of non-fossil fuels in primary energy consumption. ADB's involvement, along with the previous technical assistance (footnote 8), also enhanced the enabling environment for CSP in the PRC, including technology awareness, policy environment, institutional capacity, and efficiency. As the first CSP plant in commercial operation in the PRC and in a high altitude and extreme cold area, it has demonstrated a replicable approach to expand CSP utilization and developed institutional capacity within the PRC. CGN and CGN-DSE completed the project despite stringent local regulation restricting foreign experts' access to the project site since 2017. The project has significantly enhanced CSP utilization in the renewable energy sector, promoted clean energy development in Qinghai and western PRC, and contributed to a resource-conservative and environment-friendly harmonious development pathway in the PRC. The project's results chain was sound and its design had no deficiencies.

41. The project design also included technically innovative features to successfully develop a CSP plant in a region with high altitude (3,000 meters above sea level, the highest CSP plant in the world) and severe climate and geographic conditions, where mid-winter low temperature during night-time would be  $-27^{\circ}\text{C}$ , thus far below the  $50^{\circ}\text{C}$  designed safety temperature of HTF. Innovative measures included a circulation pump to force continuous circulation of the HTF; mineral wool insulation for pipes, valves, and instruments; and natural gas heater in the HTF. These are pioneering practices for CSP in cold areas globally and the first application in the PRC. In addition to technical innovations, this was the first experience with a CSP project in the PRC where an owner's engineer (international) was engaged to provide sufficient international experience in CSP systems with similar configuration to ensure quality and delivery. Successful deployment of these innovative features further contributed to the project's relevance.

## **B. Effectiveness**

42. The project was *less than effective* in achieving its stated outcome and outputs. All outputs were achieved, but the outcome (demonstrated feasibility and reliability of a utility-scale CSP plant with a 7-hour thermal storage system in Qinghai Province) is expected to be achieved in 2023. The plant was the first utility-scale CSP project in the PRC. Its successful integration into the state grid has significantly demonstrated the technology and approaches adopted in the project and proven the feasibility and soundness of the project design. Although it has not yet achieved its full capacity (para. 43), the plant has demonstrated its capability to convert direct normal irradiation into usable heat to generate a potential 197 gigawatt-hours (GWh) annually from 2023. The project can avoid 163,904 tons of CO<sub>2</sub> emissions annually at full capacity operation. Output targets have been overachieved: (i) the system configuration design was modified and optimized to further reduce the cost of energy without expanding the land area required for the project and increased the TES capacity to 9 hours (versus the 7 hours envisaged at appraisal), and (ii) more than 186 counterpart engineers and operators participated in 62 capacity building trainings and workshops (versus the 50 envisaged at appraisal). With the experience gained from this project, CGN is planning a 2,000 MW solar energy project including 400 MW CSP in the near future. This will contribute directly to the project's intended impact. The project was successfully implemented with no significant environmental or social safeguard issues. The capacity building under the project also significantly improved the technical and managerial capacity of the executing and implementing agency staffs and laid a solid foundation for implementing future, similar projects. Furthermore, CGN-DSE promoted social development in the project areas, including to provide employment opportunities for local ethnic minorities (mainly Mongolian) and women; ensure equal pay for equal work; and provide vocational training, skills training, and financial support to vulnerable groups of ethnic minorities. This has significantly improved social conditions in the project areas.

43. Due to the lack of domestic experience and international guidance (para. 12), the plant's operation has not yet achieved full capacity. The plant generated 29 GWh of electricity in 2019 and 63 GWh in 2020. The main remaining technical issues identified by CGN-DSE include (i) some defects, such as carbonization of the HTF due to overheating affecting the heat carrying flow regime and heat transfer efficiency; (ii) lack of flow of equilibrium algorithm leading to poor heat collection efficiency; and (iii) lack of automatic control leading to over-reliance on operators and increased risk of human errors. CGN and CGN-DSE have been greatly attentive to the plant's less-than-expected output and are implementing a practical action plan to address the identified issues and improve the technical performance toward achieving the designed full capacity in 2023. The main points of the action plan include to improve (i) HTF system performance, (ii) solar field flow balance, (iii) automatic control systems, (iv) system repair and overhaul and technical aspects, and (v) other safety performance. Since implementing the action plan from May 2020, electricity generated in 2021 reached 79 GWh, a gain of 25% more than the generated electricity of 2020. Electricity generation in the first half of 2022 reached 58.9 GWh which is 200% of the electricity generated in the first half of 2021. The electricity generation is on track to achieve 120 GWh in 2022, and 197 GWh in 2023. The detailed action plan and its progress are summarized in Appendix 9.

### C. Efficiency

44. The project was *less than efficient* in achieving its intended outcome and outputs. The CSP plant was completed in late 2018, almost 2 years behind the originally planned late 2016. The main reasons for the extended construction period are described in para. 20. The project cost at appraisal was estimated at \$322.26 million. The cost at completion was \$258.77 million, 19.70% lower. Reasons for the cost savings are described in para. 15. Power generated under the project will be directed to the state grid to supply electricity to western PRC. At full operation, the plant's annual average generation capacity could be 197 GWh, net of self-consumption and system operation loss. The project could generate considerable environmental benefits by reducing pollutant emissions. It could avoid using 60,065.3 tons of standard coal per year, translating to an annual emission reduction of 163,904 tons of CO<sub>2</sub>.<sup>16</sup>

45. **Economic reevaluation.** The economic reevaluation (Appendix 13) updates the project economic analysis with actual implementation costs and benefits at 2021 prices. It was conducted following ADB's guidelines.<sup>17</sup> The project's reevaluated economic internal rate of return is 6.27%, lower than the 13.3% estimated at appraisal and lower than the 12% discount rate assumed at appraisal. The differences are mainly due to the longer implementation period, delay in operating at 100% of capacity, and O&M costs that are higher than expected.

### D. Sustainability

46. The project is rated *most likely sustainable* considering its financial viability, operational and institutional sustainability, and the sustainability of the environmental and social impacts. The plant is technically sound and will be self-sustaining financially once it starts operating at full capacity (para. 43). The power generators can continuously produce electricity, and revenue is healthy with a feed-in tariff of CNY1.15 per kWh. This tariff is higher than that for coal thermal power plants and solar PV plants, thereby enabling the project's sustainability and profitability.

<sup>16</sup> The initial environmental examination stated 70,000 tons of standard coal and 154,446 tons of CO<sub>2</sub>. The difference is due to updated emission factors.

<sup>17</sup> ADB. 2017. *Guidelines for Economic Analysis of Projects*. Manila.

47. **Financial reevaluation.** The financial internal rate of return (FIRR) was recalculated at completion to be 4.75%, higher than the updated weighted average cost of capital (WACC) of 2.29%. The financial net present value is CNY617.16 million, indicating financial viability. FIRR is comparable with the 4.82% appraisal estimate. A sensitivity analysis retested three scenarios: (i) O&M costs increase by 10%, (ii) revenue decreases by 10%, and (iii) both together. The resulting FIRRs that are greater than the WACCs indicated that the project would remain financially viable under these adverse conditions. The financial reevaluation is in Appendix 14.

48. **Operational sustainability.** CGN-DSE was actively involved in the project's design, procurement, and construction. That laid a solid foundation for sustainable operations after commissioning. During the almost 3 years of plant operation, CGN-DSE has accumulated abundant experience in CSP O&M. This previously was lacking as this is a first-of-its-kind plant in the PRC. CGN-DSE has invested in the success of its specialized O&M team by strictly monitoring the operating status and jointly addressing O&M challenges as they occur.

49. **Institutional sustainability.** CGN is the largest nuclear power operator in the PRC and third largest in the world. As of July 2021, CGN is operating total installed capacity of 64.26 GW, more than 36 GW of which is from renewable energy sources, including this project. CGN is in a very strong financial position. According to its annual reports, the total assets grew from CNY432.00 billion in 2015 to CNY787.00 billion in 2020 and the consolidated operating revenue increased from CNY50.00 billion in 2015 to CNY111.00 billion in 2020. CGN is committed to the development of clean energy, such as wind and solar power. This project is part of CGN's commitment to support clean energy development in the PRC. In the past 3 years, CGN has provided cash flow of more than CNY270.00 million to CGN-DSE for operating the project. Continuous support from CGN ensures sustainability of the project in the long term.

50. **Environmental and social sustainability.** The project uses renewable energy to replace fossil fuels for power generation. This has a long-term positive impact on environmental sustainability and mitigating climate change. By 2023, in addition to annual savings of coal and CO<sub>2</sub> reduction, as indicated in para. 44, the project is expected to reduce annual particulate matter emissions by 6.3 tons, SO<sub>2</sub> emissions by 31.5 tons, and NO<sub>x</sub> emission by 35.3 tons.

## E. Development Impact

51. The project's impact is rated *satisfactory*. This first completed utility-scale CSP project both in the PRC and in the world within a high altitude and extreme cold area, has strongly demonstrated the feasibility and reliability of broader CSP utilization, not only for Qinghai and the PRC but for the entire world. Upon completion of this first project, CSP's capacity in the PRC's renewable energy mix went from 0.00 GW in 2013 to 0.54 GW in 2020.

52. **Socioeconomic impact.** The project has a significant impact on regional socioeconomic development. The plant is located in one of the PRC's poorest areas. Socioeconomic data show that conditions in the project area improved during project implementation. Rapid economic growth and increased fiscal revenues have raised living standards and local income, particularly for the poor. Per capita rural income in the project area (Haixi Prefecture) grew from CNY9,183 in 2013 to CNY15,052 in 2019. Utilizing the natural endowment of solar radiation, rapid development of the solar energy industry has significantly driven economic development for this region. Haixi Prefecture and Delingha City have enjoyed much faster economic growth than other, similar cities in western PRC, with particular benefits for local poor people. Together with population growth and job creation, rapid industrial growth has improved local infrastructure and

services while changing people's lifestyles and social behaviors. The improved infrastructure also enabled more national tourists to visit this place with unique natural tourism sites. These CSP plants, called "super engineering works" by the media, are also tourist attractions. In 2019, Haixi Prefecture received 20.17 million tourists, almost five times the 4.66 million tourists in 2013.

53. **Project operation impact.** The project has created five "firsts" in the PRC's CSP sector: (i) first utility scale CSP plant to begin construction; (ii) first CSP project using international financial institution funding; (iii) first CSP plant successfully achieving stepped HTF injection during winter; (iv) first completed utility scale CSP plant; and (v) first operational and grid-connected CSP plant. These unique features have made this project a real role model and provided a replicable example to other projects in the PRC and the world. Furthermore, by designing and implementing this project, CGN and CGN-DSE have nurtured a well-qualified team in CSP design, construction, and O&M that could be an invaluable asset for this sector.

#### **F. Performance of the Borrower and the Executing Agency**

54. The performance of the Ministry of Finance (borrower), CGN (executing agency), and CGN-DSE (implementing agency) was *highly satisfactory*. At appraisal, an adequate organizational framework was established for efficient and timely project management. CGN exercised coordination and monitoring of project progress. CGN-DSE was responsible for day-to-day project management and facilitated project implementation. CGN-DSE prepared the required progress reports. The China National Audit Office audited the project accounts and financial statements, and CGN submitted the audit reports to ADB as required. CGN mobilized the domestic funds on time, submitted withdrawal applications in a timely manner, and paid contractors and suppliers on time. CGN-DSE submitted the monitoring reports on time. The executing and implementing agencies facilitated and supported all ADB review missions during implementation and at completion.

#### **G. Performance of Cofinanciers**

55. CEXIM's performance was *highly satisfactory*. At appraisal, it was envisaged that CEXIM would finance \$75.58 million (23.45% of the total project cost) as counterpart financing through domestic loan. At completion, \$57.00 million equivalent (22.03% of the total project cost) was provided, that being the important collaborative direct value-added financing. The loan agreement was signed on 4 March 2016, and the loan was provided and paid on time. The advance account was opened in the name of CGN and a subaccount in the name of CGN-DSE was opened and maintained at CEXIM. The advance account was replenished and liquidated on time and no fund shortage occurred during project implementation. All the withdrawal applications were also signed by CEXIM on time. The good performance and cooperation from CEXIM contributed significantly to the project's success, not only with financing but also with managerial expertise and professionalism.

#### **H. Performance of the Asian Development Bank**

56. Overall, the performance of ADB was *highly satisfactory*. The project was administered and supervised from ADB headquarters. During implementation, ADB provided substantial guidance and support to the government and to the executing and implementing agencies in all aspects of project implementation, such as promptly reviewing all procurement and safeguards documents and evaluation reports. ADB conducted nine project review and administration missions after loan effectiveness, at least once a year before the coronavirus disease (COVID-19) pandemic outbreak. ADB was closely involved in identifying and resolving potential problems

relating to project implementation, particularly the procurement and safeguards issues. ADB’s role in promptly advising on project implementation and technical issues was well recognized by CGN and CGN-DSE.

**I. Overall Assessment**

57. Overall, the project is rated *successful*. The project formulation and design were highly relevant to both the Government of the PRC and ADB’s development strategies. It was effective in delivering the expected outcomes, especially as the first piloting CSP project in the PRC. The implementation arrangements were effective, environmental mitigation measures were satisfactory, and land acquisition and resettlement were implemented to the satisfaction of the affected people. The FIRR substantially exceeded the WACC, and sustainability of operation, institution, and social and environmental impacts project are high. The project not only has successfully demonstrated the feasibility and reliability of the utility-scale CSP plant with a thermal storage system in Qinghai, but also for the PRC and other ADB member countries.

**Table 3: Overall Ratings**

<b>Criteria</b>	<b>Rating</b>
Relevance	Highly relevant
Effectiveness	Less than effective
Efficiency	Less than efficient
Sustainability	Most likely sustainable
<b>Overall Assessment</b>	Successful
Development impact	Satisfactory
Borrower and executing agency	Highly satisfactory
Performance of Asian Development Bank	Highly satisfactory

Source: Asian Development Bank.

**IV. ISSUES, LESSONS, AND RECOMMENDATIONS**

**A. Issues and Lessons**

58. **Operation and maintenance concerns.** The plant is yet to operate at full capacity due to technical constraints. CGN and CGN-DSE are implementing an action plan to improve the plant’s technical performance. An O&M challenge is cleaning and maintaining the solar panels, especially in the unfavorable natural conditions of Qinghai with its severe water shortage, possible serious sand and/or dust storms, and extremely low temperatures during winter. CGN-DSE needs to work out a practical way to address this challenge (including adequate financing and staffing arrangements) to best maintain full-capacity operation in the future.

59. **Stakeholder consultation.** Sufficient consultation and participation with stakeholders helped promote ownership, responsibility, and dissemination of the project benefits. During processing and implementation, consultation meetings with stakeholders at various levels were held on the project’s design, construction, safeguards, job opportunities, and ethnic minority and social impacts. These meetings included the international engineers, the executing and implementing agencies, and the local people at the village, town, county, city, prefecture, and province levels. Local government of the project area associated more economic development activities with the project, including power industry, tourism, urbanization and town zoning, and the creation of more employment opportunities. Extensive and continued consultations during project implementation promoted participants’ sense of ownership and responsibility for the project and further helped to improve the project design and operation.



60. **Climate change impact.** In the past 3 years, due to climate change impact, the project encountered more cloudy and rainy days than estimated at project appraisal. This has caused there to be less solar direct irradiation and thus negatively impacted electricity generation.

## **B. Recommendations**

61. **Financial sustainability.** In case the low operating efficiency continues in the long run or feed-in tariffs are decreased in the future as the CSP sector further develops, CGN should (i) focus on controlling operational costs while improving efficiency; (ii) explore potential business opportunities, optimize service standards, and enhance mutual cooperation and seek synergies with other solar energy plants in the area to formulate a union or alliance; and (iii) closely monitor the project's financial performance, including demand growth, operating ratios, tariffs, and other factors affecting the financial status of the project, then prepare the possible solutions and mitigation measures in advance.

62. **Further action or follow-up.** CGN-DSE must closely monitor implementation of the technical improvement action plan for the plant and ensure the plant can reach its full capacity within the expected timeline. Moreover, CGN-DSE should be cooperating closely with the local meteorological stations to strengthen the weather monitoring and forecasting in order to plan the operation and maintenance schedule in a more systematic way. For investment in future CSP or solar PV projects, a comprehensive climate change model may be developed for accurately assessing climate change impact.

63. **Timing of the project performance evaluation report.** If the Independent Evaluation Department opts to prepare a project performance evaluation report, the appropriate timing for preparing that report would be in the second half of 2023, 5 years after formal launch of the CSP plant's operations and after the plant is projected to achieve full-capacity operation.

## DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Indicators and Targets in the RRP	Project Achievements
<p><b>Impact</b> Expanded share of CSP in renewable energy mix in the PRC</p>	<p>Share of CSP increases to 3 GW by 2020 (baseline: 0 GW in 2013)</p> <p>CSP capacity avoids more than 5 million tons of CO<sub>2</sub> emissions per year by 2020</p>	<p>Partially achieved. Share of CSP increases to 0.54 GW by 2020</p> <p>Partially achieved. CSP capacity avoids more than 0.91 million tons of CO<sub>2</sub> emissions per year by 2020</p>
<p><b>Outcome</b> Demonstrated feasibility and reliability of the utility-scale CSP plant with thermal storage system in Qinghai Province</p>	<p>50 MW Qinghai Delingha plant operates reliably delivering designed output (baseline: 0 MW in 2013)</p> <p>197 gigawatt-hours of clean electricity generated annually, thereby avoiding 154,446 tons of CO<sub>2</sub> per year by 2017 (baseline: 0 gigawatt-hours in 2013)</p>	<p>Partially achieved. 50 MW Qinghai Delingha plant started operation on 10 October 2018, but the plant's operation has not yet achieved full capacity</p> <p>Partially achieved. In 2021, 79 GWh of clean electricity generated, thereby avoiding 61,935.2 tons of CO<sub>2</sub> in the year. As of 30 June 2022, 58.9 GWh of clean electricity generated.</p> <p>The plant is now under technical improvement which targets to operate in full capacity in 2023. It is expected that 197 GWh of clean electricity could be generated annually, thereby avoiding 154,446 tons of CO<sub>2</sub> per year starting from 2023.</p>
<p><b>Outputs</b> 1. The construction of a first-of-its-kind utility-scale CSP plant in Qinghai Province constructed</p> <p>2. Capacity development and training in CSP construction, and operation and management</p>	<p>50 MW parabolic trough CSP plant with 7 hours thermal storage capacity is commissioned and commercially operational by 2016 (baseline: 0 MW in 2013)</p> <p>Capacity development training provided in design, construction supervision, and operation and management for 50 counterpart engineers and operators by 2016</p>	<p>Achieved. 50 MW parabolic trough CSP plant with 9 hours thermal storage capacity was commissioned and commercially operational on 10 October 2018.</p> <p>Achieved. At least 186 counterpart engineers and operators received 62 trainings and capacity building and workshops by 2021.</p>

CO<sub>2</sub> = carbon dioxide, CSP = concentrated solar thermal power, GW = gigawatt, GWh = gigawatt per hour, MW = megawatt, PRC = People's Republic of China, RRP = report and recommendation of the President.

