ENDLINE EVALUATION REPORT
Indonesia Green Prosperity Project Community-Based Off-Grid Renewable Energy Grant Portfolio

Millennium Challenge Corporation

Sky Energy Solar Grid Systems on Karampuang Island

September 2022

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MCC INDONESIA GREEN PROSPERITY COMMUNITY-BASED OFF-GRID RENEWABLE ENERGY GRANT PORTFOLIO

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CONTENTS

TABLES & FIGURES

TABLE OF TABLES

TABLE OF FIGURES

ACRONYMS

Acronym	Definition
BUMDes/BUMK	*Badan Usaha Milik Desa/Kampung*, or Village/Kampung-owned Enterprise
CBOG (RE)	Community-Based Off-Grid (Renewable Energy)
COVID-19	Coronavirus Disease 2019
CSR	Corporate Social Responsibility
DFS	Detailed Feasibility Study
EQ	Evaluation Question
ERR	Economic Rate of Return
ESDM	*Energi Dan Sumber Daya Mineral,* Ministry of Energy and Mineral Resources
ESMAP	Energy Sector Management Assistance Program
ET	Evaluation Team
FGD	Focus Group Discussion
GHG	Greenhouse Gas
GOI	Government of Indonesia
GP	Green Prosperity
GSIP	Gender and Social Integration Plan
HH	Household
IDR	Indonesian Rupiah
IE	Impact Evaluation
IIEE	Indonesian Institute for Energy Economics
KII	Key Informant Interview
KMD	Karampuang Multi-Power
kWp	Kilowatt Peak
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation
M&E	Monitoring & Evaluation
MHP	Micro-Hydro Power Plant
NGO	Non-governmental Organization
O&M	Operations & Maintenance
PLN	Perusahaan Listrik Negara (Indonesian National Electric Utility)
SOLAR PV	Solar Photovoltaic
PT	*Perseroan Terbatas*, Indonesian version of Limited Liability Company
PV	Photovoltaic
RBF	Results-based Financing
RE	Renewable Energy
RESCO	Renewable Energy Service Company
SHS	Solar Home System
SI	Social Impact
SME	Small and Medium-Sized Enterprise
SPV	Special Purpose Vehicle
SWP	Solar Water Pump
TOC	Theory of Change

EXECUTIVE SUMMARY

Project Background

The Millennium Challenge Corporation's (MCC) $474 million Compact[1] with the Government of Indonesia (GOI), from April 2013 – March 2018, aimed to reduce poverty through low-carbon economic growth. The Compact's flagship Green Prosperity (GP) project funded a multitude of strategies to achieve this goal by meeting its stated objectives to "(1) increase productivity and reduce reliance on fossil fuels by expanding RE; and (2) increase productivity and reduce land-based greenhouse gas (GHG) emissions by improving land use practices and management of natural resources".[2] Among them, a portfolio of 24[3] community-based off-grid (CBOG) renewable energy (RE) grants aimed to support the GOI's objective of 100 percent electrification by 2020. CBOG RE grants sought to substitute RE for polluting fossil fuels in remote and rural communities, opening opportunity for social and economic improvements through access to electricity.

Across all 24 grants in the CBOG RE portfolio, the total RE disbursement was $56.4 million. Grants were funded through one of three "windows" in the GP project's Grant Facility. Window 1 (W1) grants were partnership grants with private sector operators who matched funding, one of which had a substantial off-grid RE component. Window 2 (W2) grants were focused primarily on community-based natural resource management, although 18 of these also included off-grid RE components. Finally, five Window 3A (W3A) grants were focused entirely on CBOG RE.

Evaluation Approach

At endline, the evaluation primarily employs an ex-post performance evaluation methodology, taking a portfolio-wide view to assess the status of grant-funded RE technology four years after commissioning,[4] the extent to which expected outcomes may have manifested, and prospects for long-term sustainability. To accomplish this, the evaluation team conducted a multi-stage portfolio review exercise covering all grants in the portfolio and in-depth qualitative case studies for six grants. Two of the six grants selected for case studies were included in the interim evaluation conducted in 2019 (W3A Anekatek and W3A Akuo Energy). Follow-up quantitative data collection was planned for the impact evaluation of W3A Anektek and the rigorous performance evaluation of W3A Akuo Energy but was ultimately cancelled due to information uncovered during qualitative data collection that the W3A Anekatek RE grids had not been operational since December 2020 and overall efforts to reduce in-person interactions during the COVID-19 pandemic. The remaining four case study grants were selected based on initial findings from the

[1] The total value disbursed ($474 million) was 79 percent of the value of the Compact signed ($600 million).

[2] Refer to Figure 2 in the Introduction and Overview to see the GP project's overall logic.

[3] The planned number of grants in the CBOG RE portfolio was originally 26, but the RE components of two grants were cancelled (Lombok Utara Hijau Consortium and WWF Indonesia), therefore the final number of grants actually disbursed was 24. YLBHL funded a very limited RE investment (one biogas digester). While part of the list of CBOG-RE portfolio grants, it was not included in the endline evaluation as discussed in the **Evaluation Methodology** section. Therefore, the number of grants included in this evaluation is 23.

[4] RE infrastructure handover and commissioning dates varied across the portfolio. The final CBOG RE technologies were commissioned in March 2018.

portfolio review. In selection of grants, the evaluation team aimed to capture variation in the CBOG-RE portfolio, including coverage of multiple technologies, ownership approaches and geographic settings. The portfolio review relies on data collected through document review, protocols and surveys administered with grantees, and structured follow-up interviews conducted with beneficiaries of RE technology. The endline case studies draw from primary qualitative data based on interviews conducted with key stakeholders and beneficiaries of the six sampled grants. Table 1 displays summary details about the CBOG-RE portfolio as a whole by technology, including number of grants of each type, RE technology types provided, funding windows and the range of RE disbursements.

Table 1: Summary of CBOG RE Portfolio Grants, by Technology Type

Type	Number of Grants	RE Technologies Provided	Funding Windows	RE Disbursement Range (USD)
Solar	12	Solar home systems Standalone solar PVs, Solar PV grids Solar water pumps	Window 2 Window 3A	38,264 – 9,200,000
Biomass	2	Biomass plants Biogas reactors	Window 2 Window 3A	61,314 – 10,294,814
Hydro	7	Micro-hydro pumps (new and revitalized)	Window 2	121,007 – 1,767,957
Combination	2	Multiple	Window 1 Window 3A	4,598,510 – 9,796,525

**This table excludes YLBHL which funded a limited RE investment and was not included in the endline evaluation*

The endline evaluation was developed around three sets of related evaluation questions: an original set that guided the baseline and interim, a set of questions for the case studies, and a set used for the portfolio review. The three sets of evaluation questions cover common themes and outcome areas, so to better facilitate aggregation of findings, comparison of outcomes between different grants, and extraction of portfolio-wide insights, findings are organized by thematic area rather than by evaluation question. The common themes include Theory of Change (TOC); Outcomes (RE infrastructure functionality post-compact; energy sources, access, consumption, and expenditures; energy use for productive purposes; and effects on GHG emissions) and sustainability.

Findings and Conclusions

Overall, we find suboptimal functionality of grant-funded infrastructure across the portfolio, with many technologies defunct or no longer in use. Managers of most operational technologies still face significant challenges in maintaining operations, showing that a key aspect of the GP project logic was not achieved; namely that "power plants would be handed over, operated and maintained by local entities with full community participation" contributing to "reliable community-based RE provision". In turn, this situation means that expected outcomes from RE provision have not been sustained for a large portion of intended RE users. Where assets are still functioning, infrastructure is contributing to outcomes related to domestic access and use of RE, although with relatively proscribed productive use. While sustainability prospects across grants differ, most face common challenges related to financing, maintenance and repairs, potential interaction with the national grid, and ownership which should be considered in the design of similar RE programming in the future.

