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PROJECT PERFORMANCE ASSESSMENT REPORT



MONGOLIA

Renewable Energy for Rural Access Project (REAP)

Report No. 127225

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MONGOLIA

**RENEWABLE ENERGY AND RURAL ELECTRICITY ACCESS PROJECT
(IDA GRANT H2630)**

(GLOBAL ENVIRONMENT FACILITY TRUST FUND GRANT TF-90858)

(THE GOVERNMENT OF NETHERLANDS GRANT TF-57330)

June 15, 2018

*Financial, Private Sector, and Sustainable Development
Independent Evaluation Group*

Currency Equivalents (annual averages)

Currency Unit = Mongolian tugrik (Tog)

2006	US\$1.00	Tog 1,179.70
2007	US\$1.00	Tog 1,170.40
2008	US\$1.00	Tog 1,165.80
2009	US\$1.00	Tog 1,437.80
2010	US\$1.00	Tog 1,357.06
2011	US\$1.00	Tog 1,265.52
2012	US\$1.00	Tog 1,357.58

Abbreviations and Acronyms

GEF	Global Environment Facility
GEO	global environment objective
IBRD	International Bank for Reconstruction and Development
ICR	Implementation Completion and Results Report
IDA	International Development Association
IEG	Independent Evaluation Group
kWh	kilowatt hour
M&E	monitoring and evaluation
MMRE	Ministry of Mineral Resources and Energy
Tog	Mongolian tugrik
NREC	National Renewable Energy Center
PAD	project appraisal document
PDOs	project development objectives
PIU	Project Implementation Unit
PPAR	Project Performance Assessment Report
PV	photovoltaic
REAP	Renewable Energy and Rural Electricity Access Project
RET	renewable energy technology
RDHT	renewable and diesel hybrid technology
SHS	solar home system
SSC	sales and service center
Wp	watt peak

All dollar amounts are U.S. dollars unless otherwise indicated.

Fiscal Year

Government: January 1–December 31

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This report was led by Ramachandra Jammi and prepared and written by Unurjargal Demberel, who assessed the project in March 2018. The report was peer reviewed by Fernando Manibog and panel reviewed by Robert Lacey. Jean-Jacques Ahouansou provided administrative support.

Principal Ratings

	ICR*	ICR Review*	PPAR
Outcome	Satisfactory	Moderately satisfactory	Moderately satisfactory
Risk to Development Outcome	Moderate	Moderate	Significant
Bank Performance	Satisfactory	Moderately satisfactory	Moderately satisfactory
Borrower Performance	Satisfactory	Moderately satisfactory	Moderately satisfactory

* The Implementation Completion and Results (ICR) report is a self-evaluation by the responsible World Bank Global Practice. The ICR Review is an intermediate Independent Evaluation Group (IEG) product that seeks to independently validate the findings of the ICR.

Key Staff Responsible

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IEG Mission: Improving World Bank Group development results through excellence in independent evaluation.

About this Report

The Independent Evaluation Group (IEG) assesses the programs and activities of the World Bank for two purposes: first, to ensure the integrity of the World Bank's self-evaluation process and to verify that the World Bank's work is producing the expected results, and second, to help develop improved directions, policies, and procedures through the dissemination of lessons drawn from experience. As part of this work, IEG annually assesses 20–25 percent of the World Bank's lending operations through field work. In selecting operations for assessment, preference is given to those that are innovative, large, or complex; those that are relevant to upcoming studies or country evaluations; those for which Executive Directors or World Bank management have requested assessments; and those that are likely to generate important lessons.

To prepare a Project Performance Assessment Report (PPAR), IEG staff examine project files and other documents, visit the borrowing country to discuss the operation with the government and other in-country stakeholders, interview World Bank staff and other donor agency staff both at headquarters and in local offices as appropriate, and apply other evaluative methods as needed.

Each PPAR is subject to technical peer review, internal IEG Panel review, and management approval. Once cleared internally, the PPAR is commented on by the responsible World Bank country management unit. The PPAR is also sent to the borrower for review. IEG incorporates both World Bank and borrower comments as appropriate, and the borrowers' comments are attached to the document that is sent to the World Bank's Board of Executive Directors. After an assessment report has been sent to the Board, it is disclosed to the public.

About the IEG Rating System for Public Sector Evaluations

IEG's use of multiple evaluation methods offers both rigor and a necessary level of flexibility to adapt to lending instrument, project design, or sectoral approach. IEG evaluators all apply the same basic method to arrive at their project ratings. Following is the definition and rating scale used for each evaluation criterion (additional information is available on the IEG website: <http://ieg.worldbankgroup.org>).

Outcome: The extent to which the operation's major relevant objectives were achieved, or are expected to be achieved, efficiently. The rating has three dimensions: relevance, efficacy, and efficiency. *Relevance* includes relevance of objectives and relevance of design. Relevance of objectives is the extent to which the project's objectives are consistent with the country's current development priorities and with current World Bank country and sectoral assistance strategies and corporate goals (expressed in Poverty Reduction Strategy Papers, Country Assistance Strategies, Sector Strategy Papers, and Operational Policies). Relevance of design is the extent to which the project's design is consistent with the stated objectives. *Efficacy* is the extent to which the project's objectives were achieved, or are expected to be achieved, taking into account their relative importance. *Efficiency* is the extent to which the project achieved, or is expected to achieve, a return higher than the opportunity cost of capital and benefits at least cost compared to alternatives. The efficiency dimension is not applied to development policy operations, which provide general budget support. *Possible ratings for outcome:* highly satisfactory, satisfactory, moderately satisfactory, moderately unsatisfactory, unsatisfactory, highly unsatisfactory.

Risk to Development Outcome: The risk, at the time of evaluation, that development outcomes (or expected outcomes) will not be maintained (or realized). *Possible ratings for risk to development outcome:* high, significant, moderate, negligible to low, not evaluable.

World Bank Performance: The extent to which services provided by the World Bank ensured quality at entry of the operation and supported effective implementation through appropriate supervision (including ensuring adequate transition arrangements for regular operation of supported activities after loan/credit closing, toward the achievement of development outcomes. The rating has two dimensions: quality at entry and quality of supervision. *Possible ratings for World Bank performance:* highly satisfactory, satisfactory, moderately satisfactory, moderately unsatisfactory, unsatisfactory, highly unsatisfactory.

Borrower Performance: The extent to which the borrower (including the government and implementing agency or agencies) ensured quality of preparation and implementation, and complied with covenants and agreements, toward the achievement of development outcomes. The rating has two dimensions: government performance and implementing agency(ies) performance. *Possible ratings for borrower performance:* highly satisfactory, satisfactory, moderately satisfactory, moderately unsatisfactory, unsatisfactory, highly unsatisfactory.

Preface

This is the Project Performance Assessment Report (PPAR) prepared by the Independent Evaluation Group (IEG) for the Renewable Energy and Rural Electricity Access Project (REAP) in Mongolia. The project's objective was to expand access to electricity and improve reliability of electricity services in selected off-grid soum centers and among the herder population, and remove barriers to the scale-up of renewable energy use.

IEG selected the project for an in-depth assessment as it offers valuable lessons for expanding rural electricity access for dispersed populations and using public-private partnerships to broaden the reach. The PPAR also aims to provide input to IEG's upcoming major evaluation on the World Bank Group's support to renewable energy.

The assessment findings are based on a review of relevant documentation, interviews with the World Bank's staff, current and former officials from the government and implementing agencies, project implementation unit staff, industry association and academia representatives and private companies engaged in renewable energy and rural electrification, and visits to herder household beneficiaries. During its field mission in March 2018, IEG also conducted phone interviews with 28 out of 50 private dealers and sales and service centers (SSC) that benefited from the project.

The cooperation and assistance of all stakeholders is gratefully acknowledged. In particular, the PPAR team expresses appreciation to the Ministry of Energy of Mongolia and the National Renewable Energy Center for their support in collecting the available data and information relevant to the project. Also, the team is grateful to the staff at the World Bank Country Office in Mongolia for support with the mission logistics (see Appendix C for a list of persons that provided inputs to this project performance assessment).

Following standard IEG procedures, the draft PPAR was shared with relevant government officials and implementing agencies for their review and no comments were received.

Summary

The purpose of this Project Performance Assessment Report (PPAR) is to evaluate the development outcomes of the Renewable Energy and Rural Electricity Access Project (REAP) in Mongolia. The project was approved on December 19, 2006, for a total cost of \$23 million. It became effective on May 4, 2007, and closed on June 30, 2012, six months after the originally planned completion date of December 31, 2011. The project was financed by an International Development Association (IDA) Grant of \$3.4 million, a Global Environment Facility (GEF) Grant of \$3 million, a Government of the Netherlands Grant of \$5.9 million, and a contribution of \$10 million from the Government of Mongolia. The project was restructured twice: first, on August 5, 2009, to allow the Government of Mongolia to finance the bulk procurement of solar home systems (SHSs) for subsequent resale to herders; and on November 4, 2011, to reallocate savings within the project to scale up the sales of SHSs to herders, and extend the closing date by six months to allow additional time for the implementation of the scale-up.