Source: Asian Development Bank estimates.

**PROJECT COST AT APPRAISAL AND ACTUAL**  
(\$ million)

Item	Appraisal			Actual		
	Foreign Exchange Costs	Local Currency Costs	Total Costs	Foreign Exchange Costs	Local Currency Costs	Total Costs
<b>A. Investment Costs<sup>a</sup></b>						
1. Civil works	0.00	11.80	11.80	0.00	8.10	8.10
2. Solar field	92.97	39.84	132.81	66.51	28.50	95.01
3. HTF system	2.72	10.90	13.62	2.07	8.28	10.35
4. Thermal energy storage system	7.74	30.94	38.68	14.30	57.20	71.50
5. Power generation system	7.23	16.86	24.09	8.59	20.04	28.63
6. Auxiliaries	10.82	7.21	18.03	3.24	2.16	5.41
7. Other costs	16.52	11.01	27.53	12.55	8.37	20.91
8. Engineering service	4.61	3.07	7.68	7.41	4.94	12.35
<b>Sub-total (A)</b>	<b>142.60</b>	<b>131.64</b>	<b>274.24</b>	<b>114.67</b>	<b>137.59</b>	<b>252.26</b>
<b>B. Contingencies<sup>b</sup></b>						
1. Physical	7.13	6.58	13.71	0.00	0.00	0.00
2. Price	9.20	13.81	23.01	0.00	0.00	0.00
<b>Subtotal (B)</b>	<b>16.33</b>	<b>20.40</b>	<b>36.72</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>C. Financing Charges During Implementation<sup>c</sup></b>						
1. Interest During Implementation	3.83	7.19	11.02			
2. Commitment Charges	0.29	0.00	0.29			
<b>Subtotal (C)</b>	<b>4.12</b>	<b>7.19</b>	<b>11.31</b>	<b>4.12</b>	<b>2.39</b>	<b>6.51</b>
<b>Total Project Cost (A+B+C)</b>	<b>163.04</b>	<b>159.22</b>	<b>322.26</b>	<b>118.79</b>	<b>139.98</b>	<b>258.77</b>

HTF = heat transfer fluid.

Note: Numbers may not add precisely due to rounding.

<sup>a</sup> Base costs at appraisal are in October 2013 prices. Includes tax and duties estimated at \$31.33 million, of which \$14.94 million will be for Asian Development Bank-financed components. Tax and duties are not considered to be excessive and are in compliance with the country cost-sharing ceiling and financing parameters for the People's Republic of China, approved on 16 March 2011.

<sup>b</sup> Physical contingencies at appraisal are calculated based on 5% of total base costs. Price contingencies at appraisal are computed at 4% of base costs plus physical contingencies for local expenditures, and 0.5% of base costs plus physical contingencies for foreign expenditures.

<sup>c</sup> Includes interest and commitment charges. Interest during construction for the Asian Development Bank loan at appraisal had been computed at the 5-year forward London interbank offered rate plus a spread of 0.4% and a maturity premium of 0.1%. Commitment charges for an Asian Development Bank loan are 0.15% per year to be charged on the undisbursed loan amount.

Source: Asian Development Bank.

## PROJECT COST BY FINANCIER

Table A3.1: Project Cost at Appraisal by Financier  
(\$ million)

Item	ADB		Counterpart Funds		China Exim Bank		Total Cost
	Amount {A}	% of Cost Category {A/D}	Amount {B}	% of Cost Category {B/D}	Amount {C}	% of Cost Category {C/D}	Amount {D}
<b>A. Base Costs<sup>a</sup></b>							
1. Civil works	0.00	0.00	9.91	83.99	1.89	16.01	11.80
2. Solar Field	68.50	51.58	0.00	0.00	64.31	48.42	132.81
3. HTF system	13.62	100.00	0.00	0.00	0.00	0.00	13.62
4. Thermal Energy Storage system	32.70	84.55	5.98	15.45	0.00	0.00	38.68
5. Power Generation System	18.50	76.81	5.59	23.19	0.00	0.00	24.09
6. Auxiliaries	12.56	69.65	2.18	12.09	3.29	18.24	18.03
7. Other costs	0.00	0.00	27.53	100.00	0.00	0.00	27.53
8. Engineering service	0.00	0.00	7.68	100.00	0.00	0.00	7.68
<b>Subtotal (A)</b>	<b>145.88</b>	<b>53.20</b>	<b>58.86</b>	<b>21.46</b>	<b>69.49</b>	<b>25.34</b>	<b>274.24</b>
<b>B. Contingencies<sup>b</sup></b>							
<b>Subtotal (B)</b>	<b>0.00</b>	<b>0.00</b>	<b>36.72</b>	<b>100.00</b>	<b>0.00</b>	<b>0.00</b>	<b>36.72</b>
<b>C. Financial Charges During Implementation<sup>c</sup></b>	<b>4.12</b>	<b>36.42</b>	<b>1.10</b>	<b>9.73</b>	<b>6.09</b>	<b>53.85</b>	<b>11.31</b>
<b>Total Project Cost (A+B+C)</b>	<b>150.00</b>		<b>96.68</b>		<b>75.58</b>		<b>322.26</b>
<b>% Total Project Cost</b>		<b>46.55</b>		<b>30.00</b>		<b>23.45</b>	

ADB = Asian Development Bank, HTF = heat transfer fluid.

Note: Numbers may not add precisely due to rounding.

<sup>a</sup> In October 2013 prices. The base cost includes tax and duties estimated \$31.33 million, of which \$14.94 million will be for Asian Development Bank (ADB) financed.

<sup>b</sup> Physical contingencies computed at 5.0% of base cost. Price contingencies are based on estimated domestic and international inflation rates during construction.

<sup>c</sup> Includes interest and commitment charges. Interest during construction for ADB loan has been computed at the 5-year forward London interbank offered rate plus a spread of 0.4% and a maturity premium of 0.1%. Commitment charges for an ADB loan are 0.15% per year to be charged on the undisbursed loan amount.

Source: Asian Development Bank.

**Table A3.2: Project Cost at Completion by Financier**  
(\$ million)

Item	ADB		Counterpart Funds		China Exim Bank		Total Cost
	Amount {A}	% of Cost Category {A/D}	Amount {B}	% of Cost Category {B/D}	Amount {C}	% of Cost Category {C/D}	Amount {D}
<b>A. Base Costs</b>							
1. Civil works	0.00	0.00	3.76	46.41	4.34	53.59	8.10
2. Solar Field	91.21	96.00	3.80	4.00	0.00	0.00	95.01
3. HTF system	10.35	100.00	0.00	0.00	0.00	0.00	10.35
4. Thermal Energy Storage system	17.63	24.65	20.18	28.22	33.69	47.12	71.50
5. Power Generation System	0.00	0.00	13.34	46.60	15.29	53.40	28.63
6. Auxiliaries	0.00	0.00	4.60	85.16	0.80	14.84	5.41
7. Other costs	0.00	0.00	20.91	100.00	0.00	0.00	20.91
8. Engineering service	0.00	0.00	11.86	96.04	0.49	3.96	12.35
<b>Subtotal (A)</b>	<b>119.18</b>	<b>47.25</b>	<b>78.47</b>	<b>31.10</b>	<b>54.61</b>	<b>21.65</b>	<b>252.26</b>
<b>B. Contingencies<sup>a</sup></b>							
<b>Subtotal (B)</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>C. Financial Charges During Implementation<sup>b</sup></b>	<b>4.12</b>	<b>63.25</b>	<b>0.00</b>	<b>0.00</b>	<b>2.39</b>	<b>36.75</b>	<b>6.51</b>
<b>Total Project Cost (A+B+C)</b>	<b>123.30</b>		<b>78.47</b>		<b>57.00</b>		<b>258.77</b>
<b>% Total Project Cost</b>		<b>47.65</b>		<b>30.32</b>		<b>22.03</b>	

ADB = Asian Development Bank, HTF = heat transfer fluid.

Note: Numbers may not add precisely due to rounding.

<sup>a</sup> Physical contingencies are calculated based on 5% of total base costs. Price contingencies are computed at 4% of base costs plus physical contingencies for local expenditures, and 0.5% of base costs plus physical contingencies for foreign expenditures.

<sup>b</sup> Includes interest and commitment charges.

Source: Asian Development Bank.

## DISBURSEMENT OF ADB LOAN PROCEEDS

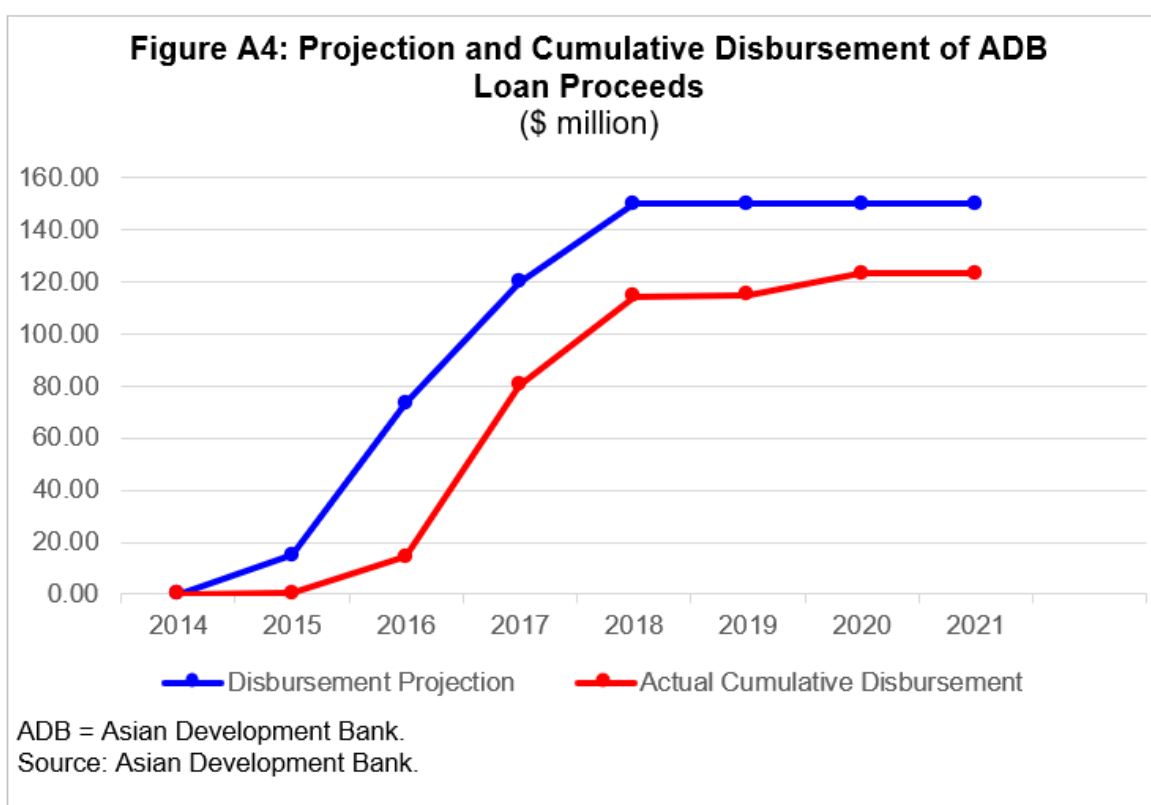
**Table A4: Annual and Cumulative Disbursement of ADB Loan Proceeds<sup>a</sup>**  
(\$ million)

Year	Annual Disbursement		Cumulative Disbursement	
	Amount (\$ million)	% of Total	Amount (\$ million)	% of Total
2014	0.14	0.12	0.14	0.12
2015	0.23	0.18	0.37	0.30
2016	14.06	11.40	14.43	11.70
2017	66.11	53.61	80.54	65.32
2018	33.83	27.43	114.36	92.75
2019	0.69	0.56	115.05	93.31
2020	8.25	6.69	123.30	100.00
<b>Total</b>	<b>123.30</b>	<b>100.00</b>	<b>123.30</b>	<b>100.00</b>

ADB = Asian Development Bank.

<sup>a</sup> Includes disbursements to advance accounts and interest during construction.

Source: Asian Development Bank.

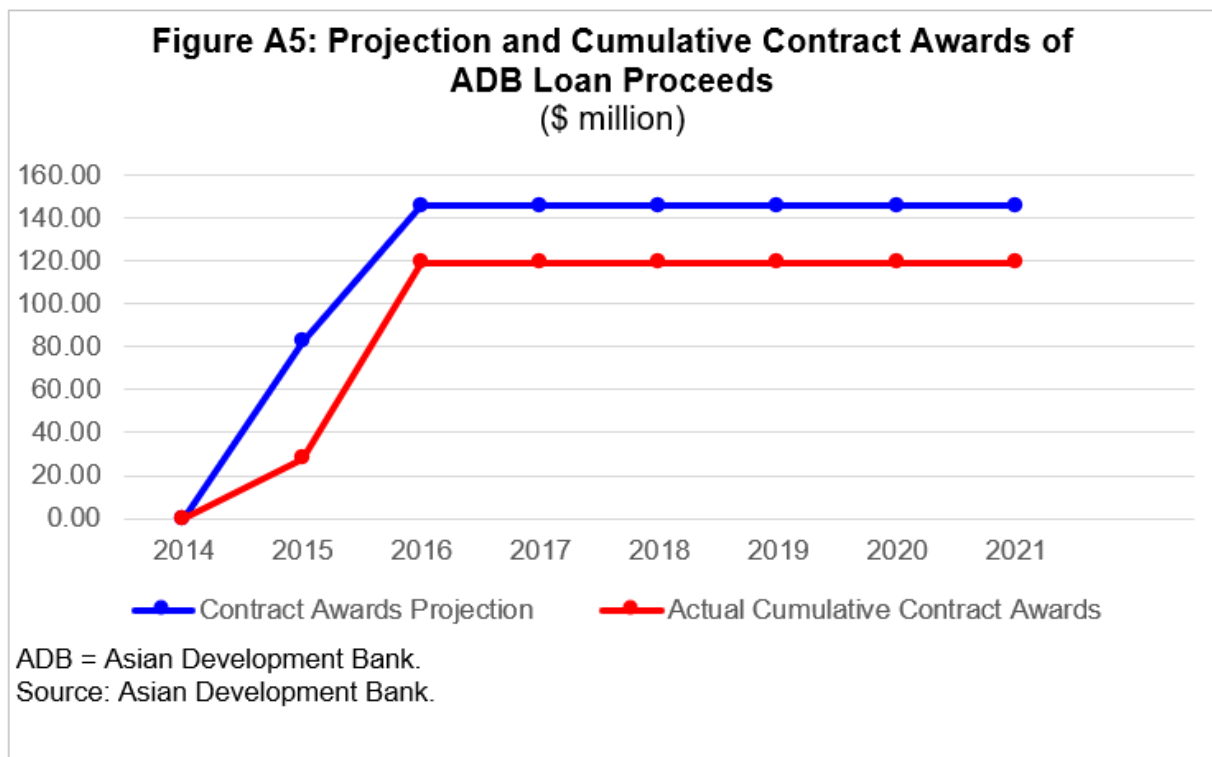


## CONTRACT AWARDS OF ADB LOAN PROCEEDS

**Table A5: Annual and Cumulative Contract Awards of ADB Loan Proceeds**  
(\$ million)

Year	Annual Contract Awards		Cumulative Contract Awards	
	Amount (\$ million)	% of Total	Amount (\$ million)	% of Total
2014	0.00	0.00	0.00	0.00
2015	27.98	23.47	27.98	23.47
2016	91.21	76.53	119.18	100.00
2017	0.00	0.00	119.18	100.00
2018	0.00	0.00	119.18	100.00
2019	0.00	0.00	119.18	100.00
2020	0.00	0.00	119.18	100.00
2021	0.00	0.00	119.18	100.00
<b>Total</b>	<b>119.18</b>	<b>100.00</b>	<b>119.18</b>	<b>100.00</b>

ADB = Asian Development Bank.  
Source: Asian Development Bank.