RE infrastructure functionality post-Compact: While most grants achieved their intended outputs in terms of infrastructure and training provision, there were significant challenges in sustaining optimal RE functioning in the four years post-Compact. RE technology associated with 26 percent of grants (6 of 23) were completely non-operational at endline. These grants implemented a range of RE technologies including large-scale solar grids, solar home systems (SHS), biomass plants, and micro-hydro power plants (MHPs), with three grants from the W3A funding window and three from W2. ***At a cost of $28.7 million these six grants represent roughly 50 percent of the financial investment on RE being non-operational four years post-compact.*** RE technology associated with 13 grants (57 percent) were partially operational or operating sub-optimally, representing 47 percent of the portfolio's RE investment ($26.5 million). Only four grants (17 percent) were considered to be functioning optimally across their entire grantee portfolio. These four grants were relatively simpler in their scope (operated in a single location each and provided only one type of RE technology), and at $1.3 million represented approximately two percent of the portfolio's RE financial investment. ***The most common reason why technologies were non-operational was due to major repairs that had not been addressed.*** Root causes for major repairs varied across grants, including damage due to climactic events and unexpected quality issues with RE infrastructure. Lack of funding was often cited as the primary reason why repairs had not been addressed. However, other common reasons were lack of interest in utilizing RE technology and lack of clarity on infrastructure ownership. We also find that grants that have performed consistently well on RE infrastructure functionality are those that have implemented smaller-scale RE technologies, such as solar water pumps, managed by a small group of user households with well-defined economic purposes.

Outcomes from RE provision for domestic use: Realization of medium and long-term outcomes from RE provision is first contingent on functionality of RE infrastructure. Where RE infrastructure was no longer functional at endline, the grants were no longer contributing to key medium-term outcomes such as energy source switching, energy access and consumption, and GHG emissions reductions.[5] More concretely, according to the Compact's closeout Indicator Tracking Table, 9,095 RE users were added by the 15 grants which targeted provision of RE electricity for household use. ***Accounting for technologies that were no longer functional at endline and updated user numbers from functional technologies, the number of users with access to grant-funded RE electricity at endline was less than 3,000.*** Our interim evaluation found that for some grants (especially larger-scale W3A and W1 grants), outcomes related to RE provision had started to emerge including improved electricity access, increased domestic electricity use, and fuel substitution.[6] At endline we find that where RE was functional,

[5] We find that grants with functional technology at endline that provided RE to substitute non-RE sources or improve existing RE sources are most likely to be contributing to reduced GHG emissions (48 percent of the portfolio, or 11 out of 23 grants), though this could not be substantiated by the evaluation due to data constraints.
[6] A summary of findings from the interim evaluation is provided in the **Summary of Interim Evaluation Findings** Annex.

the extent to which it enhanced household energy access was largely mediated by the generation capacity of RE infrastructure and its functional status (e.g. Tier 1 access enable greater lighting consumption, Tier 2+ access enabled greater use of appliances). Further limitations to electricity access were noted at endline, related to functional status of grant technologies. 78 percent of grants with functioning technology at endline were facing challenges, with technical issues or high demand limiting electricity access for existing and new users. ***Technical issues faced by RE technology have influenced energy access by either making the technology completely non-operational, reducing the hours of operation, or reducing the number of users with access to electricity.*** These limitations highlight the precarious situation of functioning RE technologies and pose a threat to long-term sustainability.

RE for economic purposes: Where grant-funded infrastructure is functioning, it is generally in use, including use for economic activities. ***Similar to effects on energy consumption, the extent of economic activity is generally mediated by the level of access supported by the RE technology. Yet even where higher levels of electricity access are supported, we find limited growth in businesses providing higher-value goods and services.*** Across grants, economic use of RE was largely limited to stalls selling products to the local community primarily for direct consumption (e.g. snacks, chilled drinks, ice), similar to findings from the interim evaluation. In terms of grant-promoted economic use of RE through provision of production houses, equipment and training, the evaluation revealed limited evidence that these had been effective, with only 5 of 15 production houses operational and in use at endline. Overall, these findings connect with the broader literature on the modest results of RE provision on productive use outcomes, given the importance of other market-based factors such as access to inputs and capital, market linkage for product sale, and infrastructure and network connectivity more generally.

Portfolio-wide sustainability outlook: Considering the status of grants holistically, including the functional status of infrastructure, management, financing and community utilization, ***only nine percent of grants in the portfolio have a strong sustainability outlook*** (W2 IIEE, W2 LATIN). These are grants where RE management have demonstrated a strong track record of operations and have systems in place for generating sufficient funding for operations and management (O&M). Alternatively, ***48 percent of grants have a poor sustainability outlook***. The majority of these are grants where the RE infrastructure is already non-functional, while a few are grants where there are serious concerns about the operational viability of the systems (W2 IBEKA, W3A Akuo Energy). The remaining grants lie somewhere in the middle of the sustainability spectrum, though many have yet to face their first major O&M hurdle which may alter their sustainability outlook substantially.

Key factors influencing sustainability: While each grant and each location in the portfolio has faced its own set of challenges in maintaining RE operations, ***we identify four key factors that are common to most grants in the portfolio: financing for RE operations, addressing maintenance and repairs***, ***the operating environment with PLN, and challenges with ownership transfer.*** Of these, financing

The interim evaluation brief is available at: https://www.mcc.gov/resources/doc/evalbrief-072220-idn-off-grid-energy, and the full evaluation report is available on MCC's Evidence Platform at: https://mcc.icpsr.umich.edu/evaluations/index.php/catalog/1872/versions/V1

RE is a common constraint across almost all grants. RE technologies in the portfolio are largely reliant on funding from users; however, the ability to set and increase user fees is subject to user willingness and ability to pay (which can be low in these contexts) and regulatory requirements. Sufficient demand and payment compliance is also needed to ensure that revenue collected is sufficient to cover costs. Almost all managers of functional RE technology in the portfolio assert that they do not have sufficient funds to manage major repairs. While a few grants have received subsidization from village or district government, this has usually been for one-time repairs, and the process for receiving that funding is governed by its own set of rules. Therefore, when faced with a serious O&M hurdle, grant-funded technologies have often been abandoned rather than repaired. ***With respect to ownership approaches, the evaluation did not find strong evidence that specific models were more sustainable than others*** (village government, village owned enterprises (BUMDes), SPV etc.). Instead, sustainability was more likely to be influenced by how well the grant's business model anticipated and mitigated potential issues post-implementation (technology failure, demand-related challenges, PLN entry, etc.), including the provision of external technical and financial support. Regarding the SPV model employed by W3A grants, three of the five SPVs were completely non-operational at endline and the two remaining were struggling to recover costs. While difficult to compare W3A grants to others in the portfolio given their scope (W3A grants were, on average, 10 times more expensive than other grants in the portfolio), when taken as a group, their end outcomes were not significantly better than the portfolio as a whole. Endline findings related to sustainability challenges align with interim evaluation findings on the questionable financial and operational sustainability of grants due to insufficient revenues (from low tariffs and low demand) and the importance of realistic business models that account for the realities of operational context.

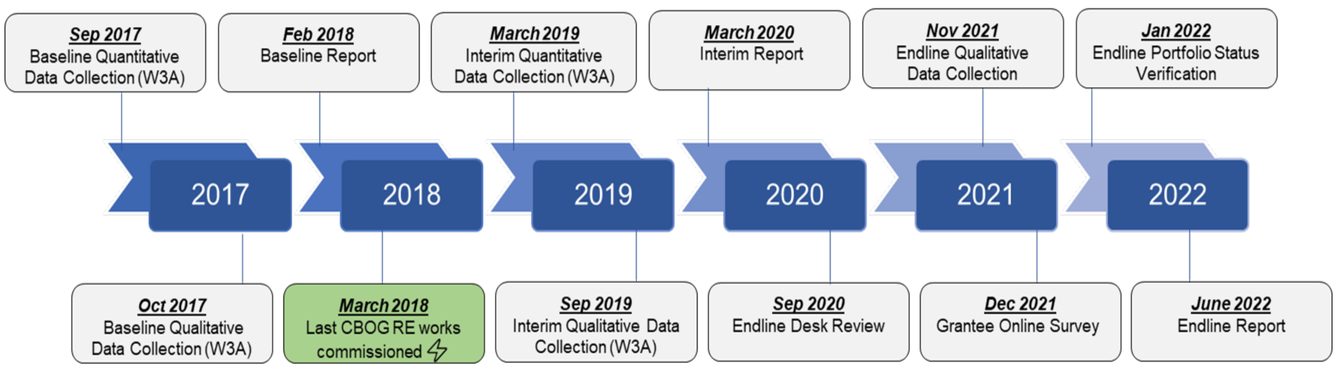
Summary implications for post-Compact ERR estimation: For all grants in the portfolio, the economic rates of return (ERRs) generally assume benefit streams lasting 20 years or more based on the intended lifespan of the funded infrastructure. It remains to be seen if these outputs will be sustained for that long. Already at endline, only four years after commissioning, RE technology associated with 26 percent of grants (6 of 23) was completely non-operational, and technologies associated with a further 57 percent of grants (13 of 23) were operating sub-optimally. ***The functional status of technologies across the portfolio at endline calls into question whether many of the grants in the portfolio would cross the ten percent threshold to justify MCC investment.***