Mongolia is the least densely populated independent country in the world, with a population of just over three million residing in its vast land area of 600,000 square miles. Over two-thirds of the population live in the capital city of Ulaanbaatar and other urban centers, while close to one third is sparsely dispersed across the country's expansive rural areas, leading a traditional nomadic lifestyle or living in small rural towns. When the project was appraised in 2006, only 40 percent of Mongolia's rural households had access to electricity, compared to over 90 percent of the urban households.

The project's development objectives (PDOs) were to expand access to electricity and improve reliability of electricity services in selected off-grid soum centers¹ and among the herder population, and to remove barriers to the scale-up of renewable energy use. Given its anticipated global environment benefits from the replacement of heavy oil-based sources by the renewable energy, the project was cofinanced by the GEF and had a global environment objective (GEO) to reduce emissions of carbon dioxide by 9,000 metric tons a year.

The project's outcome was assessed as **moderately satisfactory**. The PDOs were highly relevant to Mongolia's rural development needs and priorities and to World Bank strategy.

Relevance of design was rated **substantial**. The distribution of SHSs and installation of renewable and diesel hybrid technology (RDHT) systems were intended to expand access to electricity and improve reliability of electricity services among the herder population and in selected off-grid soum centers, while support for the development of a policy and regulatory framework for renewable energy applications and the institutional capacity building were expected to remove barriers to the scale-up of renewable energy. The reliance on private dealers, however, was overestimated. The RDHT-related activities could have been better sequenced by ensuring that public utilities had the necessary institutional and operational capacity in place before investments were made.

Regarding efficacy of the first objective, the project was highly effective in expanding and improving access to electricity for the herder population through solar home systems, and

substantially so in improving reliability. Results in the soum centers were, however, modest. Much of the government-funded equipment had operational issues and major repairs and replacements had to be carried out, local public utilities were characterized by weak institutional and operational capacity, and because most soum centers became connected to the national grid, little evidence is available of increased reliability attributable to the project. Efficacy of the second objective of removing barriers to expand renewable energy use was rated **modest**. The uncertain quality of SHS products available on the market and the lack of officially regulated standards created barriers to more widespread use. After-sales service is of variable quality, and there are environmental sustainability issues owing to a lack of proper disposal and recycling of the used batteries that contain toxic materials. In soum centers, power disruptions and performance issues with RDHT systems have hurt consumer confidence. There are no data that would permit a reliable evaluation of the GEO.

Efficiency was rated **modest**. SHSs are significantly more cost effective for herders than candles and kerosene lamps. However, for soum centers, positive changes in household and community life have been undercut by power disruptions. There were also inefficiencies related to lower than anticipated delivery and operating capacity on the part of both private and public sectors.

World Bank performance was **moderately satisfactory**. Project activities were well tailored for specific beneficiary groups, risks were identified and mitigated, and substantial grant financing mobilized. However, the capacity of private sector dealers was overestimated, the accelerated speed of soum center grid connection was not foreseen, and there were weaknesses in monitoring and evaluation design, which did not adopt indicators related to reliability of service, nor those to measure the performance of the installed RDHT systems in the soum centers. Supervision was generally flexible and responsive to changing needs and priorities of the government, although greater agility might have lessened some implementation problems, for example, slow progress in the first two years and shortcomings in RDHT system installations.

Borrower performance was assessed as **moderately satisfactory**. Government commitment to addressing rural electrification needs through renewable energy solutions was strong. The government provided substantial cofinancing in the form of “smart subsidies” to the herders.² However, oversight of RDHT installations in soum centers was deficient. Major repairs and replacements had to be carried out, and these installations also provided challenges to the Project Implementation Unit (PIU), which experienced early difficulties related to procurement and monitoring and evaluation. These challenges were subsequently overcome, and the PIU was able to accelerate the project’s progress significantly.

Lessons

- **An appropriate balance between affordability and cost recovery is essential for scaling up the adoption of portable renewable energy systems by those who cannot afford the full investment costs.** “Smart subsidies” to the targeted populations help to make the acquisition of renewable energy equipment possible. Cost recovery ensures the targeted population’s ownership of the equipment so that it is used and maintained on a sustained basis. Cost recovery also allows funding to be

leveraged by redeploying the recovered costs to finance smart subsidies for additional consumers, thereby expanding the scale of technology adoption. In Mongolia, although smart subsidies allowed a 50 percent reduction in the investment costs of herders, those costs still entailed about a third or more of annual cash income for 40 percent of the herder households. Nonetheless, the herders were expected to cover the remaining 50 percent of investment costs to ensure ownership and demonstrate ability to maintain and service the equipment.

- **Proper market assessments are an essential requirement for projects that rely on the private sector for distribution of equipment, after-sales service, or the operation of local off-grid utilities.** In small dispersed markets, scale may be insufficient for profitable private sector participation. In those circumstances it is important to determine whether the private sector has the financial capacity to benefit from purchasing the equipment at wholesale prices or to take on utility operation and maintenance. In Mongolia, owing to limited financial capacity, concentration in the capital city, and logistically challenging and small-scale market of herders, sales of SHS equipment by private dealers were slow. Similarly, owing to weak institutional and operational capacity of soum center utilities, the project-installed RDHT systems were transferred to be managed by aimag utilities.³
- **To be sustainable and to realize the potential for expansion in demand, renewable energy technologies (RETs) require established and regulated equipment quality standards to guide purchases, and proper handling and disposal of used SHS batteries.** Although the equipment supplied through the project met international technical standards, the Mongolian market has an abundance of poor quality products sold by individual entrepreneurs at a low price. Experience with such products may adversely affect demand for RETs. Similarly, early attention and support is needed to build local capacity for proper battery management and recycling to avoid adverse effects on health and on the environment from improper handling and disposal of used SHS batteries that contain toxic chemicals. Although the project supported a feasibility study for a used battery recycling factory, no investment in such a facility had materialized by closure.
- **Regular dialogue and consultation at the appropriate client government level regarding government policy intentions and their consequences are critical to inform project design and implementation.** In this project, accelerated connection to the main grid affected both the demand for RET and the optimal technical solutions to be adopted. Institutional, regulatory, and managerial arrangements were modified by the decision to hand over the newly rehabilitated RET systems to the nearest centralized energy supply companies at the aimag level. In another instance, the adoption of a Renewable Energy Law in January 2007 largely eliminated the anticipated need for the project to support the development of a regulatory framework and associated legislation for grid-connected RDHT systems.

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¹ A soum is a subdivision of aimag (a province).

² Subsidies for targeted groups of beneficiaries that would not otherwise afford to purchase the goods at prevailing market prices. REAP targeted first-time purchasers of SHSs.

³ Aimag is an administrative unit equivalent to a province.

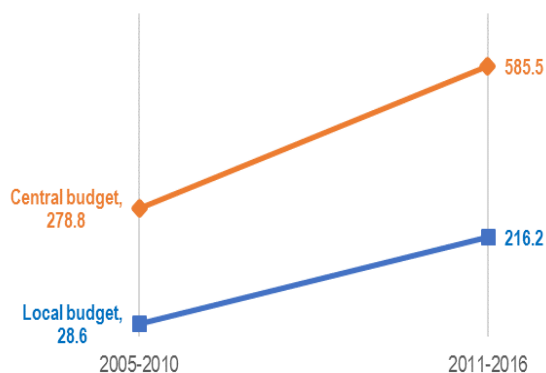
1. Background and Context

Project Context

1.1 Mongolia is one of the rapidly growing emerging economies in the world. Driven by a growth in the mining sector, Mongolia's economy expanded at an average annual growth rate of 8 percent during 2006–16, with a peak growth rate of 17 percent in 2011. After a short period of stagnation in 2015–16, the economy recovered in 2017 with a real GDP growth of 5 percent, which is expected to be maintained in 2018.¹ Currently, services account for half of the economy, and the industrial and agriculture sectors contribute 37 percent and 13 percent, respectively (World Bank 2016). With a population of just over three million residing in its vast land area of 600,000 square miles, Mongolia is also the least densely populated independent country in the world.² Over two-thirds of the population live in the capital city of Ulaanbaatar and other urban centers, while close to one third is sparsely dispersed across the country's expansive rural areas leading a traditional nomadic lifestyle or living in small rural towns.

1.2 GDP per capita increased significantly from \$1,580 in 2006 to \$4,030 currently, but disparities remain between and within the urban and rural populations. According to the World Bank (2016), 26 percent of the rural population was living below the national poverty line in 2014, as compared to 19 percent of the urban population. At 5.8 percent, the depth of poverty was more severe for the rural than for the urban population (4.9 percent). Further, the rural population's access to basic services such as drinking water, sanitation, and electricity was limited compared to that of the urban population. Responding to the development challenges faced by its people, the Mongolian government has been investing considerable sums through both central and local governments. On average, the state budget investment increased twofold from \$278.8 million a year in 2005–10 to \$585.5 million a year in 2011–16. Similarly, the local budget investment on average grew sevenfold from \$28.6 million to \$216.2 million during the same period (Figure 1).

Figure 1. Average Annual Investment by State and Local Budgets (US\$ millions)



Source: Computations by IEG using data from Ministry of Energy of Mongolia; Mongolian Statistical Information Service (www.1212.mn).

Note: Figures in Tog converted to US\$ using the annual average exchange rates.