## CHRONOLOGY OF MAIN EVENTS

Date	Events	
<b>General</b>		
<b>2013</b>	6–17 May	Loan fact-finding mission fielded
	10 July	Management review meeting held
	21–22 October	Loan negotiations
	2 December	Loan approved
<b>2014</b>	23 January	Loan signing
	21 April	Loan effectiveness
	3–4 June	Loan inception mission fielded
	July	Commencement of the construction/ground leveling
	July	Engagement of the owner's engineer
	18–19 September	1st loan review mission fielded
	<b>2015</b>	2–3 February
27 March		3rd loan review mission (safeguard) fielded
28 August		Commencement of the construction of the main structures
<b>2016</b>	4 January	Heat transfer fluid contract awarded
	4 January	Molten salt for thermal energy storage contract awarded
	8–13 May	Midterm review mission fielded
	20 September	Solar field EPC contract awarded
<b>2017</b>	1–6 May	4th review mission fielded
	June	Completion of the main plant
	31 August	Energizing of auxiliary power system
	4–7 September	5th review mission fielded
	23–24 November	6th review mission fielded
<b>2018</b>	25 December	Chemically combined water test passed
	25 January	Solar field mirror field mechanics completed
	25 January	HTF injection completed
	20 June	Auxiliary facilities field completed
	June	Molten salt started melting for the thermal energy storage system
	30 June	The plant successfully connected to the grid for the first time
	July	Molten salt completed melting for the thermal energy storage system
	30 September	Thermal energy storage system completed and enabled the switching of multi-mode power generation
	10 October	CSP plant was fully completed and started commercial operation
	21–23 October	7th loan review mission fielded
<b>2020</b>	11 November	CSP plant full capacity operation
	31 May	Loan closing

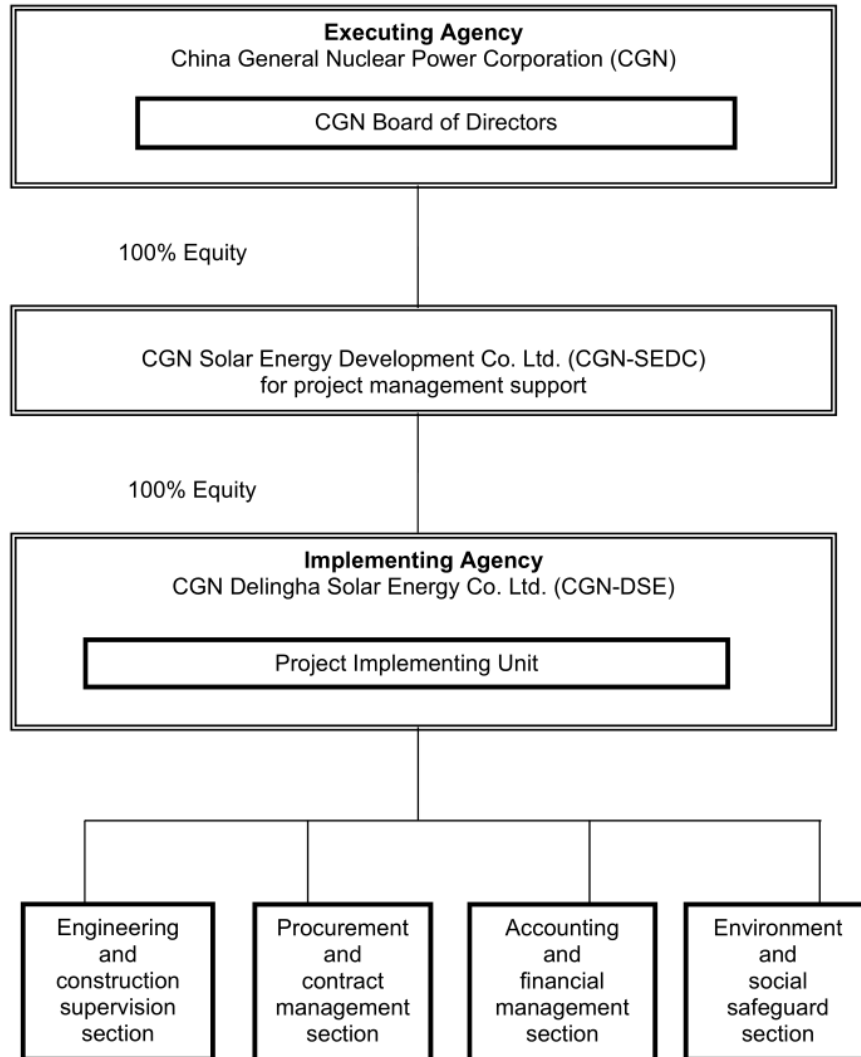


<b>Date</b>	<b>Events</b>	
<b>2021</b>	16 March	Financial closing of loan account
	13–17 September	Project completion review mission fielded
<b>Procurement</b>		
<u>1st bidding document</u>		
<b>2015</b>	16 February	Draft bidding documents for procurement of Solar field EPC using ICB submitted to ADB
	19 June	ADB sent its no objection to finalize and issue the bidding documents for Solar field EPC
	24 June	IFB published at the ADBBO website for Solar field EPC
	24 June	Implementing agency advertised the IFB in the local newspaper (China Daily) for Solar field EPC
<b>2016</b>	11 January	BERs for Solar field EPC submitted to ADB
	19 February	ADB approved contract awards for Solar field EPC
	20 September	PCSS issued for Solar field EPC
<u>2nd bidding document</u>		
<b>2015</b>	7 July	Draft bidding documents for procurement of Heat transfer fluid using ICB submitted to ADB
	20 August	ADB sent its no objection to finalize and issue the bidding documents for Heat transfer fluid
	24 August	IFB published at the ADBBO website for Heat transfer fluid
	24 August	Implementing agency advertised the IFB in the local newspaper (China Daily) for Heat transfer fluid
	19 October	BERs for Heat transfer fluid submitted to ADB
	29 October	ADB approved contract awards for Heat transfer fluid
	28 December	PCSS issued for Heat transfer fluid
<u>Last bidding document</u>		
<b>2015</b>	21 August	Draft bidding documents for procurement of Molten salt for thermal energy storage using ICB submitted to ADB
	10 September	ADB sent its no objection to finalize and issue the bidding documents for Molten salt for thermal energy storage
	16 September	IFB published at the ADBBO website for Molten salt for thermal energy storage
	16 September	Implementing agency advertised the IFB in the local newspaper (China Daily) for Molten salt for thermal energy storage
	5 November	BERs for Molten salt for thermal energy storage submitted to ADB
	16 November	ADB approved contract awards for Molten salt for thermal energy storage
	24 December	PCSS issued for Molten salt for thermal energy storage

ADB = Asian Development Bank; ADBBO = Asian Development Bank Business Opportunities; BER = bid evaluation report; CSP = concentrated solar thermal power; EPC = engineering, procurement, and construction; HTF = heat transfer fluid; ICB = international competitive bidding; IFB = invitation for bid; PCSS = procurement contract summary sheet.

Source: Asian Development Bank.



**ORGANIZATIONAL CHART**

Source: CGN.

## SUMMARY OF THE OVERALL TECHNICAL IMPROVEMENT ACTION PLAN 2020

### A. Issues and Challenges

1. The concentrated solar plant (CSP) plant is currently under trial operation since October 2018. However, the operation did not reach its designed full capacity due to the technical constrains and lack of operation support and experience. The main challenges include:

#### 1. Performance of the heat transfer fluid system not fully meeting the required technical specifications

2. The heat transfer fluid (HTF) is a synthetic heat transfer fluid widely used in the chemical industry and has more than 30 years of application performance in the photothermal industry. Its main components are 26.5% biphenyl and 73.5% biphenyl ether, the maximum allowable temperature of the medium is 400°C, and the maximum allowable oil film temperature is 425°C.

3. The over-temperature operation of the system and the oxidation of high temperature HTF during the maintenance process led to oil cracking, thermal polymerization and coking reactions, resulting in the underperformance of the HTF. The carbonized coking products of HTF are attached and deposited in some pipes and heat collector tubes, causing blockage of screens, small-diameter pipes and valves, and uneven heating of heat collector tubes and bundles of heat exchange equipment, further accelerating the trend of carbonized coking of oil products. The blockage of the recovery and reuse system also reduced the removal and cleaning ability of light and heavy fraction degradation products.

4. To improve the heat transfer and heat exchange efficiency of the whole project and enhance the safety of system and media operation, it is necessary to improve the purifying capacity of cleaning the coking and precipitation inside the system.

#### 2. Solar field flow balance scheme not effectively configured

5. The flow balance of the 190 heat collection circuits in the whole field was not satisfactorily configured due to the lack of experience. The temperature of HTF from different circuits varies greatly (close to 50°C) and cannot always reach the temperature index of  $393\pm 2^\circ\text{C}$  under rated working condition.

6. The commissioning and configuration technology of solar field is strictly controlled by the international giant companies, the implementing agency has to gradually breakthrough and manage the flow balance technology through trail and exploration.

#### 3. The insufficient automatic and systematic control of the heat transfer and thermal storage subsystems

7. The automatic operation technology is the core technology of the CSP plant. There is no available domestic data for reference, thus the operation is largely relying on manual control and experience, which significantly constrained the performance of the plant to operate in maximum capacity, thus reduced the operation efficiency.

#### **4. The limited availability and utilization rate of the equipment**

8. The quality defects during the construction, equipment failures, improper strategies in the operation stage, and the coking of the HTF have caused the limited availability and utilization rate of the equipment, far below the designed value (96%).

#### **5. Some hidden or potential safety and quality concerns**

9. There are also some other hidden or potential safety and quality concerns such as the over-temperature of the horizontal flue of the heat-conducting oil boiler, the lack of power supply for the security section of the conventional island, the lack of uninterruptible power supply capacity for the solar field, the incomplete protection measures for the slope of the solar field, no online real-time leakage monitoring devices for heat exchange equipment, etc. Such defects may also cause potential safety accidents.

### **B. Proposed Action Plan**

10. To address the above challenges, the executing agency and implementing agency have proposed a comprehensive action plan during 2020–2022, which aimed at improving the equipment availability and efficiency and then increase the power generation capacity. After the technical improvement, the plant is expected to generate 197 gigawatt per hour (GWh) electricity, the designed full capacity, from year 2023.

11. The detailed actions include the following five special action plans:

#### **1. Heat transfer fluid system performance improvement**

12. This covers two parts, releasing the HTF and cleaning the HTF. The implementing agency would first release and storage the HTF properly and replace the damaged pipes and valves. The cleaned and filtered HTF, together with the new HTF (around 800 tons) will be re-injected into the pipes as the next step.

#### **2. Solar field flow balance improvement**

13. This will be undertaken in the form of research and study topics. By cooperating with the leading think tank “Suzhou Nuclear Power Research Institute”, the implementing agency is trying to achieve some technical breakthroughs. After the improvement, it is expected that the temperature difference between the outlet of the circuit is less than  $\pm 5^{\circ}\text{C}$  or close to the design value in normal working conditions.

#### **3. Automatic control systems improvement**

14. This will also be done in the form of research and study topics under the national level study topic “Parabolic trough CSP Technical Modelling and Controlling Strategy”. By cooperating with the national CSP technical research and development center and other companies within China General Nuclear Power Corporation, this study is aiming to achieve a no-less-than 95% of the logical automatic control for key equipment and key systems.

#### 4. System repair/overhaul and technical improvement

15. It is planned to conduct a comprehensive and full coverage repairing and overhaul of all the facilities to eliminate the defects and malfunctions in the existing operations. It aims at a 95% availability of the equipment by addressing the potential defects and improving the operation efficiency.

#### 5. Other safety performance improvement

16. It will also improve other system safety and efficiency by addressing other risks identified during the implementation and improve the overall system reliability and operation.

### C. Timeline

17. The proposed timeline for each action is planned as below.

**Table A9.1: Proposed Timeline**

Action	Planned Period
HTF quality improvement	May 2020–December 2021 (completed)
Solar field flow balance improvement	May 2020–August 2020 (phase I for +/- 15°C) September 2021–December 2022 (phase II for +/- 5°C)
Automatic control improvement	January 2021–December 2022
System repair and technical improvement	May 2023–August 2023
Other safety performance improvement	May 2020–September 2022 (completed)

HTF = heat transfer fluid.

Source: CGN Delingha Solar Energy Co., Ltd.

### D. Current Progress and Implementation Plan

18. To facilitate the action plan, the implementing agency adopted a progressive and safer approach by operating the facility in the “safe mode”, which is to start the operation at a lower temperature and gradually increase the production capacity. In the second year, the implementing agency reviewed and updated the action plan. The updated action plan was approved by the management in July 2021. The progress made by the time of the project completion review (PCR) mission, is summarized as below:

#### 1. Heat transfer fluid system performance improvement

19. This action has been completed. HTF system performance improvement is a self-corrective action to purify the HTF in the system and is critical to the normal operation of the facility. The implementing agency made major technical breakthrough on cleaning and purification of the HTF. Through installing an external purification device and continuously extracting, purifying and injecting the HTF from the system, the implementing agency successfully improved the quality of the HTF in the system without interrupting the system operation. In early September 2021, the HTF quality was tested and met the national standard GB24747-*Safety Technology Conditions for Heat Transfer Fluids*, meaning that the HTF in the system now can finally meet designed operation requirements.

## **2. Solar field flow balance improvement**

20. This action is currently ongoing. In 2020 and early 2021, the task team has already finished the flow adjusting schemes, the repairing and overhaul plans, the scenarios simulations, and in particular, part of the regulating valve performance curve test. After the completion of HTF system improvement in end 2021, the task team resumed the balance improvement works in 2022 and finished 70% in overall. The temperature deviation of the HTF has decreased from 50°C to 30°C. While in the later stage, the major efforts will be the replacement of the broken valves and cleaning of the blocked pipes. This action is expected to be fully completed in Q4 2022.

## **3. Automatic control systems improvement**

21. This action plan is currently ongoing. Major progress has already been made on this action. The task team has developed 18 operation modes/options for the whole system, and developed an interlocking protection logic for the core equipment such as turbine generator sets, heat-conducting oil pumps, oil-water heat exchangers and collectors. The progress' on logic automation availability of key equipment and system control are almost at 100% and 90%, respectively. Six equipment-level logic control modules were installed, while an inter-system controlling logic module is being optimized. This action is expected to be completed by December 2022.

## **4. System repair/overhaul and technical improvement**

22. This action is currently ongoing. Currently, more than 1,400 heat collector tubes and 920 pieces of mirrors have been replaced in the overhaul. Besides, the electrical auxiliary heaters have been fully commissioned and installed while part of the heat collector tubes have been upgraded. With the efforts so far, the availability of the solar field equipment has increased from 65% to 98% and is improving steadily. Meanwhile, the 2023 overhaul plan is being prepared to achieve a gradual improvement without large scale HTF extraction and re-filling during 2021–2022. Thus, the period of this action is extended to achieve a smooth transformation. This action is expected to be fully completed by August 2023.

## **5. Other safety performance improvement**

23. Currently, many safety improvement measures have already been implemented, including the slope and rail protection in the solar field, the heat exchanging system leaking monitoring, the over-heating of the HTF heating facilities etc. In overall, this special action plan has almost completed 100% and the remaining works are planned to be conducted after September 2022 during the system break for maintenance.

## **6. Electricity generation status and plan**

24. The entire Action Plan is expected to complete by end of 2022 with an updated cost estimate of CNY95 million. With the efforts and progress made so far, especially on the purification of the HTF, the efficiency of facility operation has been improving continuously and significantly. Since implementing the action plan from May 2020, electricity generated in 2021 reached 79 GWh, a gain of 25% more than the generated electricity of 2020. Electricity generation in the first half of

2022 reached 58.9 GWh which is 200% of the electricity generated in the first half of 2021. The electricity generation is on track to achieve 120 GWh in 2022, and 197 GWh in 2023. The monthly electricity generation achievements and projections are below.

**Table A9.2: Monthly Generation Achievements and Projections**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
<b>2019P</b>	2,000	3,400	4,000	7,000	8,000	8,000	8,000	8,000	8,000	8,000	4,000	3,000	71,400
<b>2019A</b>	<b>1,003</b>	<b>2,442</b>	<b>3,432</b>	<b>7,009</b>	<b>8,270</b>	<b>3,373</b>					<b>739</b>	<b>1,525</b>	<b>27,793</b>
<b>2020P</b>	2,000	3,000	3,000	5,000	5,000	6,000	6,000	8,000	8,000	8,000	4,000	3,000	61,000
<b>2020A</b>	<b>2,072</b>	<b>3,610</b>	<b>3,010</b>	<b>4,389</b>	<b>3,148</b>	<b>5,722</b>	<b>4,521</b>	<b>7,306</b>	<b>7,689</b>	<b>10,111</b>	<b>4,633</b>	<b>3,445</b>	<b>59,656</b>
<b>2021P</b>	2,500	5,000	5,000	5,000	7,000	6,000	6,000	8,000	10,000	10,000	8,000	8,000	80,500
<b>2021A</b>	<b>2,812</b>	<b>5,009</b>	<b>6,514</b>	<b>4,508</b>	<b>6,451</b>	<b>4,072</b>	<b>8,329</b>	<b>7,834</b>	<b>9,009</b>	<b>9,167</b>	<b>8,507</b>	<b>6,356</b>	<b>78,569</b>
<b>2022P</b>	6,000	7,500	8,000	7,300	8,000	7,200	13,500	13,500	14,500	15,000	12,000	7,500	120,000
<b>2022A</b>	<b>6,056</b>	<b>7,524</b>	<b>8,738</b>	<b>12,058</b>	<b>12,580</b>	<b>12,000</b>							<b>58,956</b>
<b>2023P</b>	10,378	14,487	22,328	23,850	20,974	15,316	16,989	18,425	16,951	17,266	11,756	8,780	197,500



## ENVIRONMENTAL IMPACT ANALYSIS

### A. Introduction

1. The project was classified as category B for environment. An initial environmental examination (IEE), including an environmental management plan (EMP) and an environmental monitoring plan (EMoP), was prepared in accordance with Asian Development Bank's (ADB) Safeguard Policy Statement (2009), and disclosed on ADB website in May 2013. The preparation of the IEE involved (i) collection of information on the environmental conditions in the project area; (ii) special studies on evaluation of the terrestrial ecology, ambient air quality, acoustic environment, soil and water conservation, and physical cultural resources; (iii) assessment of potential location-specific environmental impacts; (iv) development of mitigation measures during construction and operation; (v) evaluation of alternative locations and technologies; and (vi) public consultations.

2. Domestic tabular environmental impact assessment report was prepared by Qinghai Research Academy of Environmental Sciences and approved on 31 December 2012 by Qinghai Ecology and Environment Bureau (former Qinghai Environmental Protection Bureau). Construction of the project started in August 2015, and the project was fully completed and started commercial operation on 10 October 2018.

3. ADB's project completion review (PCR) mission was conducted from 12 to 17 September 2021. The mission visited project site, including the CSP plant, and the neighboring villages and communities. The mission had extensive discussions with representatives of relevant stakeholders, including the executing agency, the implementing agency and the affected persons. This analysis was prepared based on the IEE, the environmental monitoring reports from 2015 to 2019, site visits, and information obtained during the mission.

### B. Institutional Arrangement

4. This project involves construction of a concentrating solar thermal plant in Delingha, Qinghai Province, People's Republic of China (PRC). China General Nuclear Power Holding Co., Ltd. (CGN) is the executing agency. A project leading group was established under the CGN and is responsible for directing the project and providing policy guidance during project implementation. China General Nuclear Delingha Solar Energy Co., Ltd. (CGN-DSE) is the implementing agency. The table shows the summary of institutional arrangement for the project's environmental management as agreed at appraisal and implementation status.