Considerations for future RE programming: Considering the poor functional status of grant infrastructure across the portfolio and ongoing O&M challenges faced by operational technologies, ***planning for sustainable financing schemes for O&M appears to be of utmost priority*** when considering designs for future projects. Most mini-grid programs, including the CBOG-RE portfolio, have tried to promote RE use by subsidizing the upfront capital investment costs for infrastructure, with less attention given to subsidization of O&M. Sustainable subsidy schemes, for example using ***a results-based financing approach***, are an option for funding agencies to consider that provide funding for the initial investment, but also ensure the sustainable operation of mini-grids. Such sustainable financing schemes could also indirectly mitigate the other sustainability challenges noted above by incentivizing project implementers to more closely scrutinize their proposed business plans to ensure their practicality. Though MCC's 5-year investment window may make funding long-term subsidy schemes challenging, other options could be considered such as setting up an endowment or securing commitment from the in-country government partner for setting aside funds for subsidies.

Next Steps

This report will be disseminated to MCC and Indonesian stakeholders for review and comment. A finalized version of this report will be made available on MCC's Evidence Platform. In addition, a presentation of findings will be made to stakeholders in Jakarta, Indonesia, including the post-Compact monitoring and evaluation (M&E) partner, Bappenas. A presentation to MCC will follow.

Figure 1: Evaluation Timeline



1. INTRODUCTION AND OVERVIEW

1.1. Country Context and Compact Background

In governing an archipelago nation vulnerable to climate change, the Government of Indonesia (GOI) has a stated objective of continuing the steady, "pro-poor" economic growth it has maintained since the Asian financial crisis of 1997-1999 while simultaneously reducing GHG emissions to mitigate the risk posed by climate change.[7] The Millennium Challenge Corporation (MCC) funded a five-year, $474 million Compact[8] with the GOI starting in April 2013 which aimed to reduce poverty through low-carbon economic growth. The Compact's flagship Green Prosperity (GP) Project funded technical assistance and grants targeting community-based natural resource management and renewable energy (RE) for low-carbon economic growth across the Sustainable Agriculture, Peatland, Social Forestry, Women's Economic Empowerment, On-Grid RE, and Off-Grid RE sectors. The GP Project's overall program logic is depicted in Figure 2. This logic operationalizes the stated GP objectives to "(1) increase productivity and reduce reliance on fossil fuels by expanding RE; and (2) increase productivity and reduce land-based GHG emissions by improving land use practices and management of natural resources."

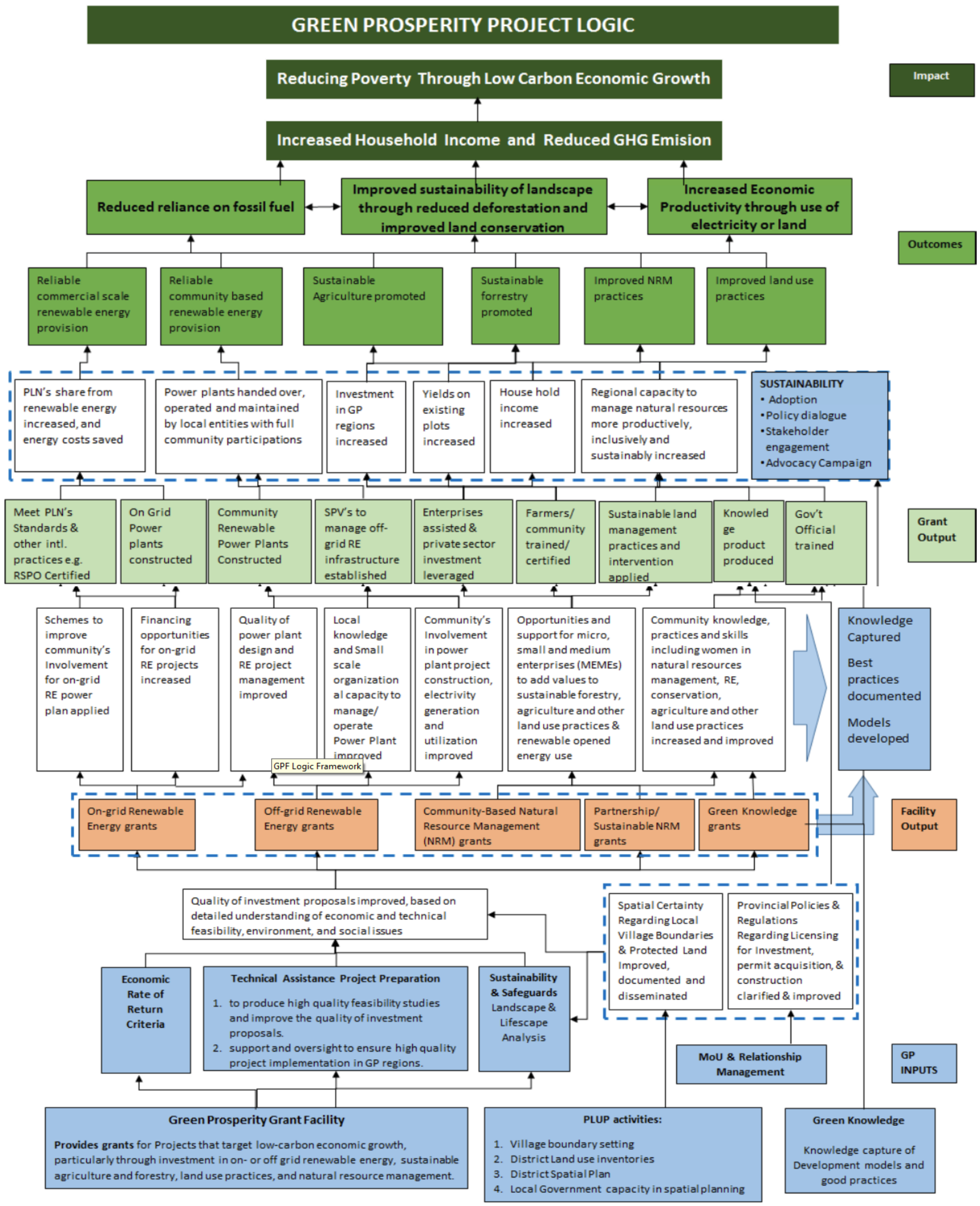
In the energy sector, the GOI's objectives were manifest in the form of paired goals to achieve a 100 percent electrification ratio by 2020 while also increasing the use of new and RE to 23 percent of all energy usage by 2025.[9] While the GOI has rapidly advanced toward its electrification goal, achieving a ratio nearing 99 percent as of 2019,[10] this national figure obscures both regional variations in electricity access and variation of the quality and capacity of electricity access. These variations are especially important in remote, rural villages where the feasibility and cost of electrification through traditional means is prohibitive.