Rural Electricity Access Issues in Mongolia

1.3 In 2006, when the Renewable Energy and Rural Electricity Access Project (REAP) was appraised, only 40 percent of Mongolia's rural households had access to electricity, compared to over 90 percent of urban households.³ Further, there were significant disparities within the rural population, 60 percent of which were nomadic herders and the remaining 40 percent residents in soum centers. Only about 25 percent of the herders had access to electricity, compared to 80 percent of people living in soum centers. All isolated soum centers were dependent on diesel generators, which were not only outdated but also expensive to operate because of high fuel and operating costs. The government had long recognized the potential of renewable energy to address these rural electrification needs and had completed various studies and pilot projects since the early 1990s with assistance from multilateral and bilateral development partners. By 2006, the government had also connected more than 100 of 331 soum centers to the national integrated power grid.

1.4 Before appraisal of the REAP, the government had adopted the National Renewable Energy Program, which set goals to increase the share of renewable energy in total energy generation to 3–5 percent by 2010 and 20–25 percent by 2020 from a low base of 1 percent in 2005.⁴ With respect to rural electrification, the program emphasized the use of renewable energy in electrification of all remote soums and settlements where connection to the integrated power grid system could not be economically justified. For the herders, the program set goals to supply all households with renewable energy by scaling up the National 100,000 solar ger⁵ program, which had, by 2005, distributed about 33,000 solar home systems (SHSs) since its initiation in 1999 but stalled owing to depletion of donor-funded grants for such projects. The REAP was designed to help the government to achieve these objectives, by scaling up the adoption of portable renewable energy systems by herders and introducing the renewable energy and diesel hybrid systems in soum centers. It was expected that the project would cover about 30 percent of the isolated soum centers dependent on diesel generation and 40 percent of the herder households with no access to electricity.

2. Objectives, Design, and their Relevance

Objectives

2.1 The project development objectives (PDOs)⁶ of REAP were “to assist the Recipient in: (i) expanding and improving access to electricity and reliability of electricity services in selected off-grid soum centers and among the herder population; and (ii) removing barriers to the scale-up of renewable energy use.”

2.2 According to the project appraisal document (PAD), the PDOs were to be achieved by: (i) assisting the development of institutions and delivery mechanisms for rural electrification that would involve public-private partnerships and community participation; (ii) facilitating herders' investments in SHSs and small wind turbine systems that would enable use of better lighting systems and information facilities; (iii) rehabilitating mini grids, improving their operations and management practices and introducing renewable or renewable and diesel hybrid technology (RDHT) systems in selected off-grid soum centers;

and (iv) strengthening the institutional and regulatory capacity at the national level to develop grid-connected and off-grid renewable energy supplies (World Bank 2006, 5).

2.3 Given its anticipated global environment benefits from replacement of heavy oil-based sources by the renewable energy, the project was cofinanced by the Global Environment Facility (GEF) and had a global environment objective (GEO) to reduce emissions of carbon dioxide by 9,000 metric tons a year through replacement of existing heavy oil-based electricity sources with renewable energy alternatives.

2.4 The project was restructured twice during implementation, but the PDOs and key associated outcome targets remained the same.

Components and Costs

2.5 **Component 1: Herders' Electricity Access** (project costs: appraisal, \$11.6 million; actual \$11.8 million). This component was intended to provide smart subsidies to herders to reduce the investment cost of at least 50,000 units of solar home or small wind turbine systems. The subsidies were designed to balance both affordability and cost recovery. At about \$400, the retail price of a good quality 50-Wp⁷ system was unaffordable for most herder households (40 percent have an annual cash income of \$450 or less, 30 percent have between \$450 and \$880, and 30% have \$880 or more). The smart subsidies would target first-time buyers and apply an \$80 subsidy for each system up to 20–49 Wp (covering 50 percent of costs), and a \$160 subsidy for each system up to 50–100 Wp (covering about 40 percent of costs). The subsidies would also provide incentives to private dealers to expand sales of certified SHSs and small wind turbine systems. Aside from the smart subsidies financed by the government and the Netherlands, this component was to support development of a rural network for sales and after-sales service, equipment quality standards and compliance, marketing and promotion of certified SHSs and small wind turbine systems.

2.6 **Component 2: Soum Center Electricity Service** (project costs: appraisal, \$10.1 million; actual \$9.3 million). This component was intended to support investments to rehabilitate mini grids in about 30 off-grid soum centers and convert the existing diesel generators to renewable or renewable and diesel hybrid systems in about 20 of these soum centers. The rehabilitation of mini grids would not only reduce distribution losses and improve reliability, but also enable more efficient electricity use through metering. The renewable energy systems introduced would replace high-cost diesel generation. In addition to the investment financing, this component was intended to support policy, regulations, capacity building of user associations and utility companies in soum centers, feasibility studies for mini grids and hybrid systems, and energy management in soum-level public institutions through technical assistance.

2.7 **Component 3: National Capacity Building** (project costs: appraisal, \$1.3 million; actual, \$1.2 million). This component was intended to strengthen the national capacity for development of a policy and regulatory framework for renewable energy applications, build the institutional capacity of the National Renewable Energy Center (NREC) and support the project's management, monitoring, and evaluation activities. Some of these activities were also directed toward removing barriers to renewable energy use.

2.8 **Cost and Financing.** The project cost at completion was \$22.2 million, close to the planned cost of \$23 million. IDA provided a grant of \$3.4 million, 98 percent of the appraisal estimate. At \$5.9 million, actual disbursement of the Netherlands grant amounted to 98 percent of the planned \$6 million. The GEF grant financed the actual cost of \$3 million, 25 percent below the appraisal estimate of \$3.5 million. The government contributed \$10 million as expected. Although it is not reflected in the total project cost, REAP also leveraged financing by herders to cover the portion of SHS acquisition cost that was not covered by subsidies.

Relevance of Objectives

2.9 The project objectives were highly relevant to Mongolia's rural development needs and priorities at the time of appraisal. The government had long recognized the potential of renewable energy to address rural electrification needs, with various studies and pilot projects completed since the 1990s with the assistance of multilateral and bilateral development partners. As already noted, the government's National Renewable Energy Program and 2015 Sector Energy Policy set ambitious goals to increase the share of renewable energy in total energy generation. The PDOs remain relevant to the government's current energy sector policy adopted in June 2015, which aims to increase renewable energy generation, reduce negative environmental effects of traditional energy generation technologies, and decrease carbon dioxide emissions.

2.10 The PDOs were highly relevant to the World Bank Group's 2005–08 Country Assistance Strategy for Mongolia, which aimed to support the government's efforts to achieve universal access to affordable energy services in rural and peri-urban areas. They remained relevant to the World Bank's subsequent 2009 Interim Strategy Note, which continued to support the expansion of access to rural services, including renewable energy. A specific milestone of the Interim Strategy Note was to increase the percentage of herders with access to energy from 55 percent in 2007 to 70 percent in 2011 through REAP. The PDOs were also consistent with the 2013–17 Country Partnership Strategy for Mongolia, particularly in the area addressing vulnerabilities through improved access to services and better service delivery.

2.11 The relevance of objectives is rated **high**.

Relevance of Design

2.12 The project's design was appropriate for achieving its development and global environment objectives. It incorporated three components, which were tailored to address the key barriers confronted by the targeted beneficiary groups in adopting and utilizing renewable energy solutions for rural electricity access and reliability. Thus, component 1 targeted the herder population, while components 2 and 3 addressed soum centers and the national frameworks, respectively. To increase effectiveness and sustainability of investment interventions for herders and soum centers, the design appropriately included specific technical assistance.

2.13 The design of the herders' access component had carefully balanced affordability and cost recovery of the portable renewable systems based on the government's prior experience. With application of "smart subsidies" covering 50 percent, the effective investment costs of herders were appropriate to ensure their ownership and demonstrate financial ability to maintain the equipment. Marketing and promotion activities were included to increase the herders' awareness and adoption of SHSs. Based on the experience of the government's national program, the project's target of 50 thousand SHSs delivered over 5 years could reasonably be expected to be achieved had the delivery approach been through the government administrative network. However, it was assumed that the private sector would be more efficient and design therefore envisaged reliance on private dealers, who proved to be less effective in distribution of SHSs in nascent markets. Nonetheless, the distribution network of sales and service centers (SSCs) was sufficient to ensure sustainability in the short to medium term.

2.14 With respect to the soum center electricity services component, it was plausible that the conversion of the existing diesel generators to RDHT systems would increase electricity availability by tapping into renewable energy sources and reducing dependence on high cost and limited diesel sources. It was appropriate to supplement these investments with capacity building of utilities and regulatory support for tariff reforms to ensure the commercial viability of RDHTs installed by the project. However, these activities could have been better sequenced by ensuring that the capacity was in place before investments were made. More attention could also have been devoted to increasing the awareness of end users in soum centers on RDHTs.

2.15 Relevance of design is rated **substantial**.

3. Implementation

3.1 Without any change to the project objective or components, the project was restructured twice: first, on August 5, 2009, to allow the government to finance the bulk procurement of solar home systems for subsequent resale to herders; and next on November 4, 2011, to reallocate savings within the project to scale up the sales of SHSs to herders and extend the closing date by six months to allow additional time to implement this scale-up.