**Table A10: Implementation Status of Institutional Arrangement**

Duties and Responsibilities as Agreed at Appraisal	Implementation Status
<p><b>Executing Agency: CGN</b> Overall responsibility for ensuring that the project is implemented in accordance with ADB's loan agreement, national legislation, the detailed design, and the EMP. Provide advice and guidance to the implementing agency. Review EMP monitoring reports and submit them to ADB.</p>	<p><b>Complied.</b> The project was implemented in accordance with ADB's loan agreement, national legislation, detailed design, and the EMP.  Executing agency provided guidance to the implementing agency and reviewed the EMP monitoring reports and submitted them to ADB.</p>
<p><b>Project Leading Group</b> Direct the project and provide guidance during project implementation. Review project implementation progress and take additional measures if necessary.</p>	<p><b>Complied.</b> A Project Leading Group was established with one Director and 12 team members, including a site manager, a HSE manager, a QC/QA manager, etc.  Monthly project meeting was held by the Project Leading Group to provide guidance, and review project implementation progress.</p>
<p><b>Implementing Agency: CGN-DSE</b> Establish EMU. Provide supervision to contractor and CSC. Submit monthly report to the executing agency on the implementation of the EMP. Work with design institutes and the tendering company in preparing bidding documents to ensure environmental protection provisions are included in them. Submit semiannual EMP monitoring reports to the executing agency and ADB. Hire environmental consultants.</p>	<p><b>Complied.</b> EMU has been established with three members. CGN-DSE provided daily supervision to contractors and CSC, submitted monthly environment reports to the executing agency, and worked with design institutes and the tendering companies in preparing bidding documents with environmental protection requirements. Eight semi-annual environmental monitoring reports were prepared and submitted to the executing agency and ADB.</p>
<p><b>Construction Supervision Company</b> Responsible for the daily inspection, monitoring, and evaluation of the implementation of EMP mitigation measures at construction site.</p>	<p><b>Complied.</b> Beijing Huaxia supervision Co., Ltd. was hired as CSC. It has four supervisors, including one HSE supervisor, who are responsible for the daily inspection, monitoring, and evaluation of the implementation of mitigation measures in the EMP, such as solid waste/wastewater/dust control at construction site.</p>
<p><b>Environmental Monitoring Companies</b> Responsible for implementing mitigation measures on a daily basis according to the contract conditions.</p>	<p><b>Complied.</b> Xi'an Jingcheng Testing Technology Co., Ltd. was engaged to conduct environmental monitoring during construction based on the EMoP included in the EMP. Haixi Prefecture Zhongke Eco-Environmental Monitoring Co., Ltd was engaged to conduct environmental monitoring between 2019 and 2020 based on the EMoP included in the EMP. Since 2021, Qinghai Lambo Monitoring Technology Co., Ltd. was engaged to conduct environmental monitoring.</p>
<p><b>Contractors</b> Responsible for implementing mitigation measures on a daily basis according to the contract conditions.</p>	<p><b>Complied.</b> Environmental management was taken seriously by contractors. Contractors implemented good environmental management practices and followed the agreed environmental management plan in their contracts.</p>

ADB = Asian Development Bank, CGN = China General Nuclear Power Holding Co., Ltd., CGN-DSE = China General Nuclear Delingha Solar Energy Co., Ltd., CSC = construction supervision company, EMP = environmental management plan, EMoP = environmental monitoring plan, EMU = environmental monitoring unit, HSE = health and security executive, QC/QA = quality control/quality assurance.

Source: Asian Development Bank.

### **C. Environmental Protection Acceptance for Project Completion**

5. Domestic environmental protection acceptance meeting for the project completion was organized by CGN-DSE on 14 March 2020.<sup>1</sup> Participants of the meeting included contractors, construction supervision company (CSC), design institute, domestic environmental impact assessment (EIA) institute, 3rd party environmental monitoring companies, and an expert panel. In addition to site visit, other activities undertaken by the expert panel were (i) review of project documents, including domestic environmental impact table report and environmental monitoring reports; (ii) consultation meetings with contractors, CSC, design institute, and EIA institute; and (iii) collection of additional information from the domestic EIA consulting firm, project design institute and contractors. Because there are no environmental receptors near the project site, public consultation with affected persons were not conducted. Based on the environmental acceptance meeting, site visit and environmental monitoring results, the project passed the environmental acceptance review.

6. It can be concluded that during the project implementation: (i) there were no major changes in project scope; (ii) all required PRC environmental protection review and approvals were completed and obtained; (iii) pollution prevention and control measures for wastewater, noise, air pollution, and solid waste were implemented following the requirements in the domestic EIA and IEE; (iv) no unexpected adverse environmental impacts other than those predicted in the original EMP were identified; and (v) the environmental protection acceptance conditions for project completion satisfied the domestic requirements. The environmental protection acceptance report is in Annex 1.

### **D. Environmental Protection and Management**

7. CGN-DSE has set-up an environmental management unit responsible for the implementation of the EMP, and daily supervision of contractors and CSC. During project construction, contracts signed between CGN-DSE and the contractors included environmental protection provisions, including general requirements and specific requirements for environmental management and mitigation measures based on the EMP. To meet these requirements, the contractors prepared EMPs (the Contractors' EMP) and appointed environmental engineers to supervise its implementation and ensure that the adverse environmental impacts during can be reduced, mitigated and minimized.

8. During the preliminary and detailed design stages, the project design was improved to minimize the impacts on the environment and the design of the mirror field and the heat transfer fluid (HTF) area were also improved to reduce the land area and cost. The estimated total investment in environmental protection was CNY31.51 million. The actual investment in environment protection is CNY31.46 million, which is 99.8 % of the estimated total investment. The main reason is the total investment of the project was reduced to CNY1.7 billion from CNY1.9 billion.

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<sup>1</sup> Based on the Interim Measures for Environmental Protection Acceptance of Completed Construction Projects issued in 2017 (MEP Decree 2017-4), environmental protection acceptance for project completion no longer needs to be conducted by a 3rd-party company, and can be arranged by the executing and implementing agencies.

## E. Environmental Monitoring and Reporting

9. CGN-DSE engaged Xi'an Jingcheng Testing Technology Co., Ltd. for environmental monitoring during construction. Scope of environmental monitoring included construction wastewater, dust and noise. CGN-DSE engaged Haixi Prefecture Zhongke Eco-Environmental Monitoring Co., Ltd. and Qinghai Lambo Monitoring Technology Co., Ltd. for environmental monitoring during operation. Scope of environmental monitoring during operation included sulfur dioxide (SO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), particulate matter (PM), noise, and wastewater. The 3rd party environmental monitoring companies carried out periodic environmental monitoring, sampling and analysis in accordance with EMP. Environmental monitoring reports were prepared and submitted to CGN-DSE. In addition, the contractors were responsible for implementation of the mitigation measures in the EMP, and CSC was responsible for the inspection, monitoring, and evaluation of the implementation of EMP. The CSC also submitted on-site environmental supervision reports to CGN-DSE. Based on the environmental monitoring reports and environmental supervision reports, CGN-DSE prepared eight semiannual environmental monitoring reports, which were disclosed on ADB's website. The monitoring results showed that the project has not caused any adverse permanent environmental impacts.

## F. Environmental Impacts and Mitigations

10. During project implementation, environmental monitoring and mitigation measures were implemented in accordance with the EMP. The following measures have been taken to minimize the adverse impacts on the environment.

11. **Land acquisition and ethnic minority.** The impacts and mitigation measures of land acquisition and ethnic minority are presented in Appendix 11.

12. **Water and soil Conservation.** At construction stage, soil-related impacts mitigation measures included such preventive and mitigation practices as minimizing active open excavation areas during trenching activities, minimizing area of soil exposed to potential erosion, and limiting construction and material handling activities during periods of rains and high winds. A spill management plan for preventing contamination of soil from accidental spills of petroleum products, chemicals and hazardous materials was developed and implemented.

13. **Wastewater.** At construction stage, mitigation measures included (i) areas where construction equipment was washed were equipped with water collection basins and sediment traps; (ii) wastewater from construction activities were collected in sedimentation tanks, retention ponds, and filter tanks to remove silts and oil; (iii) construction wastewater after sedimentation, were used as spraying water for fugitive dust control at the construction site; and (iv) adequate sanitary facilities and ablutions were provided to construction workers and the domestic sewer from workers camps was utilized for watering vegetation after septic tank treatment. At operation stage, an underground wastewater treatment equipment was installed for treatment and recycling of domestic wastewater. As the wastewater from water purification system can be reused as raw material for alkali production, IA signed a sales contract with Zhongyan Kunlun Alkali Industry Co., Ltd. in Delingha to reuse the wastewater. The wastewater is temporarily stored at a water recycling tank (148 meters [m] x 130m x 1.91m) and transported to Zhongyan Kunlun Alkali Industry Co., Ltd. regularly following the PRC regulations. Wastewater monitoring results during construction and operation complied with national standards.

14. **Ambient air quality.** At construction stage, mitigation measures included frequent water spray of the construction areas, limit of vehicle speed at the construction sites, equipping trucks transporting earth materials especially fine materials with covers, storing petroleum or other harmful materials in appropriate places, immediate cleanup of muddy or dusty materials on public roads outside the exits of construction areas, covering the stockpile areas with tarpaulin and spraying water to avoid mobilization of fine materials, good construction management, and construction area closure, etc. Monitoring results during the construction period showed total suspended particulates had complied with national standards. During operation, dust emissions were controlled through spraying water at the project site and using mirror washing water to suppress dust from solar collection field.

15. **Noise.** At construction stage, a number of mitigation measures was applied including good maintenance and operation of construction vehicles, equipment and machines, schedule of construction time, closure of construction areas, placing temporary signs and noise barriers around noise sources, slowing down and stop honking when vehicles passing through nearby environmentally sensitive locations, such as residential communities, schools and hospitals. At operation stage, mitigation measures include application of the latest technology incorporating maximum noise mitigating measures, and good maintenance and operation of equipment and plant. Noise monitoring results during construction and operation complied with national standards.

16. **Solid waste.** At construction stage, a number of mitigation measures were implemented including establishing temporary storage for solid waste, providing appropriate waste storage containers at construction sites, recycling the construction waste and excavating waste as much as possible, transporting non-recyclable construction waste to an approved landfill, contracting companies for proper removal and disposal of any significant residual materials, wastes, and contaminated soils that remained on the site after construction. At operation stage, all domestic wastes were routinely collected by appropriately licensed waste management companies for reuse, recycling or final disposal in a licensed waste facility. Golmud Environmental Protection Science and Technology Co., Ltd. was engaged as the licensed 3rd party for hazardous waste treatment and disposal.

17. **Vibration.** At construction stage, a number of mitigation measures were applied including prohibition of piling and compaction operations at night, good maintenance and operation of equipment and machine, and schedule of operation time for equipment with high vibration.

18. **Flora and fauna.** No rare, threatened, or endangered species were found within the project site boundaries. Mitigation measures were taken including preservation of existing vegetation where no construction activity was planned, properly backfill, and re-vegetating piping/cable trenches after construction, awareness enhancement on protection of and prohibition to hunt wild animals, and development and implementation of vegetation plan after construction.

19. **HTF.** HTF will cause risks to workers health and environment in case of accidental release. To mitigate potential risks from HTF, mitigation measures were taken including transportation of HTF in spill proof container, storage of HTF in designated areas with impermeable surfaces, implementation of fire protection and control procedures in HTF storage, heat conversion, and HTF expansion areas, installation of automatic pressure monitoring devices at HTF system, development and drill of emergency response plan for HTF leakage and accidental spills, and

engaging of Golmud Environmental Protection Science and Technology Co., Ltd., a licensed 3rd party for HTF waste (defined as hazardous waste) treatment and disposal following PRC hazardous waste management regulations and laws.

20. **Other Chemicals and Hazardous Materials.** During construction and operation stage, mitigation measures were taken including transportation of all toxic, hazardous, and harmful materials in spill proof container, storage of all toxic, hazardous, and harmful materials in designated areas with impermeable surfaces and protective dikes, preparation of material safety data sheets (MSDS) for all hazardous materials, establishment of good housekeeping procedures, training of workers before handling hazardous wastes, provision of personal protection equipment (PPE), development and drill of emergency response plan for accidental spills of hazardous materials, and engaging Golmud Environmental Protection Science and Technology Co., Ltd., a licensed 3rd party for hazardous waste treatment and disposal.

21. **Occupational and community health and safety.** At construction stage, mitigation measures to avoid occupational and community health and safety hazards were taken, such as providing portable toilets and proper PPE to construction staff and workers, trainings on general health and safety protocols, development of emergency preparedness and response procedures, cleaning and disinfecting the sites, hygiene and food safety management, and epidemic prevention. At operation stage, mitigation measures included providing proper PPE to staff and workers, training on general health and safety protocols, development of emergency preparedness and response procedures, installation of firefighting system, cleaning and disinfecting the sites, hygiene and food safety management, and epidemic prevention.

22. **COVID-19.** Mitigation measures to prevent and control COVID-19 outbreak were implemented follow PRC and Qinghai Province's requirements, including disinfection/cleaning of public space, temperature checks at entrances of plant, social distancing measures, mandatory use of PPE such as facemasks, and procedures to be adopted in the event any person is infected with COVID-19. At the time of PCR mission, no workers or staff were infected by COVID-19.

23. **Public consultation.** Public consultations were conducted with stakeholders including affected persons, ethnic minority households, township and city governments. Based on the social and environmental monitoring reports and interview with executing agency and implementing agency during PCR mission, no complaints were received during construction and operation.

24. **Grievance redress mechanism (GRM).** GRM was established based on the EMP and disclosed to affected people prior to construction, during construction and operation. No grievance issues arose during construction and operation. The PCR mission was informed there are no pending environment-related issues.

25. **Environmental benefits.** The project started trial operation since October 2018. In 2018, 2019 and 2020, power generated by the project were 7.1 million kWh, 29.4 million kWh and 63.3 million kWh, respectively. Compared to the equivalent power production by a traditional coal-fired plant, the project has resulted in energy savings equivalent to 30,481.2 tons of standard coal, reduction in CO<sub>2</sub> emissions by 83,243.7 tons, SO<sub>2</sub> emissions by 17.1 tons, NO<sub>x</sub> emissions by 18.5 tons, and PM emissions by 3.5 tons since trial operation.

**G. Conclusion**

26. During design, construction and operation of the project, CGN, CGN-DSE, contractors and other relevant stakeholders have implemented the mitigation measures in accordance with the requirements in the EMP. A range of good engineering practices with environmental protection measures were also adopted. No unexpected adverse environmental impacts other than those predicted in the original EMP were identified. No environmental safeguard-related complaints were received during project implementation. 11 environmental monitoring reports have been prepared and disclosed on the ADB website. Overall implementation of the EMP and EMoP is satisfactory. The environmental monitoring reports were of good quality and provided sufficient information on the EMP implementation. At the time of the PCR mission, there were no pending environmental safeguards-related noncompliance issues.

## Annex 1: Environmental Protection Acceptance Report

### 中广核太阳能德令哈有限公司中广核德令哈 50MW 光热发电项目 竣工环境保护验收意见

2020年03月12日,中广核太阳能德令哈有限公司组织召开中广核德令哈 50MW 光热发电项目竣工环境保护验收会。参加验收的单位有:建设单位(中广核太阳能德令哈有限公司)、验收监测单位(海西中科生态环境监测有限公司)、设计单位(中国电力工程顾问集团西北电力设计院有限公司)、施工单位(西北电力建设工程有限公司)、环评单位(中环慧博(北京)国际工程技术咨询有限公司)、监理单位(北京华夏石化工程监理有限公司),并特邀3名专家(名单附后)组成验收小组。验收组听取了建设单位对项目环境保护执行情况的汇报和验收监测单位对该项目竣工环境保护验收调查情况的汇报,现场检查了环保设施建设情况,经认真讨论、审核,形成以下验收意见:

#### 一、 工程建设基本情况

本次项目建设地点,位于青海省德令哈境内,位于德令哈以西5km,德令哈西出口光热产业园,中心地理坐标:东经97°16'15.20",北纬37°21'23.93"。原青海省环境保护厅以青环发[2012]706号对该环境影响评价文件进行批复,项目在进行竣工环境保护验收工作时与环评报告对比发现,新增一座回用水池、一套一体化生活污水处理装置、三台燃气导热油炉以及8.1千米110KV送出线路。项目燃气导热油炉于2017年6月25日开工建设,已于2017年7月20日完工投入使用;回用水池于2016年6月30日开工建设,已于2017年9月14日完成建设并投入使用;生活污水处理装置于2016年5月21日开工建设,并在2017年10月10日完工后投入使用根据《中华人民共和国环境影响评价法》委托中环慧博(北京)国际工程技术咨询有限公司进行本项目变更的内容进行评价,并对新建的中广核德令哈50MW光热发电项目110KV送出线路工程进行环境影响评价,2020年



3月12日由海西州生态环境局以西生审[2020]29号《海西州生态环境局关于中广核德令哈50MW光热发电项目（变更）环境影响报告表的批复》及西生审[2020]29号《海西州生态环境局关于中广核德令哈50MW光热发电项目110KV送出线路工程环境影响报告表的批复》分别对项目变更环评及线路送出工程进行了批复。

变更后项目总装机容量50MW，聚光采用抛物线型槽式聚光系统，安装1套中温、高压再热凝汽式汽轮发电机组。主要建设内容包括镜场、导热区、换热发电区、储热区、辅助能源区以及办公生活区。工程年等效发电小时数为4060h，设计年上网电量为 $2.75 \times 10^8 \text{kW}\cdot\text{h}$ 。本项目厂区总投资170000万元，其中环保投资3146万元，占总投资的1.85%，环保投资主要用于施工期环境保护措施、及生态恢复以及回用水池建设等。110KV输电线路总投资780万元，其中环保投资8.5万元，占总投资的1.095%，环保投资主要用于施工期环境保护措施、及生态恢复。