In East Sumba, for example, the electrification ratio in 2021 was 92 percent, with only 48 percent of households in the regency connected to the Perusahaan Listrik Negara (PLN)[11] grid. Meanwhile, in neighboring Central Sumba, the electrification ratio had only reached 76 percent by 2021. For many of those unconnected to the grid, "electricity access" might mean anything ranging from "tier 1" access or a government-furnished SHS capable of charging a telephone or powering four three-watt light emitting diode (LED) bulbs for a few hours per day to "tier 3" private or village-owned diesel generators or mini-grids for powering evening lighting and/or appliances.[12] Much more rarely, "tier 4" or "5" access to high-capacity 24-hour energy sources such as solar or micro-hydro (MH) powered mini-grids are available.[13] Even in rural areas where PLN has been able to extend its grid and offer subsidized electricity, the grid

[7] Ministry of Finance, Republic of Indonesia. "Economic and Fiscal Policy Strategies for Climate Change Mitigation in Indonesia" *Https://Www.illegal-Logging.info/*, Ministry of Finance, Republic of Indonesia Australia Indonesia Partnership, 2009, http://www.illegal-logging.info/sites/files/chlogging/uploads/IndonesiasiaranpdfGreenPaperFinal.pdf. pg. 20.
[8] The total value disbursed ($474 million) was 79 percent of the value of the Compact signed ($600 million).
[9] Target for RE set by ESDM. "ESDM - Kementerian Energi Dan Sumber Daya Mineral Republik Indonesia." *ESDM*, ESDM. Target for electrification set by Government Regulation No 79 of 2014, on National Energy Policy.
[10] World Bank microdata.
[11] *Indonesian* state-owned electric utility company tasked with supplying the electricity needs of the Indonesian people.
[12] *See the World Bank Energy Sector Management Assistance Program's (ESMAP) 2015 Multi-Tier Framework for Defining Access to Energy* https://openknowledge.worldbank.org/handle/10986/24368.
[13] There is not yet a population-based survey in Indonesia which allows for differentiation of electricity access by ESMAP tier. Anecdotally, especially in rural areas of Indonesia, tier 1 to tier 3 sources are much more common than tier 4 or 5 sources.

may only operate for 12 hours per day, often at night, leaving households to forego electricity or rely on alternative sources during the daytime.

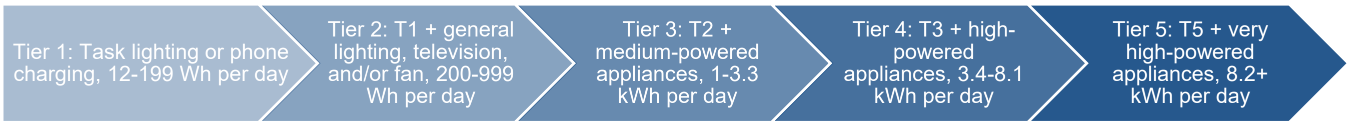
Figure 2: Green Prosperity Project Overall Logic



Source: Millennium Challenge Account Monitoring and Evaluation Plan, July 2017, Version 4

In sum, even if Indonesia succeeds in reaching 100 percent electrification in the near-term, there remains considerable low-carbon economic growth potential in graduating households and enterprises in rural Indonesia upwards along the Energy Sector Management Assistant Program (ESMAP) multi-tier electricity access framework (Figure 3), as well as in substituting renewable electricity sources in for fossil fuel-based equivalents.

Figure 3: ESMAP Multi-Tier Framework for Defining Access to Energy



Recent literature[14] shows that, in Indonesia and globally, efforts to accomplish such graduation through technology like mini-grids have struggled to achieve long-term sustainability due to regulatory challenges related to low tariffs in relation to the cost of production and low electricity demand patterns relative to initial projections (see Peters, Sievert and Toman 2019 for an overview).[15] In most cases, “institutional and political challenges impede setting electricity consumption tariffs high enough to cover operating costs, let alone capital costs so that investments into mini-grids become attractive” (Peters, Sievert and Toman 2019). This low demand does not appear to be causally related to electricity provision from a mini-grid compared to a national grid—the low electricity demand patterns after the establishment of the mini-grid have been observed even after connection to the central grid in most cases (see Blimpo and Cosgrove-Davies 2019,[16] Bos et al. 2018,[17] D’Agostino et al. 2016,[18] Lee et al. 2020,[19] Lenz et al. 2017,[20] Peters and Sievert 2015[21], Taneja 2018[22]). Altogether, in some settings where productive demand potentials and the ability to pay of households is low, mini-grid schemes might only be viable if a sustainable subsidy scheme is in place (see Urpelainen 2018).[23]

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[14] The literature cited in this paragraph is additional to that cited in our original Literature Review from the Evaluation Design Report, which is included as an Annex to this report.
[15] Peters, J., M. Sievert, and M. Toman (2019). Rural electrification through mini-grids: Challenges Ahead. Energy Policy 132 (2019) 27-31.
[16] Blimpo, M.P., Cosgrove-Davies, M., 2019. Electricity Access in Sub-saharan Africa: Uptake, Reliability, and Complementary Factors for Economic Impact. Africa Development Forum series. World Bank, Washington, DC.
[17] Bos, K., Chaplin, D., & Mamun, A. (2018). Benefits and challenges of expanding grid electricity in Africa: A review of rigorous evidence on household impacts in developing countries. Energy for Sustainable Development, 44, 64-77.
[18] D'Agostino, A. L., P. D. Lund, and J. Urpelainen (2016). The business of distributed solar power: a comparative case study of centralized charging stations and solar microgrids. Wiley Interdisciplinary Reviews: Energy and Environment, 5(6): 640-648.
[19] Lee, K., E. Miguel, and C. Wolfram (2018). Experimental evidence on the economics of rural electrification. Journal of Political Economy, forthcoming.
[20] Lenz, L., A. Munyehirwe, J. Peters and M. Sievert (2017). Does Large Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program. World Development, 89 (17): 88-110.
[21] Peters, J., & Sievert, M. (2015). The provision of electricity to rural communities through Micro-Hydro Power in rural Indonesia: Micro Hydro Power pilot programme within the national programme for community development (PNPM) supported by the Netherlands through energising development (No. 88). RWI Materialien.
[22] Taneja, J. (2018). If You Build It, Will They Consume? Key Challenges for Universal, Reliable, and Low-Cost Electricity Delivery in Kenya (No. 491).
[23] Urpelainen, J. (2018). Vouchers can create a thriving market for distributed power generation in developing countries. Energy Research & Social Science, 46: 64-67.

1.2. CBOG RE Grant Portfolio Background

The GP Project targeted this growth potential through its portfolio of community-based off-grid (CBOG) RE grants. The Compact funded 24 of these grants through the GP Grant Facility with a total RE disbursement of $56.4 million, which provided grant financing to mobilize greater private sector investment and community participation in RE and sustainable land use practices.[24] Three separate funding streams, or Windows, within the Grant Facility targeted different kinds of grants with varying levels of attention to CBOG RE. Window 1 (W1) grants were co-funded by private sector partners and generally larger in scale. Window 2 (W2) grants targeted community-based natural resource management projects, some of which included components targeted at CBOG RE. Window 3 grants targeted RE exclusively, with Window 3A (W3A) solely focused on CBOG RE grants. Another defining feature of W3A grants was the "special purpose vehicle" (SPV) approach to community ownership of the RE infrastructure. The funded grants fit into seven different "portfolios" defined by the thematic area which they covered, including Sustainable Agriculture, Peatland, Social Forestry, Women's Economic Empowerment, CBOG RE, On-Grid RE, and other Community-based Natural Resource Network grants such as ecotourism, fisheries, etc. As MCC and Millennium Challenge Account (MCA) later came to delineate GP Grant Portfolios by subject matter rather than funding window, the CBOG RE Grant Portfolio included 24 total grants, including one from Window 1, 18 from Window 2, and five from Window 3A. The scale of RE investments also varied substantially across the portfolio, ranging from a minimum RE disbursement of 38,264 U.S. Dollars (USD) for construction of a solar water pump in one village, to a maximum of USD 9,796,525 for the construction of three solar grids and one micro-hydro pump for three villages. The full list of CBOG RE grants is provided in Table 2.