3.2 In 2009, the government's reorganization of the energy sector affected the implementation arrangements for the project in two ways. First, the new Ministry of Mineral Resources and Energy (MMRE) replaced the former Ministry of Fuel and Energy as the main agency responsible for REAP. Second, the Energy Authority, an agency specifically established to implement energy sector policies and projects, took over NREC's responsibilities for day-to-day management of the project. While REAP's Steering Committee remained under the MMRE, the Project Implementation Unit (PIU) was relocated from NREC to the Energy Authority though staff were retained, allowing for a smooth transition. The PIU was also responsible for monitoring and reporting on the progress of implementation (see the detailed discussion on Monitoring and Evaluation design, implementation, and utilization at the end of this section).

3.3 Herders' Electricity Access: Initially, it was expected that selected private dealers would supply the certified SHSs to herders, using the project subsidy of \$160 a unit. However, the dealers had only sold about 200 SHSs by 2008, while the government procured and sold over 40,000 SHSs during the same period. The main reasons for the slow sales performance of dealers were identified by the World Bank team as follows: (i) owing to limited financial capacity, the dealers could buy SHSs only in small quantities and did not enjoy wholesale prices; (ii) the herders were widely dispersed in remote areas so that the market was small in scale; (iii) transportation and logistics costs were prohibitively high for reaching herders in these isolated and remote areas; and (iv) most dealers were concentrated in Ulaanbaatar whereas the herders were in the countryside. Given these challenges, the project was restructured in 2009 to include bulk procurement, which allowed the purchase of SHSs at wholesale prices and reduced the capital cost for herders. The SHSs procured in bulk were distributed to herders through both private dealers and the government's administrative network.

3.4 Soum Center Electricity Services: The scope of the project's planned activities in this area decreased during implementation because of the government's fast-track emphasis on grid connection. Using its own funds, the government rehabilitated 15 soum center mini grids and installed 11 RDHT systems that had been expected to be covered by the REAP. As a result, the REAP was asked to rehabilitate mini grids in the remaining 15 soum centers, but to undertake more comprehensive rehabilitation than initially planned so that no further improvements were needed in the medium term. For RDHT systems to be installed under the REAP in the remaining four soum centers the government requested the capacity to be increased from 100 kW expected at appraisal to 150–200 kW.

3.5 Safeguards compliance: At appraisal, the project was not expected to cause significant environmental impact and hence it was assigned a category C for safeguards compliance and management and no safeguards policies were triggered. Indeed, it was considered likely to have a positive effect by reducing carbon dioxide emissions from the use of heavy oil-based energy sources both in herder homes and in soum centers. Nonetheless, although the SHSs reduced carbon dioxide emissions, lack of appropriate battery management led to potential health and environmental hazards from improper handling and disposal of used SHS batteries that contain dangerous chemicals. In soum centers, owing to underperformance of most wind hybrid systems, the resulting carbon dioxide emission reductions from replacement of diesel fuel were smaller than expected. With hindsight, the project would have been more appropriately classified as B category. The World Bank team was proactive in supporting a feasibility study for a used battery recycling factory, although no investment in such a facility had materialized by closure.

3.6 Fiduciary compliance: The project's financial management system was reported as adequate, except for minor shortcomings in documentation and record keeping which were subsequently resolved during implementation. The financial statements and audit reports were prepared regularly without delays and did not raise qualified opinions. It is worth mentioning that the Project Implementation Unit leveraged the grant funds by deploying cash from SHS sales back to the project and investing them in buying more units. Regarding procurement, issues with documentation and reviews arose but were subsequently rectified. A six-month delay was experienced in the first batch of bulk purchase of SHSs caused by a

legal claim related to a contract, which was eventually dismissed by the Supreme Court. The most problematic issues were related to procurement of RDHT systems funded by the government, which were based on direct contracting. Most RDHTs acquired in this way, particularly wind-diesel hybrid systems did not perform as expected owing to breakages. The RDHTs funded by IDA, GEF, and the Netherlands were procured through international competitive bidding and had fewer operational issues.

3.7 Monitoring and Evaluation (M&E) Design: The results framework of the project was appropriate for tracking outputs and intermediary and final outcomes related to increasing access to electricity for both herders and soum center populations. The baselines were adequately defined and the set targets could reasonably be achieved within the planned period. However, the M&E framework did not adopt any indicators to measure achievement of the project's objectives to improve the reliability of electricity services. M&E design could also usefully have included indicators to measure the performance of the installed RDHT systems at soum centers (e.g., electricity produced, share of the renewable energy in energy generation, amount of displaced diesel). M&E design envisaged household surveys of herders and soum center residents to assist in the assessment of the adoption of renewable energy solutions. The Project Implementation Unit, housed in the Energy Authority, was responsible for the project's M&E implementation.

3.8 M&E Implementation: M&E implementation for the herders' access component allowed regular monitoring of the progress on the adoption of SHSs by herders. A quantitative survey of 789 herder households in 10 soums was conducted by the World Bank at completion, and subsequently supplemented by an in-depth qualitative survey of 10 herder households in two soums. However, there were shortcomings in regular tracking and reporting of some intermediate results indicators in earlier years related to the soum center component. This made it difficult to assess progress on achievement of capacity building interventions. Moreover, though most RDHT systems were already operational for a few years when the project closed, a reliable set of data was still not available to allow an assessment as to whether the RDHTs were financially viable and to determine the quantity of diesel displaced by these hybrid systems. It would also have been useful to have increased the survey coverage to soum centers with wind hybrid systems that were not performing as expected.

3.9 M&E Utilization: M&E data for the herders' access component enabled informed decision making concerning the reallocation of savings from other components to scale up SHS sales to herders and hence help the government to achieve its National 100,000 Solar Ger program targets. The PIU also hired technical consultants to examine issues with the underperforming hybrid systems, which helped them to identify and take corrective actions.

3.10 In summary, there were weaknesses in M&E design and implementation. There were no indicators related to reliability of service, nor to measuring the performance of the installed RDHT systems in the soum centers. There were also shortcomings in regular tracking and reporting of some intermediate results indicators related to the soum center component, and there were no data available at closure to determine the financial viability of the RDHTs. M&E is rated **modest**.

4. Achievement of the Objectives (Efficacy)

OBJECTIVE 1: TO EXPAND ACCESS AND IMPROVE RELIABILITY OF ELECTRICITY SERVICES IN SELECTED SOUM CENTERS AND AMONG THE HERDER POPULATION

Access and Reliability of Electricity Services Among the Herder Population

4.1 The acquisition of at least 50,000 systems by herders was to be facilitated through smart subsidies over 5 years. Added to the existing total of about 33,000 units, this was to help the Government of Mongolia get closer to achieving its National Solar Ger Program target to supply 100,000 herder households with portable renewable energy systems.⁸ Thus, REAP's planned contribution was to increase the share of herder population with reliable electricity access from 15 percent at baseline to 50 percent over 5 years.

4.2 By completion in 2012, 67,224 SHSs had been sold and distributed to the herder population throughout the country, reaching every aimag and 331 soums.⁹ The results surpassed the 50,000 units targeted at appraisal and 66,816 units anticipated at the time of project restructuring in 2011. This enabled 100,146 SHSs to be supplied in total, surpassing the National Solar Ger Program target. Thus, herder electricity coverage increased from 15 percent prior to the project to more than 60 percent at completion, also exceeding the 50 percent electrification rate target set at appraisal. Presently, 88 percent of the herder population is accessing electricity through portable renewable energy systems.

4.3 Having provided access to electricity for the first time, the project had a life-changing effect on the lives of its herder family beneficiaries. The most apparent outcomes were enhanced and more reliable lighting and dependable access to communication and information, as captured through a quantitative survey of 789 herder households conducted by the World Bank team in 2012. These outcomes were also confirmed by the subsequent qualitative survey by Cheng et al (2014) of 10 households in 2014, as well as by the PPAR mission's visit to four herder families in 2018. The World Bank's quantitative survey indicated a high degree of satisfaction (95 percent) among beneficiaries with improved electric lighting using the compact fluorescent light bulb, compared to candles or kerosene-based lighting. Reduction in the use of candles eliminated a potential fire hazard, while replacement of kerosene lamps helped reduce air pollution in herders' homes.

4.4 Electricity is available for powering a TV with a satellite dish and for charging mobile phones in herders' homes. The herders switched from radio to television as the main source of information. In the past, to gather information herders either listened to radio or had to visit a soum center or neighbors, which were often some distance away. Receiving up-to-date weather reports and alerts, as well as obtaining reliable market information on livestock (the main source of their income), are important to herders. According to the World Bank survey, more than 97 percent of herder respondents are now able to use mobile phones as their main means of communication, replacing more cumbersome and costly modes. Mobile phones enable herders to undertake most of their business dealings by phone, obtain reliable and timely market information, and stay connected socially. SHSs have also brought enhancements in herders' lifestyles, by enabling them to extend their evening activities by

one to two hours to complete the work at hand, attend to household chores, or spend more time with the family.

After-Sales Service

4.5 Good sales and service arrangements are important to ensure that herders have appropriate options available for regular maintenance of SHSs and repair of any breakages. Relevant to this are the sustainability of SSCs set up by the project, and the current functioning of the SHS market. Adequate handling and disposal of used batteries ensures that no hazardous and toxic chemicals from old batteries are released into the environment that would require discontinuing the use of SHSs prematurely. The assessment therefore examines the current practices for collection of used batteries and battery recycling.