## 二、工程变动情况

本项目无重大变更内容。

## 三、环境保护措施建设情况

### 1、废水治理措施

生活办公区尚未建设，其配套建设的地理式一体化生活污水处理装置无法运行，后期与办公生活区一同验收，现临时办公区生活污水经化粪池处理后抽运至德令哈污水处理厂处理。补给水系统产生的一级反渗透浓水，在厂区处理站经过TMF+CRO处理后产生的浓水排入回用水池循环使用不外排。项目回用水池采用双层人工复合防渗结构。

### 2、噪声治理措施

噪声主要为发电机及 110kv 升压站噪声。太阳能发电机噪声产生高度较高，在地面处噪声值较小；逆变器和箱式变电站均位于室内，通过墙体阻隔、定期维护保养设备等措施来降低噪声值。

本项目设备的选取上尽量采用低噪声设备，对振动噪声较大的设备，采取必要的减振措施以降低对环境的影响。

### 3、固体废物处置措施

本项目固体废物主要有废旧电子元件以及导热油泥，废旧电子元件收集于危废暂存间后由厂家运回处理、导热油泥收集于危废暂存间后委托格尔木绿水青山环保服务有限公司处理，项目危险废物暂存间依托原有实验基地危险废物暂存间，并在 110KV 升压站设置 40m<sup>3</sup> 事故油池来防止由变压器产生的矿物油对环境的影响。

### 4、生态治理措施

本项目用地为戈壁荒漠，属于生态脆弱区，土壤侵蚀类型以风能侵蚀为主。土壤类型为灰棕漠土，土层厚度 15~50cm。土壤风化程度不高，土层较薄，植被覆盖率不到 20%，只有少量植被分布，无受保护的稀有植物种类存在。项目在施工过程中，施工车辆行驶在固定线路上，减少了对地表植被的破坏；施工期合理布局，减少了施工临时占地面积；由于项目场址位于空旷地区，且附近区域内动物活动较少，项目的建设只是在小范围内暂时改变了植物的生长环境，不会引起物种消失。

根据现场调查，项目厂区均进行了场地平整，道路区铺设了砾石及水泥硬化路；施工过程未对项目占地外区域植被造成碾压、破坏。对厂区、道路区及集电线路区进行了土地整治，进一步减小了对生态环境的影响。运行期对临时占地进行了清理平整和压实平整，并播撒草籽、采取一系列绿化措施，运行期植被恢复情况较好，植被覆盖率较之前有所增加，占地范围内植被生长茂盛。

### 5、废气处理措施

本项目运营期利用太阳能发电，运营期废气主要为导热油加热炉及启动锅炉产生的废气，均采用清洁燃料天然气，且设备均属应急设备，启动锅炉废气经 12m 高排气筒排放，导热油加热炉废气经 30m 高排气筒排放。

#### 四、环境监测结果

根据海西中科生态环境监测有效公司调查报告：于 2020 年 2 月 29~3 月 2 日对该项目废气、噪声及工频磁场进行验收监测。

##### (1) 噪声

本项目运行期间变压器和蒸汽轮发电机工作噪声。监测结果表明：厂界昼间噪声值在 44~56dB(A) 之间，夜间噪声值在 38~47dB(A) 之间，均符合《工业企业厂界环境噪声排放标准》(GB12348-2008) 2 类标准的要求。

##### (2) 废气

运营期废气主要为导热油加热炉及启动锅炉产生的废气。经监测结果表明，监测期间，本项目 2#、3#天然气导热油加热炉排放口废气颗粒物排放浓度最大为 0.635mg/m<sup>3</sup>，二氧化硫未检出，氮氧化物最大排放浓度为 101mg/m<sup>3</sup>，符合《锅炉大气污染物排放标准

(GB13271-2014) 表 2 新建燃气锅炉排放限值要求；2#启动锅炉排放口废气颗粒物排放浓度最大为 0.083mg/m<sup>3</sup>，二氧化硫未检出，氮氧化物最大排放浓度为 145mg/m<sup>3</sup>，符合《锅炉大气污染物排放标准 (GB13271-2014) 表 2 新建燃气锅炉排放限值要求。

##### (3) 电磁环境

经对本项目 110kV 升压站厂界四周、110 升压站以及 110kV 输电线路监测断面工频电场强度、工频磁感应强度进行监测结论如下：

110kV 升压站垂直围墙 0~50m 范围内，工频电场强度为 0.039~82.97V/m，满足小于 4kV/m 的推荐标准限值要求；工频磁感应强度为

0.002~0.824  $\mu$ T, 小于 0.1mT 的推荐标准限值要求, 且随距离增加衰减明显。

110kV 输电线路监测断面距线路中心 0~50m 范围内的工频电场强度测量值在 6.70~812.53V/m, 工频磁感应强度测量值在 0.004~0.069nT, 分别小于 4kV/m、0.1mT 居民区评价标准限值的要求。

### 五、验收结论

中广核太阳能德令哈有限公司中广核德令哈 50MW 光热发电项目在建设过程中基本落实了建设项目“三同时”制度, 基本落实了环评及其批复的要求。验收监测期间外排污染物浓度达到验收标准限值的要求, 建议通过竣工环境保护验收。

中广核太阳能德令哈有限公司

2020年03月12日



## Annex 2: List of the Environmental Acceptance Team

中广核德令哈 50MW 光热发电项目  
竣工环境保护评审会验收组名单

	姓名	工作单位	职务职称	身份证号	联系电话	备注
组长	刘建	中广核太阳能德令哈有限公司	副总经理	622727197304260838	18566286185	
组员	冯小军	北京华夏石砾管理咨询有限公司	总代	362623199202297138	17695113161	监理单位
	刘伟	中国环境科学研究院西北分院	项目工程师	340120192312285629	18109649523	设计单位
	袁红	西北电力设计院有限公司	项目工程师	610402196212061231	13891091933	施工单位
	毛文博	中核集团北京国际工程技术有限公司	区域经理	622801199302081837	13129378895	环评单位
	董明	海西州科生环境咨询有限公司	工程师	640301199108070612	1389771122	验收监测单位

## LAND ACQUISITION AND ETHNIC MINORITIES

### A. Introduction

1. The project was classified as category B for Involuntary Resettlement and Indigenous Peoples. As all project affected persons were ethnic minority people, a combined land acquisition and ethnic minority development plan (LAEMDP) was prepared in December 2012 in accordance with the People's Republic of China's (PRC) laws and regulations and Asian Development Bank's (ADB) Safeguard Policy Statement (2009). During implementation, the project was implemented as originally designed, thus updating of LAEMDP was not required.

### B. Project Impact

2. The LAEMDP in 2012 showed that the project would permanently acquire 246 hectares (3,690 *mu*)<sup>1</sup> of jointly contracted grass land with 50 years land use rights since 1984, which belong to 153 people of 31 households in Taositu Village, Xuji Township, Delingha City, Qinghai Province. The land to be acquired is semi-arid unused land, which is 0.7% of the total grazing land area for grazing owned by the affected households. The 31 households included 30 Mongolian households of 148 persons and one Tuzu household of five members. There is no vulnerable household affected. During implementation, there was no change in project scope and land acquisition impacts.

3. The land was classified as lowest grade of V and under grazing ban since 2007. This type of land was not permitted to be grazed, so each household got a government subsidy of CNY4.5 per *mu* for 66 *mu* out of the 119 *mu* acquired. The land loss impact was very insignificant as each household lost only 0.7% of their total land on average and 0.5% of annual average net household income.

### C. Resettlement Policy and Compensation Rates

4. Land acquisition was implemented according to the LAEMDP. In accordance with *Notice of the Ministry of Land and Resources on Carrying out the Unified Annual Output Value Standard of Land Acquisition and the Comprehensive Land Price (GTZ [2005] No. 144)* issued in 2005, *Notice of the People's Government of Qinghai Province on Promulgating the Unified Annual Output Standard of Land Acquisition and the Comprehensive Land Price (QZF[2010]No.26)*, and the requirements of ADB's Safeguard Policy Statement (2009), all the affected households were entitled for cash compensation for transferring their land use rights to China General Nuclear Delingha Solar Energy Co., Ltd. (CGN-DSE) through the Delingha City Land and Resource Bureau at a compensation rate of CNY1,408/*mu*.<sup>2</sup> Prior to commencement of land levelling works in July 2014, the compensation for land acquisition was fully paid to the affected households. Each household received CNY167,552 which is equivalent to 564 times of government subsidy per year from the acquired land which is CNY297 per household per year (CNY4.5 per *mu* for 66 *mu*

<sup>1</sup> One hectare is equivalent to 15 *mu*.

<sup>2</sup> According to *QZF[2010]No.26*, the land acquisition compensation standard includes land compensation fee and resettlement subsidy. The land acquisition compensation rate is calculated according to the multiple of the unified annual output value (UAOV) for different land types. The UAOV of project area is CNY128 per *mu*. For grazing land of this project, the land acquisition compensation rate is 11 times of UAOV. In that case, the lump sum land acquisition compensation rate of this project is CNY1,408 per *mu*.

out of the 119 *mu* acquired).

5. Based upon the request of Qinghai provincial government during implementation, 50% of total land compensation (CNY2,597,760) was also paid to Delingha Land Resource Bureau in June 2014 to transfer into the endowment insurance fund pool to provide endowment insurance for farmers affected by land acquisition according to *Notice of the Qinghai Provincial People's Government on Paying Social Endowment Insurance for Farmers affected by Land Acquisition (QZB [2013] No. 23)*. The village committee confirmed that all entitled affected farmers had enrolled in social endowment insurance system and they are eligible to receive pension when they reach the age of 60. In 2021, the standard of pension is CNY450/person/month.

#### **D. Assistance and Implementation of Action Plans**

6. To better benefit the affected households and avoid any potential negative impact from the sudden flow in a large sum of compensation to the affected households, which was equivalent to three times of the annual average net household income (CNY54,837 in 2011) and 564 times of government subsidy per year from the acquired land, a number of assistance and enhancement actions were developed during project preparation and were implemented by the responsible agencies.

7. **Action 1: Employment skills training.** The project would provide: (i) 4,010 person-months of unskilled labors or 334 unskilled jobs during construction, with 800 person-months or 20% for women; and (ii) 30 permanent low-skilled positions during operation with 10 positions for women. To better benefit affected households and many others from these employment opportunities, the implementing agency would train at least 100 person-times of local laborers (2 person-times for each household), including 20 person-times of female laborers.

8. During project construction, equipment installation, and commissioning stage, a total of 800 unskilled job opportunities have been provided for local residents by project contractors and the implementing agency, of which 37.5% were provided to women. All workers participated in the skills and safety trainings organized by contractors and the implementing agency. The contractors also provided sufficient personal protective equipment to the local workers to ensure their safety. CGN-DSE supervised the contractors closely to ensure the wages were paid in time, and that men and women received equal pay for equal work according to the domestic labor laws and regulations. No complaint was received.

9. During project operation, 37 local residents worked in CGN-DSE as permanent employees, such as receptionists, cleaners, greening workers, security staff, chefs, drivers, maintenance workers, and administrative personnel of operational departments, of which 10 are women, including one ethnic minority person.

10. **Action 2: Provision of high insulation yurts and portable solar power generation sets.** Herder households had to stay in yurts in the high mountains, with the farthest of over 100km, during spring and summer grazing periods. Due to high elevation of over 3,000 m, the grazing grounds are cold in evenings even in summer. The project would provide 40 sets of high insulation yurts and portable solar power generation sets to the herder households of the affected village of Taositu.

11. The households in the affected village who needed the high insulation yurts and portable solar power generation sets had to contribute one sixth of cost for yurts (CNY12,000) and one third of cost for portable solar power generators (CNY3,000). Others would be paid by the government and the implementing agency. During implementation, the local government paid the total cost for the yurt and solar power generation sets, which was completed in the end of 2015. The implementation of this action improved the living condition of herders during grazing in high elevation of over 3,000 m.

12. **Action 3: Grassland management training.** Along with the provision of high insulation yurts and solar power generation sets, training on protection-oriented grassland management would be provided to both male and female laborers of all herder households. About 200 person-times of training (2 person-times for each household), with 40% for women, would be organized.

13. From 2013 to 2017, 216 person-times of trainings on grassland protection for grazing families in Taositu village have been carried out by Delingha Agriculture and Animal Husbandry Bureau. Among the participants, 45% were women. The trainings have effectively improved the awareness of villagers to protect the grassland and enhanced the people's understanding of protecting the grassland ecological environment.

14. **Action 4: Training on household financial management.** To enable the affected households to better use the land compensation payment, which is a large sum to each affected household, training on both household financial and assets management for both male and female adults would be carried out by the local women's federation before and after compensation disbursement. Similarly, 100 person-times of training (2 person-times for each household), with 50% for women, would be organized.

15. During project implementation, in total 112 participants joined the training on household financial and assets management. The training was conducted by Delingha Women's Federation in September 2016 for affected households and other residents in Herders' Community,<sup>3</sup> among which, 56% were women. Most of the affected households deposited the land compensation in a bank or continued to develop their animal husbandry. A small number of affected households operated small business in the Herders' Community or in the city, such as convenience stores and restaurants.

16. Overall, provision of the land compensation and implementation of the Action Plan have improved the livelihood of the affected persons. In 2020, the per capita net income of the affected households has increased to CNY17,000 (about 1.6 times of the per capita net income in 2011, which was CNY10,895), among which, about 69% from animal husbandry, 23% from non-agricultural income (including small business income and salary income) and 8% from government subsidies according to the yearbook of Xuji Township. All the activities listed in the action plan have been implemented well. The key milestones of LAEMDP implementation are presented in Table A11.1.

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<sup>3</sup> Under the government rural housing program, there are 9 buildings with 360 sets of apartments for herder households of Taositu, Wuchahan and Yikela villages of Xuji Township. 27 out of 31 affected households moved into apartment buildings with district heating before Oct 2011 and the remaining four households bought houses in city. These buildings form a compound named as Herders' Community.



**Table A11.1: Summary of Land Acquisition and Ethnic Minority Development Plan Implementation and Achievements**

No.	Tasks	Target	Responsible Agency	Schedule	Status and achievements
<b>1. Preparation of Land Acquisition and Ethnic Minority Development Plan</b>					
1.1	Draft plan		Implementing agency and PPTA	Done 30 May 2012	Completed on 25th June 2012
1.2	Information disclosure	31 HHS	Implementing agency, PPTA consultants,	Done in April and May 2012	Completed on June 2012
1.3	Finalizing Land Acquisition and Ethnic Minority Development Plan		Ditto and ADB	November 2012	Completed on December 2012
1.4	Approval of land acquisition and ethnic minority development plan		Implementing agency, DCG	December 2012	Completed on December 2012
1.5	Posting on ADB website		ADB	January 2013 or sooner	Completed on January 2013
<b>2. Implementation</b>					
2.1	Jointly signing contract	31 HHS	DCG	April 2013 or sooner	Achieved. Completed on April 2013
2.2	Disbursement of compensation fee	31 HHS	DLRB	Within 1 month after signing contract	Achieved. 100% of affected households have fully received compensation fee and payment for the endowment insurance was completed in June 2014.
2.3	Land transfer		DLRB, executing agency	Within 2 weeks after paying compensation to affected HHS	Achieved. Land transfer was completed within 2 weeks after paying compensation to affected HHS.  The certificate of state-owned land use right was obtained on 12 May 2016 by implementing agency from local government.
2.4	Provision of high insulation yurts and portable solar power generation panels	40 HHS	DCG, benefiting households	May 2013-May 2015	Achieved. The local government have paid the total cost for the yurt and solar power generation sets and the action was completed in the end of 2015.
2.5	Employment skills training for construction	100 person-times of labors	Implementing agency	June 2013-December 2016	Achieved. A total of 800 job opportunities have been provided for local residents during project construction and equipment installation and commissioning stage, of which 37.5% were women.

No.	Tasks	Target	Responsible Agency	Schedule	Status and achievements
2.6	Employment of locals as long term staff	30 locals	Ditto	January 2017 or sooner	Achieved. 37 local residents in total are working in CGN-DSE as permanent employees, among which, 10 are women.
2.7	Training on grassland management	Taositu village	DAB	March (i.e., before grazing season starts) in each year from 2013 to 2017, 40 persons time each year	Achieved. 216 times of trainings on grassland protection for grazing families in Taositu village have been carried out by DAB, among all participants, 45% are women.
2.8	Training on household financial management	100 person-time	DWF	Before and after compensation payments	Achieved. 112 participants, 56% were women, have joined the training on household financial and assets management conducted by DWF in September 2016 for affected households and other residents in Herders'

CGN-DSE = China General Nuclear Delingha Solar Energy Co., Ltd., DAB = Delingha Agriculture and Husbandry Bureau, DCG = Delingha City Government, DLRB = Delingha Land Resource Bureau, DWF = Delingha Women's Federation, HH = household, PPTA = project preparatory technical assistance.

Sources: CGN.

## E. Land Acquisition and Ethnic Minority Development Plan Cost

17. According to LAEMDP, the total budget was CNY6,625,520 including (i) land compensation of CNY5,195,520 with the rate of CNY1,408 per mu; (ii) ethnic minority development cost of CNY600,000 for 40 sets of high insulation yurts (CNY12,000 per unit) and portable solar power generation sets (CNY3,000 per unit); (iii) training expense of CNY50,000; (iv) administration and monitoring expense of CNY260,000; and (v) contingency of CNY520,000.

18. As presented in Table A11.2, the total actual cost of LAEMDP implementation was CNY8,703,280, which was 1.31 times the CNY6,625,520 estimated in the LAEMDP. The actual cost of land compensation is CNY7,793,280, which increased by 50% of the land compensation budget for permanent land acquisition in LAEMDP because of the newly added payment for the endowment insurance fund pool for farmers affected by project land acquisition.

19. There is no change of the ethnic minority development cost. However, during implementation, the local government have paid the total cost for the yurt and solar power generation sets instead of contribution by three parties.

20. The cost for trainings in action plans mentioned in section D were carried out by implementing agency, Delingha Agriculture and Animal Husbandry Bureau and Delingha Women's Federation through regular government administration budget.