Table 2: List of CBOG RE Portfolio Grants[25]

Type	Window	Grantee	Main Portfolio	RE Disbursement (USD)
Solar	3A	Puriver Consortium	Off-grid RE	7,857,419
	3A	Sky Energy Consortium	Off-grid RE	5,786,266
	3A	Anekatek	Off-grid RE	9,200,000
	2	PT Cahaya Inti Trimanunggal	Off-grid RE	1,695,632
	2	Yayasan Dian Tama	Social Forestry	661,104
	2	Javlec	Social Forestry	340,965
	2	PEKA	Off-grid RE	530,760
	2	LAKPESDAM – PBNU	Sustainable Agriculture	494,087

[24] The planned number of grants in the CBOG RE portfolio was originally 26, but the RE components of two grants were cancelled (Lombok Utara Hijau Consortium and WWF Indonesia), therefore the final number of grants actually disbursed was 24. YLBHL funded a very limited RE investment (one biogas digester). While part of the list of CBOG-RE portfolio grants, it was not included in the endline evaluation as discussed in the Evaluation Methodology section. Therefore, the number of grants included in this evaluation is 23.

[25] The Compact's closeout Indicator Tracking Table was used to identify the technology type designations for most grants, with the exception of W2 Burung. This grant was designated as biogas only in the Indicator Tracking Table; however, the biogas component was cancelled and the grant only provided solar water pumps (SWPs).

Type	Window	Grantee	Main Portfolio	RE Disbursement (USD)
	2	Kemitraan	Social Forestry	94,644
	2	Bumi Manira	Sustainable Agriculture	38,264
	2	Burung/ Konsorsium Sumba Hijau	Sustainable Agriculture	184,887
	2	YPK Donders	Sustainable Agriculture	53,216
Biomass	2	LATIN	Social Forestry	61,314
	3A	PT Charta Putra Indonesia	Off-grid RE	10,294,814
	2	YLBHL[26]	Natural Resource Management	None reported in Indicator Tracking Table
Hydro	2	LPPSLH	Sustainable Agriculture	589,911
	2	Yayasan Pena Bulu	Sustainable Agriculture	666,663
	2	IBEKA Micro-Hydro	Off-grid RE	1,767,957
	2	KKI Warsi - Jambi	Off-grid RE	485,071
	2	IIEE	Off-grid RE	808,183
	2	CU Keling Kumang	Sustainable Agriculture	312,345
	2	KKI Warsi - Sumatera Barat	Social Forestry	121,007
Combo	3A	Akuo Energy	Off-grid RE	9,796,525
	1	Hivos	Off-grid RE	4,598,510
Total value disbursed				**56,439,544**

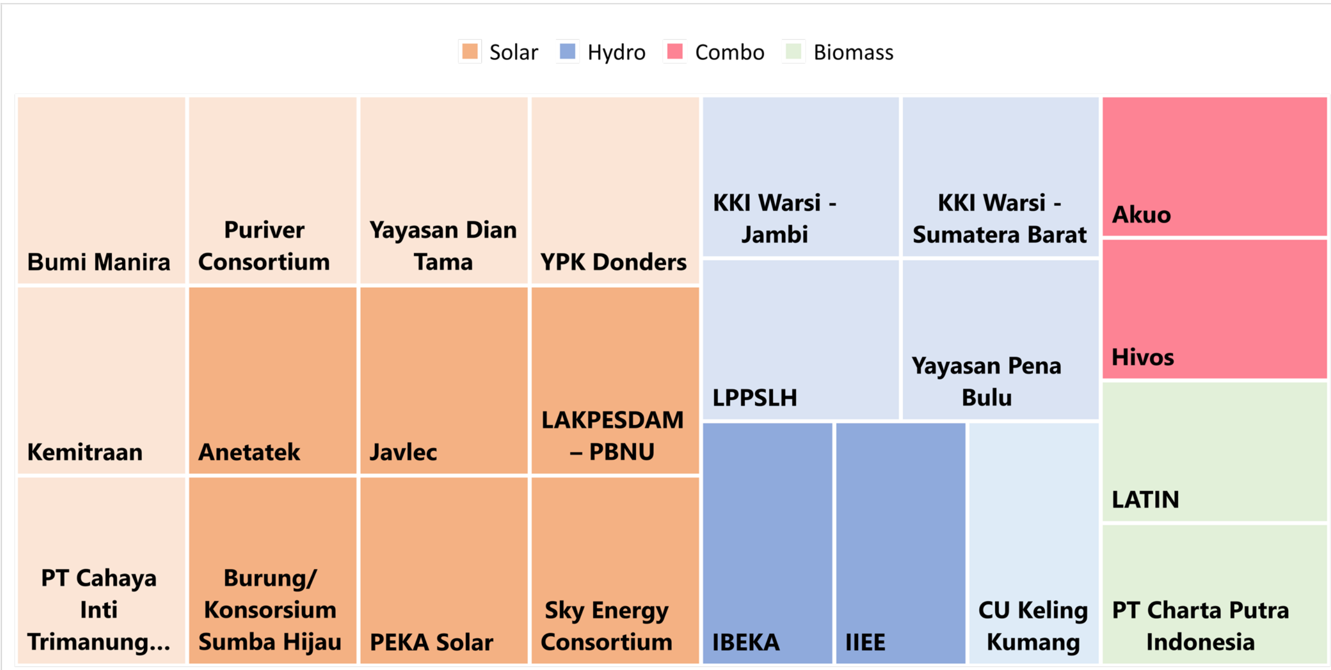
All CBOG RE grants aimed to use at least one component of their intervention to support the stated GP objectives to "(1) increase productivity and reduce reliance on fossil fuels by expanding RE; and (2) increase productivity and reduce land based GHG emissions by improving land use practices and management of natural resources," through CBOG RE schemes. However, they pursued a variety of strategies including different scopes of intervention, geographies, technologies, community ownership strategies, and approaches to ensuring the sustainability of grant assets. Each approach generated its own specific logic that serves as a connection between the outcomes of the projects within the CBOG RE grant portfolio and the intended impacts of the GP project, as depicted in Table 2 above. Some made economic use of RE technology a direct outcome of their programs, while others anticipated that it might arise naturally as a downstream impact from more proximal impacts like improved access to electricity. The variety of approaches employed by grants is further discussed in the **Theories of Change** section, and a simplified narrative of the Theory of Change for each of the six endline case study grants is available in the **Endline Case Studies** Annex at the end of this report.

Over the course of the evaluation, the evaluation team (ET) conducted in-depth data collection for ten of the 24 grants in the CBOG RE portfolio through an impact evaluation of the W3A Anekatek grant, performance evaluation of the W3A Akuo grant and qualitative case studies. In selecting grants, the ET

[26]YLBHL funded a very limited RE investment (one biogas digester). While part of the list of CBOG-RE portfolio grants, it was not included in the endline evaluation as discussed in the Evaluation Methodology section.

endeavored to ensure representation of grants across the different technology types (e.g., solar, biomass, hydro, combination) to capture the variation across the portfolio (see Figure 4). The ET also considered other criteria such as RE management approach, business model and intended use of RE. Criteria for selection of the six endline case study grants is discussed in the **Evaluation Methodology** section.

Figure 4: Distribution of RE Technology in the Evaluation Portfolio



** Darkened squares represent grants covered under interim or endline case studies*

1.3. Link to ERR and Beneficiary Analysis

No overarching cost-benefit analysis was conducted for the GP Project or the CBOG RE Grant Portfolio. Instead, individual economic rate of return (ERR) calculations were constructed for each of the grants funded. ERRs include benefit streams with details regarding causal links between short-term grant outcomes (increased access to/use of electricity) and economic growth and poverty reduction in the long-term. Summary details of ERRs and benefit streams for the six endline case study grants are included below, and the credibility of these calculations based on evaluation findings are discussed later in this report. We focus on the endline case study grants as these are the grants for which the ET has the most recent and comprehensive information needed to comment on the implications of endline findings for intended the benefit streams.