4.6 A certified network of 50 SSCs was established under the project, with at least one in every aimag to promote SHS sales and provide after-sales services to the herder population. Ten of these SSCs were also certified to work as private dealers. With respect to battery management, REAP carried out a feasibility study for a battery recycling facility.

4.7 The SSCs provided an adequate mechanism for herders to address maintenance and repairs of any breakages, but only during the warranty period of the supplied equipment. As the market evolved, SSCs either found their own niche of clients and products or discontinued operations in this area. Of the 28 SSCs in Ulaanbaatar and 17 aimags that were contacted by the IEG mission for a phone survey, half still operate in the sector.¹⁰ Most of these were already operating in the energy sector or were trading portable renewable energy systems when they came under the project. They viewed participation in REAP as an opportunity to expand their businesses. Among the SSCs still operating, all but one continue to sell SHSs or other renewable energy products without subsidy, either directly or in partnership with leading private dealers. Customers include not only herders but also military or tourist camps.¹¹ However, the scale of sales of SHSs by SSCs was modest and ranged between four and forty systems in 2017. Some shifted the focus of their sales from SHSs to other utility appliances using renewable energy technology, such as energy efficient lighting, solar pumps, etc.

4.8 The surveys of existing SSCs revealed different approaches to after-sales service. SSCs that acted also as private SHS dealers (mostly located in Ulaanbaatar) did not carry out hands-on repairs of broken SHS devices, but were responsible for replacing the defective products within a limited warranty period.¹² For some SSCs, their after-sales services were also limited to the warranty period for the SHSs. Others preferred to replace the broken unit rather than repair, likely owing to newer-technology products that became available. In a few cases, SSCs appeared to be more involved in hands-on repair or maintenance of SHSs or electronic appliances.

4.9 Half of the SSCs surveyed reported that they had either switched to other sectors such as tourism, construction materials and retail, or discontinued their operations altogether. The frequently cited reasons were unavailability of subsidies after project closure, market saturation, direct sales of SHSs by major private dealers, or competition from cheap and low-quality products in the market. The discontinued SSCs tended to be from aimags that had

relatively well-developed transport infrastructure or that were close to neighboring countries. In contrast, most existing SSCs were either from Ulaanbaatar or more remote western aimags with relatively weak infrastructure.

4.10 The current SHS market: With commercialization of the SHS market, there is an abundance of products available in the market, but after-sales services are dependent on the quality of suppliers. According to the SSCs, the herders' needs have changed to require SHSs of much larger capacity (150 Wp or larger; sometimes even larger than 500 Wp rather than 50 Wp SHSs procured by REAP) that enable use of household appliances such as freezers, refrigerators, and washing machines. These demands are, for the most part, being met by a few large private dealers and some photovoltaic (PV) panel assembling companies that directly supply a range of renewable energy portable systems, devices, and appliances under their name brands. In addition to operating their shops in Ulaanbaatar and a few branches in selected aimags, the private dealers organize seasonal and planned sales tours to the rural areas to facilitate sales of their products to herders. The PV panel assembling company visited by the mission reported that it also organizes such tours, and works with its registered distributors in aimags to promote sales. The company is equipped to carry out repairs in its own workshop and provides warranties for all its products, including PV panels, appliances, and tools powered by renewable energy.

Battery Management

4.11 Safe disposal and handling of the used batteries is essential for sustainability and reliability of SHSs. The lead acid batteries supplied with SHSs by the project were intended to last for about 3–5 years under normal operating conditions. However, according to information gathered by the mission from stakeholders, the collection system is sporadic. SSCs revealed that they did not collect the used batteries, though many expressed concern for their inadequate disposal and handling. One SSC reported that they attempted to collect old batteries, but that the payment they had offered was not attractive to prospective sellers. Collection by secondary raw material shops in aimags was cited by many, though it was not clear what happened to the batteries afterwards. A few SSCs stated that battery recycling was not a profitable business for the private sector and that the government should intensify its efforts in this area.

4.12 Recognizing potential health and environmental hazards from improper handling and disposal of chemicals in SHS batteries, REAP supported a feasibility study for a used battery recycling factory. Although some interest from the private sector to invest in such a facility was noted by the World Bank team at closure, no investments have yet materialized. Battery technology has improved from lead acid batteries at appraisal to lithium batteries at present, but the scale associated with widespread use of batteries in various applications, including SHSs, large trucks, and electric cars, makes it urgent for Mongolia to adopt appropriate measures to ensure safe disposal and handling of used batteries. NREC informed the mission that the government was keen to build domestic capacity for battery recycling, but that financing was the major constraint.

4.13 In summary, project-funded SHS systems brought access to electricity for the first time and enabled better information and communication means for about 67 thousand herder

households, corresponding to about 40 percent of the total. The SHSs significantly increased reliability of electricity supply to herders previously reliant on traditional technologies such as candles and kerosene lamps. After-sales service, however, is of variable quality, and the collection system for used batteries is sporadic. Efficacy of results concerning herder households was **substantial**.

Access and Reliability of Electricity Services in Selected Off-Grid Soum Centers

4.14 Access for about 16,000 people living in off-grid soum centers was to be improved by converting the existing diesel generators to renewable or renewable and diesel hybrid systems in 20 of 30 soum centers where the project would rehabilitate the existing mini grids. To increase the responsiveness of public utilities in providing better electricity services, the project was to establish and strengthen consumer associations in 30 soum centers. The project's direct technical assistance support to 30 utilities was to help them improve management and operational practices, including systematic reporting of costs and revenues.

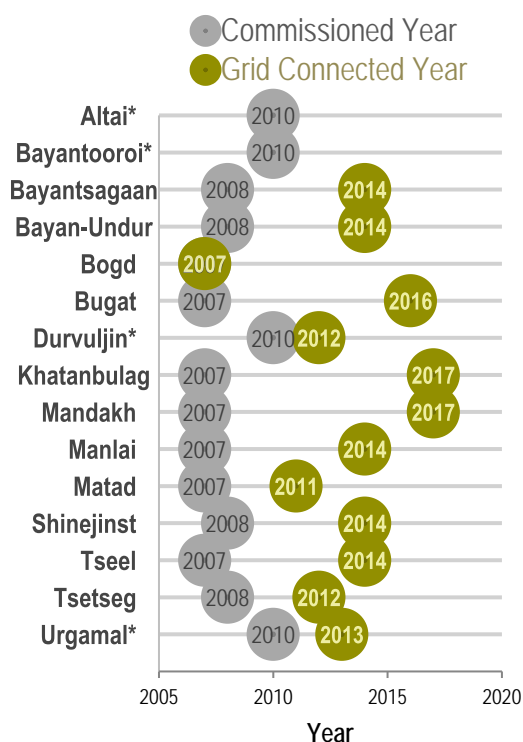
4.15 The actual scope of project activities supporting this objective was significantly smaller than planned, owing to the government's increased emphasis on grid connection during the project implementation. As a result, the project installed 15 RDHT systems of 20 planned. Of the 15 RDHTs installed, 11 were funded by the government and 4 by the World Bank. All 11 government-funded RDHTs were commissioned in 2007 and 2008, while the four donor-funded RDHTs became operational later in 2010. The project also rehabilitated mini grids in these soum centers to reduce system losses. The rehabilitation of mini grids involved more substantial work than planned and included replacement of worn-out feeder line cables, low-voltage distribution lines, and an installation of electronic meters and switch controls for all end users in these centers. Given the reduced coverage of soum centers supported, user associations had been established in only 15 of 30 centers by closure. These activities benefited about 12,000 people living in the project-supported soum centers.

4.16 However, as noted in Section 3 above, most RDHTs funded and procured by the government, particularly the wind hybrid systems, had operational issues from the outset and did not perform as expected, and major repairs and replacements had to be carried out. According to information provided to the IEG mission, the underperformance of the RDHTs was rooted in technical design shortcomings, selection of components, quality of equipment and installation work, and knowledge and training of operating staff.¹³

4.17 Nonetheless, all but 2 of the 15 RDHT project-supported soum centers were subsequently connected to the country's main grid through the government's rural electrification program (Figure 2). On average, grid connections came about 6 years after the systems were put in place, although it was estimated at appraisal that the systems would have 15 years of useful life (Figure 3). Because of performance issues, some RDHTs had already been shut down before the grid connection. In other cases, the systems were discontinued after grid connection and relocated either to increase RDHT capacity in other soum centers or for use in more remote rural areas. The two soum centers not yet connected to the grid are solar hybrids in Bayantooroi bag and Altai soum center of Gobi-Altai aimag.¹⁴ Because connection of the former is planned for the near future, Altai will remain the only off-grid soum center in Mongolia relying on renewable energy. The project-financed solar hybrid

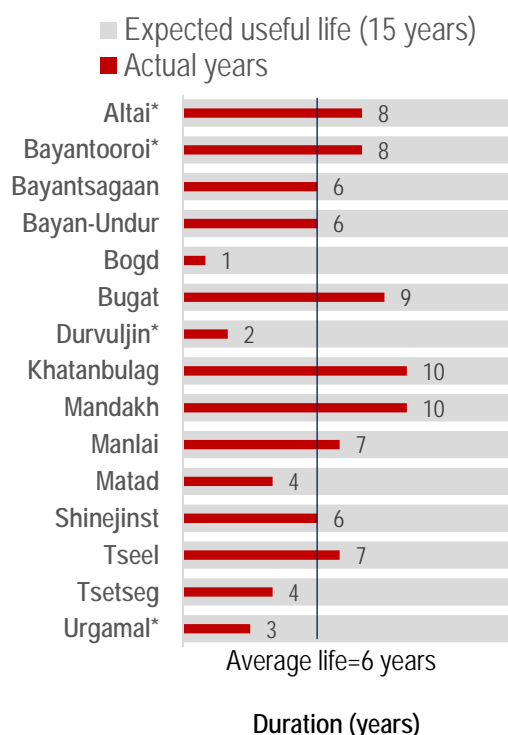
systems in these two soum centers are still operational, although the performance was reported to be deteriorating owing to worn out batteries and other broken components.