**Table A11.2: Land Acquisition and Ethnic Minority Development Plan Implementation Cost**

Item	LAEMDP				Implementation				
	Budget (CNY)	Funding Source (CNY)			Cost (CNY)	Funding Source (CNY)			
		Implementing agency	Gov't	HHs		Implementing agency	Gov't	HHs	
1. Permanent land acquisition	5,195,520	5,195,520	0	0	7,793,280	7,793,280	0	0	
2. Ethnic minority development	High insulation yurt	480,000	0	400,000	80,000	480,000	0	480,000	0
	Portable solar power generation set	120,000	40,000	40,000	40,000	120,000	0	120,000	0
3. Training activities	50,000	50,000	0	0	50,000	0	50,000	0	
4. Administration and monitoring	260,000	260,000	0	0	260,000	0	260,000	0	
5. Contingency	520,000	520,000	0	0	0	0	0	0	
<b>Total</b>	<b>6,625,520</b>	<b>6,065,520</b>	<b>440,000</b>	<b>120,000</b>	<b>8,703,280</b>	<b>7,793,280</b>	<b>910,000</b>	<b>0</b>	

HH = household.

Source: China General Nuclear Power Corporation.

## F. Institutional Arrangements

21. There was a well-organized institutional structure for the management and implementation of the LAEMDP. The implementing agency, Delingha Land Resource Bureau, Delingha Agriculture and Animal Husbandry Bureau and Delingha Women's Federation and Xuji township government was responsible for the implementation of the LAEMDP.

22. Within CGN-DSE, the Project Management Department was mainly in charge of project land acquisition, resettlement and monitoring, supervision of the implementation of the LAEMDP and addressing complaints of APs.

## G. Monitoring and Evaluation

23. CGN-DSE have prepared and submitted four LAEMDP monitoring reports to ADB from 2014 to 2018 during project implementation which have been disclosed on ADB's website according to the requirements in LAEMDP. Please find the submission details in Table A11.3.

**Table A11.3: Land Acquisition and Ethnic Minority Development Plan Monitoring and Evaluation**

Name of documents	Monitoring period	Submission time
Social monitoring report No. 1	July 2014–December 2014	January 2015
Social monitoring report No. 2	January 2015–June 2016	June 2016
Social monitoring report No. 3	July 2016–June 2017	June 2017
Social monitoring report No. 4 (completion report)	July 2017–December 2018	December 2018

Source: China General Nuclear Power Corporation.

## **H. Information Disclosure, Participation and Consultation in Ethnic Minority Community**

24. During project preparation, five rounds of consultations among affected EM households, township and city governments, were carried out in the EM community from June 2011 to October 2012 for the discussion of project site selection and optimization, land acquisition, social, and environmental impacts assessment, household survey, compensation policy, standards, and actions, etc.; based on the consultation, all affected households and government departments supported the project. The affected EM households had experienced land acquisition for the same type of solar thermal power plants four times before, and are satisfied with the land acquisition policy, procedures and compensation rates.

25. During land acquisition and resettlement implementation stage, the resettlement implementing agencies closely worked with heads of EM community and affected households to conduct detailed survey and confirm the final land acquisition and resettlement impacts, discussed and determined compensation and income restoration plan, disclosed final resettlement policies, and signed compensation agreements based on meaningful consultation. The social monitoring reports conclude that no complaints were received during implementation of land acquisition and resettlement.

26. The grievance redress mechanism (GRM) for resettlement was well established and described clearly in the LAEMDP and disclosed to affected people prior to land acquisition implementation. Since the entire resettlement and rehabilitation program was carried out with the participation of affected persons (AP), no grievance issues arose during the implementation period.

## **I. Conclusions and Lessons Learned**

27. There was a well-organized institutional structure for the management and implementation of the LAEMDP. A GRM was set-up and was publicized among APs. Extensive consultation with local governments, affected EM community, and affected persons throughout the implementation of land acquisition and resettlement was conducted. Land Acquisition and Resettlement (LAR), assistance and action plans for EM households of the project was implemented well in compliance with the LAEMDP. The project had no negative impact on the development of ethnic minorities in the project area. Provision of the land compensation and implementation of Action Plans have improved the livelihood of the affected persons, and there are no remaining issues.

## STATUS OF COMPLIANCE WITH LOAN COVENANTS

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<b>Implementation Arrangement</b>		
<p>1. CGN, CGN-SEDC, CGN-DSE, and CEXIM will ensure that the Project is implemented in accordance with the detailed arrangements set forth in the project administration manual (PAM). Any subsequent change to the PAM will become effective only after approval of such change by CGN, CEXIM, and ADB. In the event of any discrepancy between the PAM and the Project Agreement, the provisions of the Project Agreement will prevail.</p> <p>The Borrower shall cause CGN and EXIM, and through CGN, cause CGN-SEDC and CGN-DSE to ensure that the Project is implemented in accordance with the detailed arrangements set forth in the PAM. Any subsequent change to the PAM shall become effective only after approval of such change by CGN and ADB. In the event of any discrepancy between the PAM and this Loan Agreement, the provisions of the Loan Agreement shall prevail. In particular the implementation arrangements as set forth in paragraphs 2 to 5 below shall apply.</p> <p>The Borrower shall cause EXIM, as a principal onlending agency, to be responsible for: (a) onlending the proceeds of the Loan from the Borrower to CGN in accordance with the terms of conditions set out in Section 3.01(b) of this Loan Agreement and Section 2.01(a) of the Project Agreement; and (b) related disbursement, repayment and administration matters.</p> <p>The Borrower shall cause CGN, as the Project Executing Agency, to be responsible for: (a) onlending the proceeds of the Loan onlent from EXIM to CGN-DSE; and (b) the overall coordination and supervision of the Project. The Borrower shall cause CGN to follow the implementation arrangements set forth in this Schedule.</p> <p>The Borrower shall, through CGN, cause CGN-DSE to be the Project Implementing Agency and shall be responsible for the implementation of the Project.</p> <p>The Borrower shall, through CGN, cause CGN-SEDC to be responsible for: (a) providing management support and oversight to CGN-DSE; and (b) supporting Project implementation, particularly in relation to procurement and contract management under the Project. The Borrower shall, through CGN, also cause CGN-SEDC to be responsible for liaising with CGN.</p>	<p>PA, Schedule, para. 1</p> <p>LA, Schedule 5, para. 1</p> <p>LA, Schedule 5, para. 2</p> <p>LA, Schedule 5, para. 3</p> <p>LA, Schedule 5, para. 4</p> <p>LA, Schedule 5, para. 5</p>	<p>Complied.</p>
<b>Environmental</b>		
<p>2. CGN, SGN-SEDC and CGN-DSE shall ensure, and cause other involved agencies to ensure, that the preparation, design, construction, implementation, operation and decommissioning of the Project, and that all Project facilities comply with (a) all applicable laws and regulations of the PRC relating to environment; (b) the Environmental Safeguards; and (c) all measures and requirements set forth in the IEE, the EMP, and any corrective or preventative actions (i) set forth in a Safeguards Monitoring Report, or (ii) as subsequently agreed between ADB and CGN.</p>	<p>PA, Schedule, para. 2</p>	<p>Complied. The EMP was included in all the EPC and goods packages contracts and fully implemented. Semi-annual Environment monitoring reports were submitted on time.</p>

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<b>Land Acquisition</b>		
3. CGN, CGN-SEDC and CGN-DSE shall ensure that all land and all rights-of-way required for the Project are made available to the civil works contractor in a manner and within timeframes compliant with the Land Acquisition and Ethnic Minority Development Plan (LAEMDP) and all land acquisition and resettlement activities are implemented in compliance with (a) all applicable laws and regulations of the PRC relating to land acquisition and involuntary resettlement; (b) the Involuntary Resettlement Safeguards; and (c) all measures and requirements set forth in the LAEMDP, and any corrective or preventative actions (i) set forth in the Safeguards Monitoring Report, or (ii) as subsequently agreed between ADB and CGN.	PA, Schedule, para. 3	Complied. All land and all rights-of-way required for the Project were acquired on time and the LAEMDP was implemented as planned. The semi-annual monitoring reports were submitted on time.
4. Without limiting the application of the Involuntary Resettlement Safeguards or the LAEMDP, CGN, CGN-SEDC and CGN-DSE shall ensure, that no physical or economic displacement takes place in connection with their respective part of the Project until:  (a) compensation and other entitlements have been provided to the displaced persons under Involuntary Resettlement Safeguards as described in and in accordance with the LAEMDP; and  (b) a comprehensive income and livelihood restoration program has been established in accordance with the LAEMDP.	PA, Schedule, para. 4	Complied. Details are provided in Appendix 11.
<b>Ethnic Minorities</b>		
5. CGN, CGN-SEDC and CGN-DSE shall ensure that the preparation, design, construction, implementation and operation of the Project and all Project facilities comply with (a) all applicable laws and regulations of the PRC relating to indigenous peoples; (b) the Indigenous Peoples Safeguards; and (c) all measures and requirements set forth in the LAEMDP, and any corrective or preventative actions (i) set forth in the Safeguards Monitoring Report, or (ii) subsequently agreed between ADB and CGN.	PA, Schedule, para. 5	Complied. 153 persons of 31 ethnic minority households (148 Mongolian and five Tuzu) were affected by the project. It caused no loss of income and fixed assets for the Ems. The measures for improving the livelihood of the Ems have been carried out according to the LAEMDP with the employment opportunity and skills training provided for the EMS.
<b>Applicability of ADB's Safeguard Policy</b>		
6. CGN, CGN-SEDC and CGN-DSE shall ensure that the provisions of the IEE, EMP and LAEMDP as well as any requirements under the Safeguard Policy Statement also apply to the portion of the Project to be financed by CGN and the CEXIM.	PA, Schedule, para. 6	Complied. The entire project has strictly followed the ADB safeguard requirements, all the civil works contracts have also incorporated the relevant requirements.
<b>Human and Financial Resources to Implement Safeguards Requirements</b>		
7. CGN, CGN-SEDC and CGN-DSE shall make available, and cause CGN-DSE to make available, necessary budgetary and human resources to fully implement the EMP and the LAEMDP.	PA, Schedule, para. 7	Complied. The EMP and the LAEMDP were implemented successfully by CGN and CGN-DSE.

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<b>Safeguards-Related Provisions in Bidding Documents and Civil Works Contracts</b>		
<p>8. CGN-DSE shall ensure, that all bidding documents and civil works contracts contain provisions that require contractors to:</p> <p>(a) comply with the measures relevant to the contractor set forth in the IEE, the EMP and LAEMDP (to the extent they concern impacts on respective affected people under Environmental Safeguards, Involuntary Resettlement Safeguards and Indigenous Peoples Safeguards during construction), and any corrective or preventative actions (i) set forth in the Safeguards Monitoring Report, or (ii) as subsequently agreed between ADB and CGN;</p> <p>(b) make available a budget for all such environmental and social measures;</p> <p>(c) provide CGN-DSE with a written notice of any unanticipated environmental, resettlement or social risks or impacts that arise during construction, implementation or operation of the project that were not considered in the IEE, the EMP and the LAEMDP; and</p> <p>(d) reinstate pathways and other local infrastructure to at least their pre-Project condition as soon as possible and no later than the completion of construction.</p>	PA, Schedule, para. 8	<p>Complied.</p> <p>All the bidding documents and contracts had environmental clauses and EMP and LAEMDP provisions. The provisions were also carried out on time and with adequate budget and staffing. No significant unexpected environmental or resettlement issues were raised during the project implementation. The pathways and other local infrastructure including the temporary land and access roads were also restored after the project completion.</p>
<b>Safeguards Monitoring and Reporting</b>		
<p>9. CGN, CGN-SEDC and CGN-DSE shall do, or cause the CGN-DSE to do, the following:</p> <p>(a) submit a Safeguards Monitoring Reports to ADB:</p> <p>(i) in respect of implementation of and compliance with the Environmental Safeguards and the EMP, annually during construction and the implementation of the Project and the EMP until the issuance of ADB's Project completion report unless a longer period is agreed in the EMP; and</p> <p>(ii) in respect of the implementation of and compliance with the Involuntary Resettlement Safeguards and Indigenous Peoples, Safeguards and LAEMDP, semi-annually during the implementation of the Project, the LAEMDP until the issuance of ADB's Project completion report unless a longer period is agreed in the LAEMDP;</p> <p>and disclose relevant information from such reports to respective affected people under Environmental Safeguards, Involuntary Resettlement Safeguards and Indigenous Peoples Safeguards promptly upon submission.</p> <p>(b) if any unanticipated environmental and/or social risks and impacts arise during construction, implementation or operation of the Project that were not considered in the IEE, the EMP and the LAEMDP, promptly inform ADB of the occurrence of such risks or impacts, with detailed description of the event and proposed corrective action plan; and</p>	PA, Schedule, para. 9	<p>Complied.</p> <p>Monitoring reports were submitted to ADB, as required. Also, the reports were disclosed on ADB website periodically.</p>

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
(c) report any actual or potential breach of compliance with the measures and requirements set forth in the EMP or the LAEMDP promptly after becoming aware of the breach.		
<b>Safeguards - Prohibited List of Investments</b>		
10. CGN, CGN-SEDC, CGN-DSE and CEXIM shall ensure that no proceeds of the Loan are used to finance any activity included in the list of prohibited investment activities provided in Appendix 5 of the Safeguards Policy Statement.	PA, Schedule, para. 10	Complied.
<b>Civil Works Contracts</b>		
11. CGN-DSE shall ensure that civil works contracts include provisions to require the contractors (a) not to discriminate against people seeking work on the basis of age, provided they are capable of doing such work; (b) to provide equal pay for equal work, regardless of gender or ethnicity; (c) to comply with core labor standards and the applicable labor laws and regulations, including stipulations related to employment, such as health, safety, welfare, the workers' rights and anti-trafficking laws; (d) not to force the labor to work against their will; and (f) not to employ child labor.	PA, Schedule, para. 11	Complied. During construction, all PRC labor laws, and core labor standards were respected and included in bidding contracts, and ensured women received equal pay for equal work as men. No child labor was used during the entire project period.
12. CGN-DSE shall ensure that the civil works contractors (a) implement HIV/AIDS and STIs awareness and prevention training for all employees; (b) provide necessary measures to ensure the safety and health of their employees; and (c) together with the local centers of disease control, disseminate information on the risks, hazards, impacts and prevention know-how on HIV/AIDS and STIs among the staff, workers on the construction sites and the local community by means of information disclosure, education and consultation.	PA, Schedule, para. 12	Complied. The HIV/AIDS and STIs prevention plan was implemented in accordance with its terms. Information booklets and training on risk prevention measures for HIV and other infectious diseases, and free physical examination services were provided to relevant personnel. The contractors were required to provide all workers training on safety issues and communicable diseases.
<b>Counterpart Funding</b>		
13. CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, provide counterpart funding in a timely manner, including any additional counterpart funding required for any shortfall of funds or cost overruns. CGN will also cause CGNDSE to ensure that O&M of all Project facilities is fully funded without any delay.  The Borrower shall cause CGN and EXIM, and, through CGN, cause CGN-SEDC and CGN-DSE to ensure that (a) all counterpart funds are made available to CGN-DSE in a timely manner; and (b) operation and maintenance of all Project facilities are fully funded.	PA, Schedule, para. 13  LA, Schedule 5, para. 6	Complied. The counterpart financing was provided on time to ensure the timely project delivery. No fund shortfall or inadequacy were incurred during the project implementation period.
<b>Financial Management</b>		
14. CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, develop and maintain sound financial management systems in accordance with ADB's Financial Management and Analysis of Projects, including the establishment of separate Project accounts and the maintenance of minimum balances to ensure smooth cash flow and the timely settlement of project	PA, Schedule, paras. 14-15	Partly Complied. Records were maintained in accordance with sound accounting principles. Debt service coverage ratio was applicable (not achieved) due to



Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<p>construction liabilities and future debt servicing. In particular, CGN-DSE shall maintain (a) a debt service coverage ratio of at least 1.2 times, and (b) a long-term debt-to-equity ratio of at least 80:20.</p> <p>15. If, in the opinion of ADB, it appears that CGN-DSE cannot meet the requirements set forth in paragraph 14 above or cannot or cannot meet any debt service obligations, CGN shall take appropriate measures for CGN-DSE to strengthen its financial management systems, including, but not limited to, provision of necessary financing to CGN-DSE.</p>		<p>the negative owners' equity at the initial stage of the operation. The long-term debt to equity ratio is not applicable (not achieved) due the negative revenue of the company at the initial stage of the operation. However, the financial performance of the company and the debt repayment capacity will be significantly improved after the full operation of the plant. CGN-DSE is taking measures to improve the technical performance of the plant, targeting to reach the designed full capacity in 2023 (para. 43 and Appendix 9).</p>
<b>Operation and Maintenance</b>		
<p>16. CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, enter into the performance-based O&amp;M contract with an O&amp;M contractor for the first two years of commercial operation of the CSP plant in accordance with the Section XI. B of the PAM. In particular, such O&amp;M contract will include O&amp;M training for operators from CGN-DSE.</p>	PA, Schedule, para. 16	<p>Not Complied. The performance-based O&amp;M contractor was not engaged due to the limited access to the military restricted area and number of qualified contractors available.</p>
<b>Design and Construction Quality and Management</b>		
<p>17. CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall ensure that the owner's engineer is engaged in accordance with Section XI. A of the PAM and will (a) assist CGN-DSE in engineering design, tender document preparation, bid evaluation, construction supervision, and test run, and (b) provide CGN-DSE with design and construction supervision training. Such owner's engineer shall have experiences in engineering design and construction supervision for similar parabolic trough CSP. Prior to engaging the owner's engineer, CGN will cause CGN-DSE to submit the name and qualifications of the proposed owner's engineer to ADB for its concurrence.</p>	PA, Schedule, para. 17	<p>Complied. The owner's engineer—Aries S. A (Spain) was engaged in 2014 to assist CGN-DSE in engineering design, tender document preparation, bid evaluation, construction supervision, and test run and provided CGN-DSE with design and construction supervision training.</p>
<b>Governance and Anticorruption</b>		
<p>18. CGN, CGN-SEDC, CGN-DSE and CEXIM (a) acknowledges ADB's right to investigate, directly or through its agents, any alleged corrupt, fraudulent, collusive or coercive practices relating to the Project; and (b) agrees to cooperate, and shall cause all other government offices, organizations and entities involved in implementing the Project to cooperate, fully with any such investigation and to extend all necessary assistance, including providing access to all relevant books and records, as may be necessary for the satisfactory completion of any such investigation. In particular, CGN, CGN-SEDC, CGN-DSE and CEXIM, shall ensure, or cause to be ensured, that (a) periodic inspections of the Project contractors' activities related to fund withdrawals and settlements are carried out; (b) relevant provisions of ADB's Anticorruption Policy (1998, as amended to date) are included in all bidding documents for the Project; and (c) contracts, financed under the</p>	PA, Schedule, para. 18	<p>Complied. Annual review missions were fielded.</p>