Table 3: CBOG RE Grant Ex Ante ERRs and Benefit Streams

Grant	RE Functionality at Endline[27]	ERR Main Benefit Streams	20-year ERR
W3A Anekatek	Not operational	Consumer Surplus, Electricity Access	19.45%
		Reduced Expenditure, Energy Consumption	
W3A Akuo Energy	Sub-optimal functioning	Consumer Surplus, Electricity Access	25.03%
		Reduced Expenditure, Energy Consumption	
		Increased Income/Reduced Cost, Productive Use	
W3A Sky Energy	Sub-optimal functioning	Consumer Surplus, Electricity Access	34.90%
		Reduced Expenditure, Energy Consumption	
		Increased Income/Reduced Cost, Productive Use	
W2 IIEE	Functioning optimally	Reduced Expenditure, Energy Consumption	14.20%
		Increased Income/Reduced Cost, Productive Use	
		Increased Income from Eco-tourism and MHP Workshops	
		Increased Income, Education Improvement	
W2 LAKPESDAM-PBNU	Sub-optimal functioning	Consumer Surplus, Lighting Access	19.71%
		Reduced Expenditure, Energy and Water Consumption	
		Increased Income/Reduced Cost, Productive Use	
W2 Burung	Sub-optimal functioning	Unknown (ERR not available for review)	Unknown

[27] "Not operational" indicates that none of the grant-funded RE was operational at endline. "Sub-optimal functioning" indicates that some of the grant-funded RE was not delivering anticipated benefits due to equipment or operational issues. "Functioning optimally" refers to grants where all funded RE were operating as intended. RE infrastructure functionality at endline is discussed further in the **RE Infrastructure Functionality Post-Compact** section.

2. ENDLINE EVALUATION DESIGN

2.1. Evaluation Type

This endline portfolio evaluation primarily employs an ex-post performance evaluation methodology. SI previously conducted an interim impact and performance evaluation of the CBOG RE portfolio in 2019, which is available on MCC's Evidence Platform.[28] Several changes were made to the evaluation design since the interim phase, including removal of quantitative impact and performance evaluations of the W3A Anekatek and W3A Akuo grants respectively and the addition of a portfolio-level review. The quantitative component for the W3A Akuo Energy evaluation was dropped in an effort reduce in-person interactions during the COVID-19 pandemic. The evaluation team had planned to proceed with the quantitative component for the impact evaluation of the W3A Anekatek grant, but this component was cancelled due to information that the W3A Anekatek RE grids had not been operational since December 2020 due to widespread battery failure. Revisions to the evaluation design were made in coordination with MCC to ensure that learning priorities for the endline evaluation would still be addressed. Also, based on findings from the portfolio review, four additional grants were identified for in-person case studies. Therefore, the endline phase of this evaluation draws from qualitative case studies conducted for six CBOG RE grants (including W3A Anekatek and W3A Akuo), and the portfolio-level review. More information on evaluation design changes and rationale are detailed in the **Endline Evaluation Design Changes** Annex.

[28] MCC, 2019, Indonesia - Green Prosperity: Community-based Off-grid Renewable Energy Grant Portfolio. https://mcc.icpsr.umich.edu/evaluations/index.php/catalog/1872/versions/V1

2.2. Evaluation Questions

The endline evaluation was developed around three sets of related evaluation questions: an original set that guided the baseline and interim, a set of questions for the case studies, and a set used for the portfolio review. The three sets of evaluation questions cover common themes and outcome areas, so to better facilitate aggregation of findings, comparison of outcomes between different grants, and extraction of portfolio-wide insights, findings are organized by thematic area rather than by evaluation question. Table 4 shows how evaluation questions map to six thematic areas. For brevity, this table does not contain the full text of each evaluation question, which is available in **Evaluation Questions** Annex. Based on findings from the interim evaluation, the endline evaluation placed particular focus on sustainability, following-up on O&M concerns that were present at interim, and validation of longer-term outcomes of interest, such as productive use of RE assets.

Table 4: Mapping of Evaluation Questions to Evaluation Themes[29]

Evaluation Theme	Original	Case Study	Portfolio-level Review
Theory of Change		CS1. How did each grant intend to deploy renewable energy resources in target communities? How did each intend for target communities, households, and enterprises to use the new renewable energy source(s)?	
RE Infrastructure Functionality Post - Compact			PR1. To what extent are off-grid RE assets funded within the grant portfolio functioning as intended three years following Compact closure?
Outcomes - Energy sources, access, consumption, and expenditure	OR1. How have energy consumption patterns changed among beneficiary households and businesses in response to the provision of a renewable source of electricity?	CS3. What changes do households, enterprises, and leaders in target communities perceive to be caused by grant outputs? Do these changes map onto planned outcomes for the grants? Do perceived outcomes appear to be consistent with quantitative changes observed in the Akuo and Anekatek grants? Do perceived outcomes vary across different RE technologies, different management arrangements, or different geographic settings?	
Outcomes - Energy use for economic purposes	OR2. Has the electricity provided through the RE infrastructure been used for economic purposes at the community or household level?		
Outcomes- Effects on GHG emissions	OR3. To what extent do any changes in energy consumption patterns favor reduced GHG emissions?		
Sustainability	OR4. Has the Special Purpose Vehicle been an effective intervention to improve community buy-in and sustainability of the infrastructure?	CS2. How did the grants approach achieving sustainability of the RE infrastructure in each community?	PR2. What challenges to sustainability have these assets experienced three years following Compact closure? What are the prospects for the long-term sustainability of each grant?

[29] The coding of evaluation questions in this table corresponds to coding in the **Evaluation Questions** Annex. The Case Study and Portfolio-level Review also included an evaluation question on lessons learned for future RE programming. This question is addressed in the Synthesis of Findings and Policy Implications section of the report.

2.3. Evaluation Methodology

The portfolio review relies on data collected through document review, protocols and surveys administered with grantees, and structured follow-up interviews conducted with beneficiaries of RE technology. The endline case studies draw from primary qualitative data based on interviews conducted with key stakeholders and beneficiaries of the six sampled grants. The Coronavirus Disease 2019 (COVID-19) pandemic impacted both the evaluation timeline and methodology, beyond the removal of the quantitative components of the W3A Anekatek and W3A Akuo Energy grant evaluations. The portfolio review proceeded as planned as associated data collection activities could be conducted virtually. The in-person data collection for qualitative case studies was originally planned for March 2021 but was delayed until November 2021 when conditions allowed for inter-provincial travel by evaluation team members to case study locations.

2.3.1. Portfolio Review

The portfolio review consisted of three components and was implemented as follows:

Desk Review: The Desk Review was conducted in September 2020 and centered around a “Grantee Desk Review Protocol” which was sent to the main point of contact at each Grantee organization. The protocol aimed to construct or confirm each grant’s Theory of Change, identify intended users and uses of grant-funded off-grid RE infrastructure, and understand arrangements for ownership, management, operation, and maintenance of grant-funded off-grid RE infrastructure. SI implemented an iterative process with each grantee, exchanging versions of the protocol and/or discussing the protocol over the phone until the protocol was complete.

Grantee Online Survey: The aim of the grantee survey was to inquire as to the experience of grant implementation and the perceived sustainability of grant-funded infrastructure over three years after project completion. The grantee survey was administered online via Survey Monkey in December 2021 to grantee contacts collected during the desk review and previous evaluation rounds.

Grant Beneficiary Follow-up Verification: SI conducted two rounds of telephone follow-up with operators and direct beneficiaries of the RE technology to triangulate information from the Desk Review and Grantee Online Survey. The first round of verification was conducted upon completion of the desk review in November 2020, and the second round of verification was conducted after the Grantee Online Survey in January 2022. The aim of the follow-up was to verify the current operational, financial and sustainability status of grantee infrastructure.

The Desk Review Protocol, Online Survey and Follow-up Verification protocol are available in the **Data Collection Instruments** Annex.