Figure 2. Soum Centers with Renewable Energy Technology and Diesel Hybrid Systems Installed by REAP



Sources: National Renewable Energy Center, Ministry of Energy of Mongolia, Independent Evaluation Group computations using grid connection year data.
 Note: REAP = the Renewable Energy and Rural Electricity Access Project. Systems in soum centers marked with an asterisk were funded by the World Bank.

Figure 3. Actual Years versus Expected Useful Life of Mini Grid RDHTs Installed by the Project



Sources: National Renewable Energy Center, Ministry of Energy of Mongolia, and Independent Evaluation Group (IEG) computations using grid connection year data.
 Note: Actual use years were estimated by IEG based on the grid connection year. Systems in soum centers marked with an asterisk were funded by the World Bank.

4.18 With respect to other expected outcomes, REAP was not successful in strengthening the responsiveness of the local utilities in soum centers.¹⁵ The 15 user associations established under the project had already become inactive by closure. Similarly, owing to weak capacity of soum center utilities, the management of the 15 RDHTs had been transferred to aimag utilities by closure. Aimag utilities were expected to track revenues and operating costs systematically so that tariffs could be set by aimag regulators that would cover operating costs. However, no information was provided to the mission on whether the utilities had in fact maintained such systematic reporting or whether the RDHTs operated on a commercial basis until the grid connection.

4.19 No concrete data are available to assess whether reliability improved as a result of the project. Owing to shortcomings in M&E design, there were no indicators to monitor progress in achieving the reliability objectives during implementation and thus no concrete evidence was available at the time of completion. The PPAR mission attempted to obtain such evidence and requested from the Ministry of Energy the data on distribution losses and outages in the relevant soum centers rehabilitated. However, no statistical information was provided.

4.20 With regard to displacement of diesel, partial data for 2017 were provided by the Ministry of Energy only for Altai and Bayantooroi solar hybrid systems that were still unconnected to the grid. In 2017, 64 percent of the total annual electricity generation in Altai soum center was from the renewable energy sources, while in Bayantooroi bag it was 33 percent. This suggests that the two RDHTs may have helped to reduce the dependence on diesel fuel, likely contributing to reduction of outages owing to unavailability of diesel. While no evidence is available for the remaining soum centers, the subsequent grid connection made the project outcomes in this area irrelevant.

4.21 In summary, the project-financed solar hybrid systems in two soum centers are still operational despite the deterioration owing to worn out parts; much of the government-funded equipment had operational issues; local utilities were characterized by weak capacity; and because most soum centers became connected to the national grid, little evidence is available of increased reliability attributable to the project. Results in soum centers were thus modest.

4.22 Overall, the project's contribution to objective 1 is rated **substantial**. The project was highly effective in expanding and improving access to electricity for the herder population through solar home systems, and substantially so in improving reliability. Results in the soum centers were, however, modest.

OBJECTIVE 2: TO REMOVE BARRIERS TO THE SCALE-UP OF RENEWABLE ENERGY USE

4.23 Objective 2 was to remove barriers to development and use of renewable energy technologies in off-grid and grid-connected systems. For herder populations in Mongolia, barriers to adoption of emissions-reducing RETs at the time were the high up-front cost of SHSs, generally low awareness of renewable technologies and their benefits, uncertainty about quality of SHS equipment, and logistical challenges because of geographic terrain. In soum centers, the barriers were similar. One further barrier for soum centers was a policy of accelerated connection to the main grid.

4.24 As already noted, the barrier of the high up-front cost of SHSs was overcome by a 50 percent smart subsidy provided to herders to effectively reduce the initial investment cost. The market has since become commercialized. Public awareness and knowledge of RETs and their benefits has increased among the herder population, aided by promotion of the certified SHS products by SSCs using the marketing materials produced under the project. The widespread adoption of SHSs was also influenced by a push from some local governments to equip all herders in their community. Such local governments actively organized community-wide orders for SHSs through SSCs. Moreover, the benefits of SHSs

were demonstrated by the early adopters of SHSs, encouraging other herders to follow. Local government administrations and SSCs also played an important role in overcoming the logistical challenges to reach herders in all 331 soums of the country.

4.25 However, there is an issue of quality of equipment that may potentially undermine demand for renewable energy systems. Findings from the surveys and the IEG mission indicate an extensive availability of cheap and low-quality products in the market, frequently imported from China and sold mostly by individuals. This makes it difficult to sell good-quality SHSs, even with the guarantees provided. In the absence of product quality standard certification, it is problematic for users to determine the quality of the products in the market. NREC informed the mission that development of PV panel quality standards was advanced, with standards already translated and circulated for commenting, after which they are scheduled to be revised and presented to Parliament for adoption in late 2018. This would empower NREC to certify PV panels, enabling herders to make more informed decisions concerning quality. Project-supplied SHSs were reportedly known for their good quality, and herders still look for “project products.” This stems from REAP’s efforts to ensure that all SHS equipment sold under the project met international technical standards, with performance inspection at the manufacturer and at the project lab.

4.26 Barriers in soum centers could not be overcome, first because of the accelerated grid connections,¹⁶ and, second, insufficient awareness and knowledge of the local population despite efforts to educate the population. Efficacy of Objective 2 is rated **modest**.

GLOBAL ENVIRONMENT OBJECTIVE

4.27 The project was cofinanced by the GEF, given its potential global environment benefits. The efficacy of the project’s GEO is unrated. No data are available for actual emissions reductions from displaced use of kerosene in herder households and diesel in soum center generators. At project closure, the World Bank team estimated the carbon dioxide emission reductions to be about 8,390 tons a year from SHSs delivered to herders and about 2,943 tons a year resulting from mini grid rehabilitation and 15 RDHTs installed in soum centers.¹⁷ However, these estimates were based on appraisal assumptions. Moreover, the less than satisfactory performance of most wind-hybrid systems installed in soum centers would mean lower than estimated reductions of carbon dioxide.

5. Efficiency

5.1 An analysis at closure showed that SHSs are significantly more cost effective for herders than candles and kerosene lamps, the traditional alternatives. Unit costs measured in terms of U.S. dollars per thousand lumen hours were reduced by a factor of 94 compared to candles and by a factor of 9 when compared to kerosene lamps. Electric light is also substantially safer, cleaner, and more reliable than that provided by the other sources.

5.2 However, in the soum centers there were a number of sources of inefficiency. The Implementation Completion and Results report (World Bank 2012, 17) cites positive changes in household and community life that have been undercut by power disruptions that have occurred at each of the four project sites surveyed. Unforeseen repairs have had to be

undertaken on many of the government-funded RDHT systems, and other issues, especially related to low staff technical capacity, persisted. Some RDHTs were shut down before grid connection. In other cases, systems were discontinued after grid connection and relocated to other, more remote sites. No information is available about their performance at these sites. In one of the two remaining off-grid solar-diesel hybrid centers, operation is undermined by worn-out batteries and broken components. Management of the local utilities was weak. There were also inefficiencies related to lower than anticipated delivery and operating capacity on the part of both private and public sectors.

5.3 Efficiency is rated **modest**.

6. Ratings

Outcome

6.1 The PDOs were highly relevant to Mongolia's rural development needs and priorities and to World Bank strategy. Relevance of design is rated **substantial** because there was a reasonably robust causal chain between planned activities and expected outcomes. Regarding efficacy of the first objective, the project was highly effective in expanding and improving access to electricity for the herder population through solar home systems, and substantially so in improving reliability. Results in the soum centers were, however, modest. Much of the government-funded equipment had operational issues; local utilities were characterized by weak capacity; and because most soum centers became connected to the national grid, little evidence is available of increased reliability attributable to the project. Efficacy of the second objective of removing barriers to expanded renewable energy use is rated **modest**. The uncertain quality of SHS products available on the market and the lack of officially regulated standards present barriers to more widespread use. After-sales services is variable. In soum centers, performance issues with RDHT systems have hurt consumer confidence. There are no data that would permit a reliable evaluation of the GEO. Efficiency is rated **modest**. Although much more cost-effective lighting was supplied to herders, there were important inefficiencies in project activities related to the soum centers. Overall, these are considered moderate shortcomings and outcome is assessed as **moderately satisfactory**.

Risk to Development Outcome

6.2 The risk to development outcomes is significant owing to environmental and technical sustainability issues. The herder population seems aware of the benefits of renewable energy, and the risk of falling demand among herders for SHSs is low. The SHS market has become commercialized with various private players. The results of some of the project's capacity building efforts look robust, for example, the NREC continues to operate on a commercial basis and has become the government's main agency for implementing RET solutions. However, as also noted in Section 4 there are environmental sustainability issues owing to a lack of proper disposal and recycling of the used batteries that contain toxic materials. Moreover, there are serious concerns with respect to the uncertain quality of much SHS equipment available in the market owing to a lack of standards certification and control,

although this could be resolved through NREC's ongoing efforts. With respect to RDHT systems installed in soum centers, all but two were subsequently connected to the main grid.