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
Project, include provisions specifying the right of ADB to audit and examine the records and accounts of CGN, CGN-SEDC, CGN-DSE, CEXIM, contractors, suppliers, consultants, and other service providers as they relate to the Project.		
<b>Change in Ownership</b>		
19. In the event of (a) any change in ownership of the Project facilities, or (b) any sale, transfer or assignment of shares or interest or other change of control in CGN, CGN-SEDC or CGN-DSE is anticipated, CGN, CGN-SEDC and CGN-DSE, as the case may be, shall consult with ADB and CEXIM at least 6 months prior to the implementation of such change. CGN, CGN-SEDC and CGN-DSE, as the case may be, shall ensure that such change be carried out in a lawful and transparent matter. CGN, CGN-SEDC and CGN-DSE, as the case may be, shall further ensure that their new controlling management complies with (a) all Project related agreements executed between ADB and the Borrower, CGN, CGN-SEDC, CGNDSE, or CEXIM; and (b) the policies of ADB relevant to the Project.	PA, Schedule, para. 19	Not applicable.
<b>Condition for Disbursement</b>		
20. Withdrawal from the Loan account is conditional upon the execution of all the subsidiary loan agreements and onlending agreements satisfactory to ADB.	LA Schedule 3, para. 8	Complied. The onlending agreement between MOF and CEXIM was signed and delivered on 12 June 2014; and the onlending agreement between CEXIM and CGN was signed and delivered on 25 November 2014, while the onlending agreement/MOU between CGN and CGN-DSE was signed and delivered on 27 November 2014.
<b>Particular Covenants</b>		
21. (a) The Borrower shall cause the Project to be carried out with due diligence and efficiency and in conformity with sound applicable technical, financial, business, and development practices. (b) In the carrying out of the Project and operation of the Project facilities, the Borrower shall perform, or cause to be performed, all obligations set forth in Schedule 5 to this Loan Agreement and the Schedule to the Project Agreement.	LA Article IV Section 4.01	Complied.
22. The Borrower shall make available, or cause to be made available, promptly as needed, the funds, facilities, services, land and other resources, as required, in addition to the proceeds of the Loan, for the carrying out of the Project.	LA Article IV Section 4.02	Complied.
23. The Borrower shall ensure that the activities of its departments and agencies with respect to the carrying out of the Project and operation of the Project facilities are conducted and coordinated in accordance with sound administrative policies and procedures.	LA Article IV Section 4.03	Complied.
24. The Borrower shall cause C EXIM and CGN to enable ADB's representatives to inspect the Project, the Goods and any records and documents related to the Project.	LA Article IV Section 4.04	Complied.

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
25. The Borrower shall take all actions which shall be necessary on its part to enable CGN, CGN-SEDC, CGN-DSE and CEXIM to perform their obligations under the Project Agreement, and shall not take or permit any action which would interfere with the performance of such obligations.	LA Article IV Section 4.05	Complied.
26. (a) The Borrower shall exercise its rights under its Onlending Agreement with CEXIM in such a manner as to protect the interests of the Borrower and ADS and to accomplish the purposes of the Loan. (b) No rights or obligations under its Onlending Agreement with CEXIM shall be assigned, amended, abrogated or waived without the prior concurrence of ADB.	LA Article IV Section 4.06	Complied.
<b>Particular Covenants</b>		
27. (a) CEXIM shall make the proceeds of the Loan, onlent from the Borrower as described in Section 3.01(a) of the Loan Agreement, available to CGN through the CEXIM Onlending Agreement upon terms and conditions acceptable to ADB. Except as ADB may otherwise agree, the terms for the proceeds of the CEXIM Onlending Loan made available to CGN shall include (i) commitment charge and interest at the rates identical to those applied to the Loan; (ii) onlending fee as agreed upon between CEXIM and CGN, (iii) a repayment period including a grace period identical to those applied to the Loan; and (iv) CGN bearing the foreign exchange and interest rate variation risks of the proceeds of the Loan made available thereto. (b) CGN shall make the proceeds of the CEXIM Onlending Loan available to CGN-DSE through the CGN Onlending Agreement upon terms and conditions acceptable to ADB. Except as ADB may otherwise agree, the terms for the proceeds of the CGN Onlending Loan made available to CGN-DSE shall include (i) commitment charge and interest at the rates identical to those applied to the Loan; (ii) onlending fee as imposed by CEXIM under the CEXIM Onlending Agreement; (iii) a repayment period including a grace period identical to those applied to the Loan; and (iv) CGN-DSE bearing the foreign exchange and interest rate variation risks of the proceeds of the Loan made available thereto. (c) CGN, CGN-SEDC, CGN-DSE and CEXIM shall carry out, or cause to be carried out, the Project with due diligence and efficiency, and in conformity with sound applicable technical, financial, business, and development practices. (d) In the carrying out of the Project and operation of the Project facilities, CGN, CGN-SEDC, CGN-DSE and CEXIM shall perform all obligations set forth in the Loan Agreement to the extent that they are applicable to CGN, CGN-SEDC, CGN-DSE and CEXIM, and all obligations set forth in the Schedule to this Project Agreement.	PA Article II Section 2.01	Complied.
28. CGN, CGN-SEDC, CGN-DSE and CEXIM shall make available, promptly as needed, the funds, facilities, services, land and other resources as required, in addition to the proceeds of the Loan, for the carrying out of the Project.	PA Article II Section 2.02	Complied.

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<p>29. (a) In the carrying out of the Project, CGN-DSE shall employ competent and qualified contractors for the Goods, acceptable to ADB, to an extent and upon terms and conditions satisfactory to ADB.</p> <p>(b) Except as ADB may otherwise agree, all items of expenditures to be financed out of the proceeds of the Loan shall be procured in accordance with the provisions of Schedule 4 to the Loan Agreement. ADB may refuse to finance a contract where any such item has not been procured under procedures substantially in accordance with those agreed between the Borrower and ADB or where the terms and conditions of the contract are not satisfactory to ADB.</p>	PA Article II Section 2.03	Complied.
<p>30. CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, carry out the Project in accordance with plans, design standards, specifications, work schedules and construction methods acceptable to ADB. CGN, CGN-SEDC and CGN-DSE shall furnish, or cause to be furnished, to ADB, promptly after their preparation, such plans, design standards, specifications and work schedules, and any material modifications subsequently made therein, in such detail as ADB shall reasonably request.</p>	PA Article II Section 2.04	Complied.
<p>31. (a) CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, take out and maintain with responsible insurers, or make other arrangements satisfactory to ADB for, insurance against such risks and in such amounts as shall be consistent with sound practice.</p> <p>(b) Without limiting the generality of the foregoing, CGN and CGN-SEDC shall cause CGN-DSE to undertake to insure, or cause to be insured, the Goods to be imported for the Project against hazards incident to the acquisition, transportation and delivery thereof to the place of use or installation, and for such insurance any indemnity shall be payable in a currency freely usable to replace or repair such Goods.</p>	PA Article II Section 2.05	Complied.
<p>32. CGN, CGN-SEDC and CEXIM shall cause CGN-DSE to, and CGN-DSE shall, maintain, or cause to be maintained, records and accounts adequate to identify the items of expenditure financed out of the proceeds of the Loan, to disclose the use thereof in the Project, to record the progress of the Project (including the cost thereof) and to reflect, in accordance with consistently maintained sound accounting principles, its operations and financial condition.</p>	PA Article II Section 2.06	Complied.
<p>33. (a) ADB, CGN, CGN-SEDC, CGN-DSE and C EXIM shall cooperate fully to ensure that the purposes of the Loan will be accomplished.</p> <p>(b) CGN, CGN-SEDC, CGN-DSE and CEXIM shall promptly inform ADB of any condition which interferes with, or threatens to interfere with, the progress of the Project, the performance of their obligations under this Project Agreement or the respective Onlending Agreements, or the accomplishment of the purposes of the Loan.</p> <p>(c) ADB, CGN, CGN-SEDC, CGN-DSE and CEXIM shall from time to time, at the request of either party, exchange views</p>	PA Article II Section 2.07	Complied.

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
through their representatives with regard to any matters relating to the Project, CGN-DSE, and the Loan.		
<p>34. (a) CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, furnish to ADB all such reports and information as ADB shall reasonably request concerning (i) the Loan and the expenditure of the proceeds thereof; (ii) the items of expenditure financed out of such proceeds; (iii) the Project; (iv) the administration, operations and financial condition of CGN-DSE; and (v) any other matters relating to the purposes of the Loan. CGN and CGN-SEDC shall furnish to ADB all such reports and information as ADB shall reasonably request concerning the administration, operations and financial condition of CGN and CGN-SEDC relating to the Project.</p> <p>(b) Without limiting the generality of the foregoing, CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, furnish to ADB periodic reports on the execution of the Project and on the operation and management of the Project facilities. Such reports shall be submitted in such form and in such detail and within such a period as ADB shall reasonably request, and shall indicate, among other things, progress made and problems encountered during the period under review, steps taken or proposed to be taken to remedy these problems, and proposed program of activities and expected progress during the following period.</p> <p>(c) Promptly after completion of the Project as set forth in paragraph 4 of Schedule 1 to the Loan Agreement, but in any event not later than 6 months thereafter or such later date as ADB may agree for this purpose, CGN and CGN-SEDC shall cause CGN-DSE to, and CGN-DSE shall, prepare and furnish to ADB a report, in such form and in such detail as ADB shall reasonably request, on the execution and initial operation of the Project, including its cost, the performance by CGN, CGN-SEDC and CGN-DSE of their obligations under this Project Agreement and the accomplishment of the purposes of the Loan.</p>	PA Article II Section 2.08	Complied.
<p>35. (a) CGN and CGN-DSE shall (i) maintain, and cause to be maintained, separate accounts and records for the Project; (ii) prepare, and cause to be prepared, annual financial statements for the Project in accordance with financial reporting standards acceptable to ADB; (iii) have such financial statements audited annually by independent auditors whose qualifications, experience and terms of reference are acceptable to ADB, in accordance with international standards for auditing or the national equivalent acceptable to ADB; (iv) as part of each such audit, have the auditors prepare a report (which includes the auditors' opinion on the financial statements, use of the Loan proceeds and compliance with the financial covenants of this Loan Agreement as well as on the use of the procedures for the imprest account and its sub-account) and Management Letter; and (v) furnish to ADB, no later than 6 months after the end of each related fiscal year, copies of such audited financial statements, audit report and management letter, all in the English language, and such other information</p>	PA Article II Section 2.09	Complied.

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
<p>concerning these documents and the audit thereof as ADB shall from time to time reasonably request.</p> <p>(b) ADB shall disclose on its website the annual audited financial statements for the Project and the opinion of the auditors on the financial statements within 30 days of the date of their receipt.</p> <p>(c) In addition to annual audited financial statements referred to in subsection (a) hereinabove, CGN and CGN-DSE shall (i) provide their annual financial statements prepared in accordance with national accrual-based financing reporting standards acceptable to ADB; (ii) have its financial statements audited annually by independent auditors whose qualifications, experience and terms of reference are acceptable to ADB, in accordance with international standards for auditing or the national equivalent acceptable to ADB; and (iii) furnish to ADB, no later than 1 month after approval by the relevant authority, copies of such audited financial statements in accordance with the PAM and such other information concerning these documents and the audit thereof as ADB shall from time to time reasonably request.</p> <p>(d) CGN and CGN-DSE shall enable ADB, upon ADB's request, to discuss the financial statements referred to in subsections (a) (ii) and (c) above, and their financial affairs where they relate to the Project with the auditors appointed pursuant to subsections (a)(iii) and (c) hereinabove, and shall authorize and require any representative of such auditors to participate in any such discussions requested by ADB. This is provided that such discussions shall be conducted only in the presence of an authorized officer of CGN and CGN-DSE, unless CGN and CGN-DSE shall otherwise agree.</p>		
<p>36. CGN, CGN-SEDC, CGN-DSE and CEXIM shall enable ADB's representatives to inspect the Project, the Goods and any relevant records and documents.</p>	<p>PA Article II Section 2.10</p>	<p>Complied.</p>
<p>37. (a) CGN, CGN-SEDC, CGN-DSE and CEXIM shall, promptly as required, take all action within their powers to maintain their corporate existence, to carry on their operations, and to acquire, maintain and renew all rights, properties, powers, privileges and franchises which are necessary in the carrying out of the Project or in the conduct of its operations.</p> <p>(b) CGN, CGN-SEDC, CGN-DSE and CEXIM shall at all times conduct their operations in accordance with sound applicable technical, financial, business, development and operational practices, and under the supervision of competent and experienced management and personnel.</p> <p>(c) CGN, CGN-SEDC and CGN-DSE shall at all times operate and maintain their plants, equipment and other property, and from time to time, promptly as needed, make all necessary repairs and renewals thereof, all in accordance with sound applicable technical, financial, business, development, operational and maintenance practices.</p>	<p>PA Article II Section 2.11</p>	<p>Complied.</p>
<p>38. Except as ADB may otherwise agree, CGN-DSE shall not sell, lease or otherwise dispose of any of its assets which shall be required for the efficient carrying on of its</p>	<p>PA Article II Section 2.12</p>	<p>Complied.</p>

Project Specific Covenants	Reference in Legal Agreement	Status of Compliance
operations and none of CGN, CGN-SEDC and CGN-DSE shall sell, lease or otherwise dispose of any of their assets the disposal of which may prejudice their ability to perform satisfactorily any of their obligations under this Project Agreement.		
39. Except as ADB may otherwise agree, CGN, CGN-SEDC and CEXIM shall cause CGN-DSE to, and CGN-DSE shall apply the proceeds of the Loan to the financing of expenditures on the Project in accordance with the provisions of the Loan Agreement and this Project Agreement, and shall ensure that all items of expenditures financed out of such proceeds are used exclusively in the carrying out of the Project.	PA Article II Section 2.13	Complied.
40. Except as ADB may otherwise agree, CGN, CGN-DSE and CEXIM shall duly perform all their obligations under the respective Onlending Agreements, and shall not take, or concur in, any action which would have the effect of assigning, amending, abrogating or waiving any rights or obligations of the parties under the respective Onlending Agreements.	PA Article II Section 2.14	Complied.
41. CGN, CGN-SEDC, CGN-DSE and CEXIM shall promptly notify ADB of any proposal to amend, suspend or repeal any provision of their] charters, which, if implemented, could adversely affect the carrying out of the Project or the operation of the Project facilities. CGN, CGN-SEDC, CGN-DSE and CEXIM shall afford ADB an adequate opportunity to comment on such proposal prior to taking any affirmative action thereon.	PA Article II Section 2.15	Complied.

ADB = Asian Development Bank, AIDS = acquired immunodeficiency syndrome, AP = affected person, CEXIM = The Export-Import Bank of China, CGN = China General Nuclear Power Corporation, CGN-DSE = CGN Delingha Solar Energy Co. Ltd., CGN-SEDC = CGN Solar Energy Development Co. Ltd., CO<sub>2</sub> = carbon dioxide, CSP = concentrated solar thermal power, EMP = environmental management plan, GRM = grievance redress mechanism, ICB = international competitive bidding, IEE = initial environment examination, LAEMDP = land acquisition and ethnic minority development plan, LAR = land acquisition and resettlement, O&M = operation and maintenance, PAM = project administration manual, PCR = project completion report, PRC = People's Republic of China, RP = resettlement plan, STI = sexually transmitted infection, TA = technical assistance.

Source: Asian Development Bank.

## ECONOMIC REEVALUATION

### A. Introduction

1. The economic analysis is conducted in accordance with Guidelines for the Economic Analysis of Projects of the Asian Development Bank (ADB) to evaluate the economic viability of the Qinghai Delingha Concentrated Solar Thermal Power (CSP) Project at the project completion. The economic viability of the project was assessed by computing the economic internal rate of return (EIRR) and economic net present value (ENPV) from a stream of incremental benefits and costs attributable to the investments comparing with the economic opportunity cost of capital, which was assumed to be at 12%.<sup>1</sup> The project financial projection was conducted based on updated information including investment and financial plan, project implementing schedule, revenues and operating costs following as much as possible assumptions used at appraisal through an economic model to the project for the study years of 2013–2041, of which the first eight years are historical years and 2021–2041 are projected years.

### B. Assumptions

2. The economic feasibility was evaluated through a comparison of the with- and without-project scenarios as follows:
- (i) Under the without-project (baseline) scenario, the energy would be provided by an existing or committed coal-fired power plant.
  - (ii) Under the with-project scenario, the project would generate solar energy which would replace the energy generated by the equivalent capacity of coal-fired power plant.

### C. Demand Analysis

3. The energy sector in the People's Republic of China (PRC) has grown rapidly in tandem with economic growth. The energy sector relies heavily on coal-fired power generation, which accounts for 70% of the total capacity in 2013, and reduced to 58% in 2019. Its coal consumption has been a major source of carbon dioxide (CO<sub>2</sub>) emissions—50% of total CO<sub>2</sub> emissions in the PRC. Diversifying the energy mix by promoting renewable energy is one of the core development agendas to attain the carbon intensity reduction target. The Twelfth Five-Year Plan, 2011–2015 has set targets to increase the share of renewable energy from 8.9% in 2010 to 11.4% in 2015, and decrease carbon intensity by 17% by 2015 compared with 2010 levels. The Thirteenth Five-Year Plan has set target to increase the share of renewable energy to over 15% by 2020.

4. The rapid development of solar photovoltaic and wind power capacity has been posing new challenges to grid stability because of the intermittent nature of power supplied by these plants. For instance, in 2013, the curtailment of wind power<sup>2</sup> in certain regions of the PRC was as high as 45%, compared with less than 10% in Europe. At higher penetration of solar photovoltaic and wind power generation, increased grid flexibility is needed to fully utilize the variable and uncertain output from these plants.