2.3.2. Qualitative Case Studies

The team developed semi-structured interview guides for each qualitative data collection activity, tailored based on respondent type, specifics of each grant, and engagement with grant-supported interventions (RE technology, trainings, etc.). The respondent list for interviews with Bappenas (MCC’s post-Compact

M&E partner) and PLN was developed through coordination with Bappenas. Grantee contacts were available from interim data collection and the portfolio review. The respondent lists for district Bappeda offices (Regional Development Planning Agency), village government, RE management and RE users were developed by evaluation team members upon arriving at case study locations. Sampling for government, grantee, and RE management respondents was conducted purposively based on their involvement with the project and relevance of their position. Sampling for RE users was conducted using convenience sampling, though the evaluation team implemented guidelines for respondent selection to capture a variety of experiences (outlined in the **Study Sample** section).

Interviews with Bappenas and grantees were primarily conducted remotely via Zoom. Due to remoteness of case study locations, interviews with PLN, Bappeda, village government, RE management and RE users were conducted in-person, while implementing COVID-19 risk mitigation protocols and following Government of Indonesia guidelines. Originally, focus groups discussions were planned with RE users but these were converted to key informant interviews (KIIs) to minimize group interactions. Where possible, interviews were attended by two ET members, a facilitator and a notetaker. In addition, interviews were audio recorded with respondent consent.

2.4. Study Sample

2.4.1. Portfolio Review

The portfolio review covered 23 of the 24 grants from the CBOG RE portfolio. The excluded grant funded a very limited RE investment, and the ET jointly agreed with MCC to exclude this grant from the portfolio review and overall evaluation.[30]

Desk Review: The 17 grants not included in the interim evaluation were targeted for the desk review. The evaluation team already had access to information covered in the Grantee Desk Review protocol from the interim evaluation. The list of contacts for each grantee organization was provided to the evaluation team by MCC and Bappenas.

Grantee Online Survey: The online survey was administered with all 23 grantees in the portfolio. The respondent list for disseminating the survey was obtained from the desk review for 17 grants, and from interim data collection for the balance six grants.

Grant Beneficiary Follow-up Verification: During the desk review, grantees were asked to provide community contacts including operators and/or managers of the infrastructure, as well as business groups and/or village leadership that could speak to the status of the RE infrastructure. This was the primary source of contacts for the follow-up verification exercise. In a few cases where the contact individual noted did not have the requested information, a snowball sampling approach was employed to identify a more knowledgeable respondent.

2.4.2. Qualitative Case Studies

Grant Sampling: The W3A Anekatek and W3A Akuo grants, which were evaluated at baseline and interim also, were selected as two endline case studies to enable qualitative follow-up of trends in outcomes and sustainability themes noted at interim. Review of data collected through the desk review and first round of beneficiary verification helped inform selection of four additional grants included as case studies at endline. The four additional case study grants[31] were selected collaboratively with MCC to capture variation within the CBOG RE portfolio, with a priority of covering a wide range of factors theorized to affect sustainability (see the **Endline Evaluation Design Changes** Annex for more details).

Respondent Sampling: Government, PLN, grantee and RE management KII respondents were selected purposively. Criteria used for each respondent type are outlined in the table below:

Table 5: Respondent Selection Criteria for KIIs

Respondent Type	Criteria for Selection
Bappenas	• Knowledge of the CBOG RE portfolio and grant program implementation.

[30] The RE component of the YLBHL grant only funded one biogas digester.
[31] W3A Sky Energy, W2 Burung, W2 IIEE, and W2 LAKPESDAM - PBNU

Respondent Type	Criteria for Selection
Grantee	• Knowledge of grant design, implementation, and current status
Regional PLN	• Geography and role in regional PLN office • Knowledge of regional PLN operational information and planned grid extensions
District-level Bappeda	• Geography and role in district Bappeda office • Knowledge of grant implementation and current status
Village Government	• Geography and role in village government • Knowledge about grant implementation and current status of RE infrastructure in their village
RE Management/operators	• Current or past involvement in O&M of RE infrastructure • Involvement in other related activities implemented by grants

The last category of KIIs respondents were RE users. Where relevant, RE users were further sub-divided depending on user groups targeted by each grant (e.g., households, small businesses, processing facility users). For each grant, sampling of RE users was stratified by geography, user group and gender, and convenience sampling was used for respondent selection based on individuals available in the community during the data collection period. For grants that were implemented in multiple villages or hamlets, the ET sampled village officials, RE management/operators and RE users from each location. In addition, as part of the W3A Anekatek case study, the evaluation team conducted KIIs with individuals living in comparison communities close to where the Anekatek RE grids were built. These communities were previously part of the impact evaluation of this grant that was conducted at interim. Qualitative data collection was conducted in these communities at endline to provide a reference point for understanding changes independent of MCC intervention.

In total, the ET conducted KIIs with 227 respondents across seven stakeholder groups. Refer to the **Detailed Sample Information** Annex at the end of this report for full details on sampling for each case study grant.

Table 6: Number of KII Respondents, by Respondent Type and Gender

Respondent Type	Female	Male	Total
Bappenas	0	4	4
Grantee	3	10	13
Regional PLN	0	12	12
District-level Bappeda	2	15	17

Respondent Type	Female	Male	Total
Village Government	6	18	24
RE Management/operator	6	33	39
RE User	58	48	106
Comparison Community member–*W3A Anekatek Case Study Only*	6	6	12
Overall	**81**	**146**	**227**

2.5. Evaluation Timeframe and Justification of Exposure Period

The portfolio review started in September 2020, between 2.5 and 3 years after commissioning of the mini-grids, and the endline case studies were conducted in November and December 2021, between 3.5 to 4 years after commissioning. As noted earlier, endline data collection was delayed by nine months due to the COVID-19 pandemic. The key outcomes of interest at endline, productive use and sustainability, were both longer term outcomes that benefit from an extended exposure period. Therefore, the delayed data collection was well-aligned with the objective of capturing these outcomes of interest. Additionally, official transfer of ownership of most RE assets from grantees to communities occurred in 2020. The delay in data collection allowed more time to observe communities' independent management of the infrastructure and provided a more realistic picture of the viability of the various management models.

3. FINDINGS

In this section we discuss findings organized by four main evaluation themes: Theory of Change, RE Infrastructure Functionality Post-Compact, Outcomes from RE Provision, and Sustainability. Within outcomes, we focus on three outcome areas in particular— Energy Sources, Access and Consumption, and Energy Expenditure; Use of Energy for Economic Purposes; and Effects on Greenhouse Gas Emissions. Findings are drawn primarily from the endline qualitative data collection, desk review and beneficiary verification. Where relevant, findings from the interim evaluation are referenced. While the portfolio-wide desk review and verification exercises were conducted remotely and intended to provide a high-level overview of the planned design, current status, and use of the RE technology, the in-depth qualitative data collection for the six endline case study grants allowed for more detailed exploration of the evaluation themes and perceived outcomes and for in-person verification of RE status by the evaluation team. Therefore, we generally rely on the portfolio-wide review to explain the outcomes of the CBOG-RE Grant Facility overall and leverage data from the endline case studies to illustrate key takeaways.

3.1. Theories of Change

Across the portfolio, grants employed different TOCs implying different pathways for how RE would affect community-level use (see Table 7). In general, grantees noted minimal deviation from their proposed TOC during implementation. However, the evaluation found that several underlying assumptions, including RE infrastructure functionality, management and use were challenges post-Compact. These challenges are discussed further in the **Sustainability** section.

Some grants had explicit theories of change articulated in existing documentation while others did not. For those without documented TOCs, program logics were derived by the evaluation team based on available program documentation and grantee input. At the most basic level, grants proposed that the provision of RE infrastructure (and sometimes complementary trainings on infrastructure management, agricultural techniques, or raw material processing), managed locally, would lead to increased use of renewable energy for household and/or economic purposes. Eventually, this would result in improved well-being and/or increased income generation while reducing reliance on non-renewable sources. Key assumptions to these TOCs were that the technology selected would remain functional and provide reliable RE access to communities, that management structures would be in place to ensure continuity of operations, and that there would be sufficient utilization of RE technology from target customers. Each of these three assumptions mark pivotal points in design: (1) Technology Choice, (2) Management Model, and (3) Targeted Use, and are explored further in the remainder of this section.