Bank Performance

6.3 **Quality at Entry:** To inform the project's design, the World Bank effectively engaged a diverse group of representatives from the government and private sector to identify the most pressing rural energy needs using a structured brainstorming approach. The exercise revealed that the electrification of rural community service institutions, herders, and soum households was of the highest priority. The effectiveness of this participatory approach in developing the project concept was noted by several stakeholders during the PPAR mission. The World Bank's preparation team tailored specific project components for herders and soum centers and proactively mobilized a substantive amount of grant financing from the GEF and the Government of the Netherlands. The lessons from the experience of the World Bank's rural electrification project in Inner Mongolia and China, as well as the government's own National 100,000 Solar Ger Program, were adequately reflected in the design of the herders' electricity access component.¹⁸

6.4 The key risks were identified and mitigated with specific technical assistance to ensure effectiveness and sustainability of interventions. However, the capacity of the private sector to carry out sales and distribution of the portable systems to dispersed herders was overestimated. Also, given a significant risk of improper handling and disposal of used SHS batteries that contain dangerous chemicals, it would have been appropriate to assign an environmental category B to the project, rather than C. The preparation team worked closely with the government to align the project with the latter's rural electrification efforts at the time and expected to cover the soum centers that could not be connected to the main grid for economic viability reasons. The pace of national grid expansion was underestimated, but that may have been difficult to predict at the time of appraisal.¹⁹ One moderate shortcoming in M&E design was the lack of indicators to track improvements in reliability of electricity services, and to monitor the performance of the RDHTs installed under the project (see discussion of M&E in Section 3).

6.5 Quality at entry is rated **moderately satisfactory**.

6.6 **Quality of Supervision:** The feedback received from the government at completion was that the World Bank generally responded to the requests of the PIU and the government adequately and in a timely manner, but that there were occasional delays in receiving the World Bank's "no objection." Those consulted by the PPAR mission did not express particular concerns arising from the working relationship with the World Bank. There were few changes in the supervision team, which helped to maintain a productive working relationship with the project's key counterparts. However, supervision could have been more proactive and agile especially during the initial implementation period when the project could not keep pace with the government's parallel efforts. Nonetheless, the early bottlenecks were resolved by restructuring and adjusting the delivery approach. The World Bank was generally flexible and responsive to the changing needs and priorities of the government, for example, project resources were redeployed to scale up SHS adoption, enabling the

government to achieve its national targets by completion. Beneficiary surveys of herders were carried out and disseminated.

6.7 More attention could have been paid to the implementation of renewable energy hybrid system installations in soum centers, particularly those that were within the project but funded by the government. Although the World Bank supported the PIU in addressing the underperforming systems, earlier interventions might have lessened the shortcomings. Similarly, the supervision team could have been more forceful on implementing capacity building activities, for example, for the battery management and commercial management of the rural utilities.

6.8 The quality of World Bank supervision and of overall World Bank performance is rated **moderately satisfactory**.

Borrower Performance

6.9 **Government Performance:** As indicated in the Relevance of Objectives section, the government was strongly committed to addressing rural electrification issues and promoting the development and use of the renewable energy solutions. The commitments that were declared in the National Renewable Energy Program in 2005 were reaffirmed with adoption of the Renewable Energy Law in 2007 and Integrated Power Grid Program in 2007 and considerable funds were allocated for implementation of rural electrification projects. An increased emphasis was put on expanding the main grid connection to off-grid soum centers, including five soum centers that were initially meant to be covered by the project. Using its own resources, the government proceeded with the mini grid rehabilitation in 15 soum centers and the installation of RDHT systems in 11 soum centers that were initially planned to be covered by the project. This necessitated some adjustments but also created a complementary momentum for the project. The government also provided considerable funding to augment the smart subsidies to the herders. One moderate shortcoming was weak oversight in implementation of RDHT installations in soum centers, several of which suffered operational problems.

6.10 Government performance is rated **moderately satisfactory**.

6.11 **Implementing Agency Performance:** The Project Implementation Unit (PIU) was initially housed in the National Renewable Energy Center, but with the government's reorganization in 2009 it was taken over by the Energy Authority. The transition was reportedly smooth, with most PIU staff retained and the project's oversight kept under the Steering Committee at the Ministry of Mineral Resources and Energy. Progress on both the herder and soum center components was slow in the early years of implementation, reflected in low disbursement of IDA and GEF grants. This was frequently owing to shortcomings in PIU performance with respect to financial management, record keeping, procurement documentation and reviews, and monitoring, but these were subsequently rectified. Once the project's delivery approach had been adjusted to include the bulk procurement and the scope of mini grid activities agreed and aligned with the government's other initiatives, the PIU was able to accelerate implementation significantly. A testimony of the PIU's sustained

capacity was dismissed by the local courts of a complaint case by one of the bidders in the first batch of the bulk procurement.

6.12 Implementing agency performance and overall borrower performance are rated **moderately satisfactory**.

7. Lessons

- **An appropriate balance between affordability and cost recovery is essential for scaling up the adoption of portable renewable energy systems by those who cannot afford the full investment costs.** “Smart subsidies” to the targeted populations help to make the acquisition of renewable energy equipment possible. Cost recovery ensures the targeted population’s ownership of the equipment so that it is used and maintained on a sustained basis. Cost recovery also allows funding to be leveraged by redeploying the recovered costs to finance smart subsidies for additional consumers, thereby expanding the scale of technology adoption. In Mongolia, although smart subsidies allowed a 50 percent reduction in the investment costs of herders, those costs still entailed about a third or more of annual cash income for 40 percent of the herder households. Nonetheless, the herders were expected to cover the remaining 50 percent of investment costs to ensure ownership and demonstrate ability to maintain and service the equipment.
- **Proper market assessments are an essential requirement for projects that rely on the private sector for distribution of equipment, after-sales service, or the operation of local off-grid utilities.** In small dispersed markets, scale may be insufficient for profitable private sector participation. In those circumstances it is important to determine whether the private sector has the financial capacity to benefit from purchasing the equipment at wholesale prices or to take on utility operation and maintenance. In Mongolia, owing to limited financial capacity, concentration in the capital city, and logistically challenging and small-scale market of herders, sales of SHS equipment by private dealers were slow. Similarly, owing to weak institutional and operational capacity of soum center utilities, the project-installed RDHT systems were transferred to be managed by aimag utilities.
- **To be sustainable and to realize the potential for expansion in demand, RETs require established and regulated equipment quality standards to guide purchases, and proper handling and disposal of used SHS batteries.** The equipment supplied through the project met international technical standards, but the Mongolian market has an abundance of poor quality products sold by individual entrepreneurs at a low price. Experience with such products may adversely affect demand for RETs. Similarly, early attention and support is needed to build local capacity for proper battery management and recycling to avoid adverse effects on health and on the environment from improper handling and disposal of used SHS batteries that contain toxic chemicals. Although the project supported a feasibility study for a used battery recycling factory, no investment in such a facility had materialized by closure.

- **Regular dialogue and consultation at the appropriate client government level regarding government policy intentions and their consequences are critical to inform project design and implementation.** In this project, accelerated connection to the main grid affected both the demand for renewable energy technology and the optimal technical solutions to be adopted. Institutional, regulatory, and managerial arrangements were modified by the decision to hand over the newly rehabilitated RET systems to the nearest centralized energy supply companies at the aimag level. In another instance, the adoption of a Renewable Energy Law in January 2007 largely eliminated the anticipated need for the project to support the development of a regulatory framework and associated legislation for grid-connected RDHT systems.

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¹ Based on IMF (2018) projected real GDP (percent change) is 5 percent.

² One person per square mile of land.

³ See the project appraisal document (PAD), Annex 16, 77.

⁴ The 2015 Sector Energy Policy stepped up this timetable to achieve 20 percent of the installed capacity in 2023 and 30 percent in 2030.

⁵ Ger is a Mongolian traditional portable dwelling used by nomads.

⁶ As stated identically in the project’s financing agreement between Mongolia and the International Development Association (IDA; Schedule 1, 5) and the GEF grant agreement between Mongolia and the International Bank for Reconstruction and Development (IBRD) acting as an implementing agency of the GEF (Schedule 1, 6).

⁷ Watt peak capacity, the maximum capacity of a module under optimal conditions.

⁸ It was expected that REAP would help the government achieve more than 80 percent of the national program’s target, and that the market would deliver the remainder.

⁹ Corresponding to about 40 percent of herder households.

¹⁰ Using a list of 50 SSCs and their contacts provided by NREC and with the support of a local consultant, IEG’s mission attempted to contact all SSCs for a phone survey. In 22 cases, SSCs could not be contacted, likely because of outdated contact information.

¹¹ The one exception shifted its focus to providing after-sales services since the leading private dealer started seasonal direct sales by itself.

¹² A limited warranty for replacement of a defective photovoltaic panel was 2-3 years, while for both battery and controller it was 1 year.