5. CSP plants have inherent capacity to store surplus heat energy in thermal storage for sufficiently long periods of time (currently up to 15 hours in operation) and can be equipped with

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<sup>1</sup> The RRP adopted 12% as the discount rate, therefore PCR needs to use the same 12% for consistency of the calculations, although the Guideline changed the discount rate from 12% to 9%.

<sup>2</sup> Non-absorption of electricity generated by wind power plants via the power system dispatch center.



a natural gas backup system to generate electricity when there is not enough solar irradiation. CSP is an alternative to fossil fuel power plants to supply reliable and predictable electricity at any time of day. It also enables grid operators to schedule their dispatch economically, which enhances grid stability.

#### **D. Economic Costs**

6. Economic analysis was conducted for the project lifespan of 25 years, plus the project implementation period of 8 years of which the power plant was operated with partial capacity in the last 2 years of the implementation period. The residual value at the end of the project life is assumed to be zero. All prices and costs are expressed in 2021 prices and in the domestic currency using the world price numeraire. As the analysis is carried out using the world price numeraire, the conversion factors are the standard conversion factor of 0.9 for non-tradable, 1.0 for tradable and the following specific conversion factors: 1.0 for equipment, 1.0 for skilled labor, and 0.7 for unskilled labor. The financial costs are adjusted to exclude price contingencies, interests during construction, and taxes. A discount rate of 12% per annum is assumed (footnote 1).

7. The financial capital costs were converted to the relevant economic values after deducting taxes, subsidies, and price contingencies, then applying the respective conversion factors specified above. The capital costs of the project include costs related to civil works, the solar field system, heat transfer fluid, the power block system, thermal energy storage, the auxiliary system, other associated costs. The operation and maintenance (O&M) costs, assumed to remain constant in real terms, comprise costs for maintenance, raw materials, energy inputs (natural gas), salaries, overheads, and administration expenses. There is periodical maintenance of CNY5.5 million, which will incur every 5 years since the project is operating in 100% capacity.

#### **E. Economic Benefits**

8. The economic benefits of the project include (i) coal saving (non-incremental), incremental electricity sale<sup>3</sup> (ii) direct environment benefits, and (iii) grid reliability.

- Coal saving. Coal consumption will be reduced since solar energy is replacing coal as a fuel for power generation. The coal saving benefit is derived by multiplying the amount of coal saving by the economic cost of coal.<sup>4</sup>
- Incremental electricity sale. This benefit is calculated by multiplying the amount of incremental electricity generation by willingness to pay.
- Grid reliability. CSP plants with thermal energy storage have the capability to (a) shift energy to higher price intervals, (b) supply ancillary service, and (c) reduce the curtailment of intermittent renewable electricity such as solar photovoltaic and wind power. In a power system with low penetration of renewable, this added economic value is generally calculated as \$5–\$10/MW/hour. The grid reliability benefit of \$10/MW/hour was used since the PRC currently experiences the higher wind curtailments rate than Europe and the United States.

<sup>3</sup> At appraisal stage, 70% (coal contribution to the provincial power generation mix) of electricity generation from the proposed CSP plant was counted for coal saving. The remaining output (30%) is defined as incremental benefit. By end of 2018, electricity from non-fossil fueled power plants is more than 33%. By 2030, electricity from non-fossil fueled power plants will be more than 50%. If 50% is defined as incremental benefits, the EIRR will be increased to 6.80%.

<sup>4</sup> The economic value of coal applied for the benefit computation, CNY1,175/ton, is based on the thermal coal spot price of the People's Republic of China in September 2021.

9. The project will generate considerable environmental benefits through the reduction of pollutant emissions. It will avoid 60,065.3 tons of standard coal equivalent per year, which translates to an annual emission reduction of 163,904 tons of CO<sub>2</sub>,<sup>5</sup> 31.5 tons of sulfur dioxide, 35.3 tons of nitrogen oxides, and 6.3 tons of particulate matter. The economic evaluation of the environmental impact is based on the benefits transfer method described in ADB's Workbook on Economic Valuation of Environmental Impact.

## F. Economic Reevaluation

10. Results of the economic analysis have been presented in the key economic indicators, such as the EIRR and the ENPV of the project. The calculated EIRR is 6.27%, which is lower than the estimated EIRR of 13.3% at appraisal, and the 12% economic cost of capital (discount rate). The main reasons for the difference are the longer implementation period; delay in the project to operate with 100% capacity; and higher than expected O&M costs. The details of the economic reevaluation are shown in Table A13.1.

**Table A13.1: Economic Reevaluation**  
(CNY million)

Year	Capital Costs	O&M Costs	Economic Benefits	Environmental Benefits	Total Benefits	Net Economic Benefits
2013	(4.33)					(4.33)
2014	(51.03)					(51.03)
2015	(102.36)					(102.36)
2016	(42.03)					(42.03)
2017	(788.10)					(788.10)
2018	(340.58)					(340.58)
2019	(156.35)	(39.15)	25.97	6.27	32.25	(163.25)
2020	(24.55)	(72.70)	55.22	13.40	68.62	(28.63)
2021		(78.99)	68.84	16.63	85.47	6.49
2022		(99.52)	113.96	27.53	141.49	41.96
2023		(53.89)	173.13	41.72	214.84	160.95
2024		(44.00)	173.13	41.72	214.84	170.84
2025		(44.00)	173.13	41.72	214.84	170.84
2026		(44.00)	173.13	41.72	214.84	170.84
2027		(48.95)	173.13	41.72	214.84	165.90
2028		(44.00)	173.13	41.72	214.84	170.84

<sup>5</sup> The environmental benefits of a CO<sub>2</sub> emission reduction were estimated at US\$36.30 per ton in 2016 price and increase by 2% annuity to bring it to 2021 price in real term. *Guidelines For the Economic Analysis of The Projects*, ADB, 2017

Year	Capital Costs	O&M Costs	Economic Benefits	Environmental Benefits	Total Benefits	Net Economic Benefits
2029		(44.00)	173.13	41.72	214.84	170.84
2030		(44.00)	173.13	41.72	214.84	170.84
2031		(44.00)	173.13	41.72	214.84	170.84
2032		(48.95)	173.13	41.72	214.84	165.90
2033		(44.00)	173.13	41.72	214.84	170.84
2034		(44.00)	173.13	41.72	214.84	170.84
2035		(44.00)	173.13	41.72	214.84	170.84
2036		(44.00)	173.13	41.72	214.84	170.84
2037		(48.95)	173.13	41.72	214.84	165.90
2038		(44.00)	173.13	41.72	214.84	170.84
2039		(44.00)	173.13	41.72	214.84	170.84
2040		(44.00)	173.13	41.72	214.84	170.84
2041		(44.00)	173.13	41.72	214.84	170.84
2042		(48.95)	173.13	41.72	214.84	165.90
2043		(44.00)	173.13	41.72	214.84	170.84
2044		(44.00)	173.13	41.72	214.84	170.84
					<b>EIRR</b>	<b>6.27%</b>
					<b>ENPV</b>	<b>(417.63)</b>

( ) = negative, O&M = operation and maintenance, EIRR = economic internal rate of return, ENPV = economic net present value.

Source: Asian Development Bank estimates.

## G. Sensitivity Analysis

11. To address the inevitable uncertainty surrounding some of the parameters and assumptions used in the economic analysis, the EIRR was complemented by sensitivity testing. The sensitivity analysis considers the different situations when the O&M costs increases, and the price of coal and willingness to pay decrease, and delay in the power generation with 100% capacity. The details of sensitivity analysis are shown in Table A13.2.

**Table A13.2: Sensitivity Analysis**

<b>Case</b>	<b>EIRR</b>
Base Case	6.27%
Case 1 O&M +10%	5.95%
Case 2 Economic Benefits -10%	5.14%
Case 3 O&M +10% and Economic Benefits -10%	4.80%
Case 4 100% Capacity Power Generation Delayed by 2 years	5.98%
Case 5 Price of Coal -10%	5.75%
Case 6 Willingness to Pay -10%	5.97%
Case 7 Both Price of Coal and Willingness to Pay -10%	5.44%

O&M = operation and maintenance.

Source: Asian Development Bank estimates.

## FINANCIAL REEVALUATION

### A. Introduction

1. This financial reevaluation was performed for the Qinghai Delingha Concentrated Solar Thermal Power Project. It assesses the project's ability to generate sufficient revenues from operations to meet all project costs—including operation and maintenance (O&M), debt service, and depreciation—while providing a reasonable rate of return on investment. The analysis was performed in accordance with *the Asian Development Bank's Guidelines for Financial Management and Analysis of Projects*. All costs and prices are in constant 2021 currency values. The financial internal rate of return (FIRR) was derived using incremental annual cash flows throughout the 25-year lifespan of the project. The straight-line depreciation method was used with no residual value at the end of the evaluation period. The financial analysis model compared the project's FIRR with the weighted average cost of capital (WACC). Sensitivity analyses were conducted to assess the impact of various adverse conditions.

### B. Project Cost and Financial Plan

2. The actual total cost of the project at completion is estimated at \$258.77 million (CNY1,723.14 million equivalent), lower than at appraisal of \$322.26 million. Total project cost decreased mainly due to (i) actual cost lower than procurement cost at appraisal, and (ii) depreciation of the Chinese yuan to CNY6.66 per \$1 from CNY6.20 per \$1 at appraisal (Table A14.1).

**Table A14.1: Comparative Project Cost Estimates**

Item	At Appraisal		At Midterm	
	CNY million	\$ million	CNY million	\$ million
Base Cost				
Civil works	73.15	11.80	53.90	8.10
Solar field	823.44	132.81	632.39	95.01
HTF system	84.45	13.62	68.58	10.35
Thermal energy storage system	239.79	38.68	475.88	71.50
Power generation system	149.33	24.09	190.56	28.63
Auxiliaries	111.80	18.03	35.98	5.41
Other cost	170.67	27.53	139.19	20.91
Engineering service	47.62	7.68	82.22	12.35
<b>Subtotal (A)</b>	<b>1,700.26</b>	<b>274.24</b>	<b>1,678.70</b>	<b>252.26</b>
B. Contingency	227.68	36.72	-	
C. Financial Charges During Implementation	70.09	11.31	44.44	6.51
<b>Total (A+B+C)</b>	<b>1,998.03</b>	<b>322.26</b>	<b>1,723.14</b>	<b>258.77</b>
Exchange rate	6.20		6.66 (Average)	

HTF = heat transfer fluid.

Source: Asian Development Bank estimates.

3. There are also changes in the financing plan for the project at completion. The ADB contribution increased from 46.55% at appraisal to 47.65% at completion. The comparative financing plan is presented in Table A14.2.

**Table A14.2: Comparative Financing Plan**

Source	At Appraisal			At Completion		
	CNY million	\$ million	%of Total	CNY million	\$ million	%of Total
ADB	930.00	150.00	46.55	826.25	123.30	47.64
CEXIM	468.60	75.58	23.45	386.98	57.00	22.03
CGN	599.43	96.69	30.00	509.91	78.47	30.33
<b>Total</b>	<b>1,998.03</b>	<b>322.26</b>	<b>100.00</b>	<b>1,723.14</b>	<b>258.77</b>	<b>100.00</b>

ADB = Asian Development Bank, CEXIM = The Export-Import Bank of China, CGN = China General Nuclear Power Corporation.

Source: Asian Development Bank estimates.

### C. Revenues and Operation and Maintenance Costs

4. The project will generate revenue mainly from the sale of electricity generated by the power plant, based on projected yearly net generation of 29.63 gigawatt-hours (GWh) in 2019, 59.25 GWh in 2020, 79.00 GWh in 2021 and 197.50 GWh from 2023 onwards, with a gross tariff of CNY1.15 per kilowatt-hour (kWh),<sup>1</sup> including 13% value-added tax (VAT)—equal to a net tariff, excluding VAT, of CNY1.02kWh. It is expected that this tariff will be inflation indexed. As the lifetime of a concentrated solar thermal power (CSP) plant is 25 years, under good feed-in tariff legislation, annual tariff payments are adjusted for inflation.

5. O&M include cost of purchased materials, purchased fuel and power, staff salary and welfare, maintenance and repair, and administration, insurance, and other expenses. There is a one-time plant utilization charge of CNY95 million, which will occur between 2020 and 2022. The periodical maintenance costs are expected to be CNY5.5 million and will incur every 5 years. The routine O&M costs is assumed to remain constant after 2023 when the power generation is operating with 100% capacity.

### D. Weighted Average Cost of Capital

6. The WACC was calculated after tax, in real terms, using the actual capital mix and costs of funds (Table A14.3). The interest rate of ADB loan is at 2.33%, the interest rate of domestic loan is at 4.4%, and the cost of equity was assumed to be 8%. The corporate income tax rate is 25.0%, and the annual inflation rate is assumed to be 1.5%<sup>2</sup> domestic and 4.4%<sup>3</sup> international. The calculated WACC is 2.29%, slightly higher than 1.97% at the appraisal due to the lower domestic inflation rate at the completion.

<sup>1</sup> National Development and Reform Commission approved the fit-in tariff of CNY1.15/kwh for the CSP projects operated before 31 December 2018.

<sup>2</sup> ADB, Asian Development Outlook, July 2021.

<sup>3</sup> World Bank, Global Economic Prospects, June 2021.

Table A14.3: Weighted Average Cost of Capital

Item	ADB	Domestic Loan	Equity
Amount (CNY million)	826.25	386.98	509.91
Weighting (%)	47.95%	22.46%	29.59%
Nominal cost (%)	2.33%	4.41%	8.00%
Tax rate (%)	25%	25%	
Tax-adjusted nominal cost (%)	1.74%	3.31%	8.00%
Inflation rate (%)	1.80%	1.50%	1.50%
Real Term Rate	0.00% <sup>a</sup>	1.78%	6.40%
Share	0.00%	0.40%	1.90%
<b>WACC (%)</b>			<b>2.29%</b>

ADB = Asian Development Bank, WACC = weighted average cost of capital.

<sup>a</sup> As the inflation-adjusted rate for the ADB loan is negative, the rate has been set equal to zero.

Source: Asian Development Bank estimates.

## E. Financial Reevaluation

7. The FIRR and financial net present value (FNPV) of the project were reassessed (Table A14.4). The FIRR is 4.75%, which is greater than the WACC at 2.29%, and the FNPV is CNY617 million at this WACC. Thus, the project is considered financially feasible. However, the calculated FIRR at completion is slightly lower than the estimated FIRR of 4.82% at appraisal.

Table A14.4: Projected Cash Flow

(CNY million)

Year	Capital Investment	O&M Cost	Project Revenue	Tax	VAT Refund	Net Cash Flow
2013	(4.82)	0	0	0		(4.82)
2014	(56.75)	0	0	0		(56.75)
2015	(113.85)	0	0	0		(113.85)
2016	(46.75)	0	0	0		(46.75)
2017	(876.53)	0	0	0		(876.53)
2018	(378.80)	0	0	0	12.30	(366.50)
2019	(173.90)	(43.54)	34.07	0		(183.36)
2020	(27.31)	(80.86)	72.45	0		(35.72)
2021		(87.85)	90.31	0	32.50	34.96
2022		(110.69)	149.50	0		38.81
2023		(59.94)	227.13	(18.88)		148.30
2024		(48.94)	227.13	(22.29)		155.89
2025		(48.94)	227.13	(22.95)		155.23
2026		(48.94)	227.13	(23.61)		154.57
2027		(59.94)	227.13	(21.52)		145.66
2028		(48.94)	227.13	(24.93)		153.25
2029		(48.94)	227.13	(25.48)		152.70
2030		(48.94)	227.13	(25.72)		152.47
2031		(48.94)	227.13	(25.95)		152.23

Year	Capital Investment	O&M Cost	Project Revenue	Tax	VAT Refund	Net Cash Flow
2032		(59.94)	227.13	(23.43)		143.75
2033		(48.94)	227.13	(26.42)		151.77
2034		(48.94)	227.13	(26.65)		151.53
2035		(48.94)	227.13	(26.88)		151.30
2036		(48.94)	227.13	(27.12)		151.07
2037		(59.94)	227.13	(24.60)		142.58
2038		(48.94)	227.13	(27.58)		150.60
2039		(48.94)	227.13	(27.76)		150.43
2040		(48.94)	227.13	(27.76)		150.43
2041		(48.94)	227.13	(27.76)		150.43
2042		(59.94)	227.13	(25.01)		142.18
2043		(48.94)	227.13	(27.76)		150.43
2044		(48.94)	227.13	(27.76)		150.43
<b>FIRR</b>						<b>4.75%</b>
<b>FNPV</b>						<b>617.16</b>

( ) = negative, O&M = operation and maintenance, FIRR = financial internal rate of return, FNPV = financial net present value, VAT = value added tax.

Source: Asian Development Bank estimates.

## F. Sensitivity Analysis

8. Sensitivity analysis was performed to test the FIRR's sensitivity to certain changes in parameters. The sensitivity analysis focused on following variables: (i) increase in O&M costs, (ii) decrease in revenue, (iii) a combination of both, and (iv) delay in the power generation with 100% capacity. The analysis shows when the O&M costs increase by 10%, the FIRR is 4.38%, and when the total revenue decrease by 10%, the FIRR is 3.47%. In the worst scenario when the O&M costs increase by 10% and revenue decrease by 10% at the same time, the FIRR of the project is 3.07%, still higher than WACC. Therefore, the project is considered financially sustainable. The sensitivity analysis is shown in Table A14.5.

**Table A14.5: Sensitivity Analysis**

Cases	FIRR	FNPV (CNY million)
<b>A. Base case</b>	4.75%	617.16
<b>B. Sensitivity cases</b>		
(i) O&M costs increase by 10%	4.38%	520.40
(ii) Benefits decrease by 10%	3.47%	278.96
(iii) O&M increase by 10% and Benefits decrease by 10%	3.07%	182.21
(iv) 100% capacity operation delayed by 2 years	4.45%	546.97

O&M = operation and maintenance, FIRR = financial internal rate of return, FNPV = financial net present value.

Source: Asian Development Bank estimates.