¹³ Although repairs had mostly been completed by project closure, several issues persisted, including technical capacity weaknesses of operating staff, breakdowns in wind turbine plants because of high winds, and instruction manuals untranslated into local languages.

¹⁴ Bag is the smallest administrative unit after soums.

¹⁵ Probably due to weak management capacity. According to information received during the IEG mission, many utilities were managed by the governor's administrative offices, which were frequently understaffed.

¹⁶ Grid connection is perceived by local population as superior to off-grid RETs because electricity supply by grid would be less vulnerable to interruptions caused by breakdowns in RET systems.

¹⁷ Carbon dioxide emission reductions from SHSs were based on appraisal assumptions that 48 liters of kerosene would be displaced per household each year for a lifetime of 20 years and 2.6 kilograms of carbon dioxide emissions abated per liter of kerosene.

¹⁸ The project used the technical specifications for equipment supplied under the World Bank's rural electrification project in Inner Mongolia and China. The "smart" subsidies were defined based on the government's National 100,000 Solar Ger Program experience.

¹⁹ Parliament approved a resolution to spend \$64 million for rural electrification, with secured funds in March 2007, four months after World Bank Executive Board approval and two months before effectiveness. By the time of effectiveness, the government had already reduced the number of planned off-grid soum centers from 36 to 14, with the remaining 22 to be connected to the grid. As noted earlier, this was expanded still further to cover all but two soum centers. The unexpected expansion was partly determined by the underperformance of government-funded RDHT systems.

Appendix A. Basic Data Sheet

RENEWABLE ENERGY AND RURAL ELECTRICITY ACCESS PROJECT (H2630)

Key Project Data (US\$, millions)

<i>Financing</i>	<i>Appraisal estimate</i>	<i>Actual or current estimate</i>	<i>Actual as percent of appraisal estimate</i>
Total project costs	23.00	22.23	97
IDA Grant	3.50	3.43	98
Global Environment Facility	3.50	2.96	85
Government of the Netherlands	6.00	5.85	98
Government of Mongolia	10.00	10.00	100

Cumulative Estimated and Actual Disbursements (p099321, p084766)

<i>Project Costs</i>	<i>FY07</i>	<i>FY08</i>	<i>FY09</i>	<i>FY10</i>	<i>FY11</i>	<i>FY12</i>
Appraisal estimate (US\$, millions) IDA	0.10	0.90	1.90	2.90	3.50	3.50
Appraisal estimate (US\$, millions) GEF	0	0.59	0.59	1.70	2.50	3.50
Appraisal estimate (US\$, millions) IDA+GEF	0.10	1.49	2.49	4.60	6.00	7.00
Actual (US\$, millions)	0.40	1.00	1.00	4.08	5.90	6.40
Actual as percent of appraisal	400%	67%	40%	89%	98%	91%

Date of final disbursement: April 17, 2012

Note: Including the Global Environment Facility grant.

Project Dates (p099321)

<i>Stage of Project Cycle</i>	<i>Original</i>	<i>Actual</i>
Concept review		02/16/2006
Appraisal	08/25/2006	10/02/2006
Board of Executive Directors approval	12/12/2006	12/19/2006
Effectiveness	03/31/2007	05/04/2007
Mid-term review	11/30/2008	09/21/2009
Closing date	12/31/2011	06/30/2012

Staff Time and Cost for IDA Grant (p099321) and GEF Grant (p084766)

Stage of Project Cycle	Staff Time and Cost (World Bank budget only)	
	<i>Staff Weeks (number)</i>	<i>US\$ thousands (including travel and consultant costs)</i>
Lending		
P084766	36.8	202,698
P099321	13.1	73,067
Total:	49.9	275,765
Supervision/ICR		
P084766	13.2	27,576
P099321	61.5	178,005
Total:	74.7	205,582

Other Project Data
Borrower/Executing Agency:
Follow-on Operations

<i>Operation</i>	<i>Credit no.</i>	<i>Amount (US\$ millions)</i>	<i>Board date</i>
Second Energy Sector Project	IDA 61020	42.00	June 15, 2017

Task Team Members

<i>Name</i>	<i>Title (at time of appraisal and closure, respectively)</i>	<i>Unit</i>	<i>Responsibility/Specialty</i>
Lending			
Arturo S. Rivera	Lead Energy Specialist	ECSS2	Task Team Leader
Bernard Baratz	Consultant	MNSEG	
Carla Teresa Sarmiento	Program Assistant	EASIN	
Ricardo Escudero	Consultant	LEGLA	
Charles A. Husband	Consultant	ECSS2	
David I Sr	Financial Management Specialist	EAPFM	
Xiaoping Li	Senior Procurement Specialist	AFTPC	
Ximing Peng	Senior Energy Specialist	EASCS	
Supervision/ICR			
Arturo S. Rivera	Lead Energy Specialist	ECSS2	
Chrisantha Ratnayake	Consultant	EASIS	
Cristina Hernandez	Program Assistant	EASWE	
Dhruva Sahai	Senior Financial Analyst	EASIN	
Dulguun Byambatsoo	Consultant	EACMF	
Feng Liu	Senior Energy Specialist	SEGES	
Haixia Li	Senior Financial Management Specialist	EAPFM	
James A. Reichert	Senior Infrastructure Specialist	EASCS	
Jinan Shi	Senior Procurement Specialist	EAPPR	
Joanne S. Nickerson	Operations Analyst	EASSD	
Martin M. Serrano	Senior Counsel	LEGES	
Migara Jayawardena	Senior Energy Specialist	EASCS	
Nina Masako Eejima	Senior Counsel	LEGEN	
Nomuutugs Tuvaan	Program Assistant	EASMF	
Peter Johansen	Senior Energy Specialist	EASWE	
Robert J. van der Plas	Consultant	EASCS	
Tumentsogt Tsevegmid	Senior Infrastructure Specialist	EASCS	

Appendix B. List of Persons Met

Ministry of Energy (MoE)

Bavuudorj Ovgor, Head of Renewable Energy Division, Policy Planning Department
 Bayasgalanbaatar Baasankhuu, Specialist of Renewable Energy, Policy Implementation and
 Coordination Department

National Renewable Energy Center

Tseren Tsedev, Director
 Purevsuren Dorj, General Engineer, former Director of the REAP Project Implementation Unit

Energy Regulatory Commission

Jambaa Lkhagva, Director of Energy Market Research and International Cooperation Division

National Dispatching Center

Burentogtokh Sereenendorj, Vice Director

Third parties

Enebish Namjil, former Director, National Renewable Energy Center; a shareholder of the first
 grid-connected solar independent power producer; Professor, School of Engineering and Applied
 Sciences, National University of Mongolia
 Tserenchimed Namnandorj, former Project Manager, 100,000 Solar Ger National Program
 Oyun Sanjaasuren, former Minister of Nature and Member of Parliament
 Myagmardorj Enkhmend, President, Renewable Energy Industry Association
 Bayasgalan Dugarjav, PhD, Associate Professor, School of Engineering and Applied Sciences,
 Renewable Energy, National University of Mongolia
 Garamkhand, Engineer, Sopoco LLC (the photovoltaic panel manufacturer and solar system
 installer company)

World Bank

James Anderson, World Bank Country Manager and Resident Representative
 Erdene-Ochir Badarch, Operations Officer
 Gerelgua Tserendagva, Procurement Specialist
 Peter Johansen, Senior Energy Specialist
 Roberto La Rocca, Energy Specialist
 Arturo Salvador Rivera, Lead Energy Specialist
 Migara Jayawardena, Lead Evaluation Officer, Independent Evaluation Group; formerly Task
 Team Leader of the REAP

The mission also visited and met four herder families in Erdene soum of the Central aimag. In
 addition, the mission team phone interviewed personnel at 28 sales and service centers, including
 private dealers in Ulaanbaatar and 17 aimags.

Sales and Services Centers (SSCs)

Baga Rashaant LLC, Arkhangai aimag
Murap LLC, Bayan-Ulgii aimag
Sher Orog Saaral LLC, Bayan-Ulgii aimag
Ajnai Tsegts LLC, Bulgan aimag
Darkhan Kherlen LLC, Darkhan aimag
Talai LLC, Dornod aimag
Tsatsrag Trade LLC, Dornod aimag
Mongolt LLC, Dornogobi aimag
Janst Chandmana LLC, Gobi-Altai aimag
Luckydent LLC, Gobisumber aimag
Otsol Gurvan Sansar LLC, Gobisumber aimag
Narnii Buman Gerel LLC, Khentii aimag
Altain Buyan LLC, Khovd aimag
Tungalag Ust Shurag LLC, Khovd aimag
Tusheeshut LLC, Khuvsgul aimag
Agaariin Suvag LLC, Orkhon aimag
Narnii Buman Gerel LLC, Sukhbaatar aimag
Devjikh Naran San Cooperative, Tuv aimag
Det LLC, Umnugobi aimag
Ikher Bayan Gobi LLC, Umnugobi aimag
Bor Zalaat Khairkhan LLC, Uvs aimag
Doono Oigon LLC, Zavkhan aimag
Undrakh LLC, Zavkhan aimag
Grand Power LLC, Ulaanbaatar
Irradiance LLC, Ulaanbaatar
Monmar LLC, Ulaanbaatar
New Mega Energy LLC, Ulaanbaatar
Sobbi LLC, Ulaanbaatar