Table 7: Grantee Overview

Technology Choice		Management Model	Targeted Use	Grantee
Solar	Solar Power Plant (SOLAR PV) connected to a Grid	Special Purpose Vehicle (SPV)	Households (HHs) & Small Businesses	(W3A) Puriver Consortium
				(W3A) Sky Energy Consortium
				(W3A) Anekatek
		Village Government	Households & Small Businesses	(W2) PT Cahaya Inti Trimanunggal
	SOLAR PV for single entity	Cooperatives	Production Houses	(W2) Yayasan Dian Tama
		Village Owned Enterprise (BUMDes)	Production Houses	(W2) Javlec
				(W2) Peka
	SOLAR PV / SHS	Mixed Ownership (BUMDes, government., HHs)	Productions House(s) / Public Facilities & HHs	(W2) LAKPESDAM – PBNU
	SOLAR PV / Solar Lanterns	RESCO	Productions House(s) & Public Facilities / HHs	(W1) Hivos
	SHS	Public Facilities	Public Facilities	(W2) Kemitraan
	Solar Water Pumps	Village Government	Households	(W2) Bumi Manira
				(W2) Burung/ Konsorsium Sumba Hijau
	Solar & Barsha Water Pumps	Farmer's Group	Households	(W2) YPK Donders
Biomass	Biogas Digesters	Households	Households	(W2) LATIN
	Biomass Plant	Village Owned Enterprise	Households & Small Businesses	(W3A) PT Charta Putra Indonesia
Hydro	Micro Hydro Plant (MHP)	Village Government	Households & Small Businesses	(W2) LPPSLH
			HHs, Small Businesses & Production Houses	(W2) Yayasan Pena Bulu
		Cooperative	Households & Small Businesses	(W2) IBEKA
	MHP (revitalized)	Village Government	Households & Small Businesses	(W2) KKI Warsi - Jambi
		Cooperative	HHs, Small Businesses & Production Houses	(W2) IIEE
	MHP (revitalized) / Biogas Digesters	Govt. / Households	Households & Small Businesses	(W2) KKI Warsi - Sumatera Barat
Combo	MHP / SOLAR PV Grid	SPV	Households & Small Businesses	(W3A) Akuo
	MHP / Solar Home Systems	Mixed (MHP Management Team / Govt. / HHs)	Households & Small Businesses	(W2) CU Keling Kumang

**BUMDes - Village/Kampung-owned Enterprise*

3.1.1. Technology Choice

Grantees were responsible for proposing the RE technology in consideration of the local context and available resources (natural and financial). Renewable energy in solar, biomass and hydro included stand-alone systems (e.g., solar home systems, water pumps, biogas digesters) and those integrated into a localized grid (e.g., solar, micro hydro and biomass plants). 64 percent (14/22) of grantees noted they considered alternative RE technologies, primarily solar alternatives, before settling on their final design. Table 8 displays the extent to which alternatives were considered during design and which proportion of grants ultimately utilized a given technology. Most grantees (55 percent) cited the availability of the RE source as the primary design factor while 32 percent noted ease/simplicity of installation and maintenance as their top consideration. An additional 13 percent (3/22) cited other reasons including consideration of the target customer (e.g., powering a production house).

Table 8: RE Technology Considered and Utilized

Technology	Considered	Utilized[a]
SOLAR PV Grid	27%	22%
SOLAR PV	41%	22%
Solar Home System (incl lanterns)	36%	17%
Solar Water Pump	13%	13%
Micro-Hydro Plant	35%	35%
Hydro Pump (Barsha)	4%	4%
Biogas Digester	18%	9%
Biogas Plant	4%	4%

[a] *Total is greater than 100 percent as some grants implemented more than one technology*

Recommendations were vetted through a detailed feasibility study undertaken by the grantee which took into consideration topical, geological, hydrological, and structural measurements necessary to support the technology (as well as environmental, operational, and social considerations among others). The ET did not have access to full proposal documentation and final implementation designs for all grants and largely relied on grantee feedback during data collection to understand potential deviations from the original proposals.

In general, most grants proceeded with the technology selected during the design stage though the vendor and exact specifications may have changed over time. Out of 23 grants, the ET identified only four cases where the scope of implementation was altered due to considerations that arose during the feasibility study though there may be more. In two cases (W2 Bumi Manira and W2 Burung) the number of solar water pumps (SWPs) were reduced due to the accessibility of ground water and the appropriateness of the selected location (e.g., some were more appropriate for a traditional dug well).

One of these two grants (W2 Burung) also experienced the cancellation of a biogas digester component due to delays in approvals according to the grantee. A third grantee (W2 KKI Warsi - Jambi) reduced the number of planned MHPs from nine to four in compliance with local regulations and available water flows. A final grantee (W2 Kemitraan) reduced the number of SHS after realizing overlap in implementation area with another grantee. Overall, technology dependent on water resources (as opposed to solar and biomass) experienced greater challenges in initial implementation, producing lower than expected capacity at commissioning, due to flooding and/or low water levels. Technology functionality is explored further under **RE Infrastructure Functionality Post-Compact**.

3.1.2. Management Model

A key component of the GP logic model included improving local knowledge for community operation and maintenance of RE technology with the understanding that community ownership would promote sustainability. In the case of W3A grants the community ownership model, the Special Purpose Vehicle (SPV), was dictated by the terms of the agreement. For W1 and W2 the ownership model was proposed by the grantee though community consultations and included transferring ownership and management of the technology post implementation to individual households, facilities and production houses, village government, village owned enterprises (BUMDes), village cooperatives, and regional enterprises. While 90 percent of grantees in the endline survey noted the ownership model at the time of the endline evaluation was consistent with the planned approach, the desk review and beneficiary verification exercises presented a more nuanced picture with additional transfers in ownership after the Compact's close. Changes in ownership are discussed further in the **Sustainability** section but key challenges included lack of clarity around the status of assets (including handover from the grantee or Bappenas post-Compact) and inability or unwillingness of the original management structure to maintain assets. These challenges most commonly interact with village government management given the need for clear ownership of assets to invest village funds or a village government subsuming or relinquishing responsibilities to individuals or local enterprises due to capacity constraints.

3.1.3. Targeted Use

MCC projects aim to reduce poverty through economic growth primarily in the form of increased household income. While most grants in the portfolio highlighted pathways to increase income there were a few exceptions. Four grants in the portfolio did not explicitly promote any income generating activities, focusing more on provision of RE for household use and public facilities. These grants commonly had other non-RE components intended to improve economic outcomes, including trainings on agroforestry, natural resources management and sustainable agriculture.

For example, **W2 Kemitraan's** main portfolio was social forestry though it also provided RE technology to public facilities. The grantee noted during the 2020 desk review that while investments were not intended for economic improvements, they assumed there would be indirect effects through increased utilization of public facilities and expansion of services, leading to better service provision to communities.

Alternatively, six grants in the portfolio had logic models that were purely based on use of RE for income-generating purposes with no intended household use. These grants either attempted to establish new income-generating activities based on natural resource availability or local demand through the establishment of production houses or sought to increase the income-generating potential of existing activities (namely crop cultivation).

Falling into this category of grants, **W2 Yayasan Dian Tama's** (YDT) logic model assumed that providing a community with support for honey and fish production houses, along with solar systems to power them, would lead to increased economic productivity. YDT constructed five production houses, one for each beekeeper Association/Cooperative, each powered by a 10-kW solar plant and providing facilities to increase output and efficiency. These facilities included both equipment for beekeepers and honey processing as well as equipment for fish processing.

Other grants focused on provision of SWPs for irrigation and trainings on agroforestry and sustainable agriculture to farmers to improve income through increase in agricultural sales. The **W2 Burung** grant aimed to train farmers on agroforestry and sustainable agriculture, including the provision of crop irrigation and fertilizer, in order to provide communities with food security and increased income in a sustainable manner. The RE component of the grant assumed that provision of SWPs to farmers groups would provide irrigation to increase crop diversity, quantity, and thus sales.

The remaining grants (13), including all W3A grants, employed a hybrid logic model which included provision of RE for household use, ***and*** explicit interventions to encourage productive use of RE. Productive use interventions included provision of production houses and machinery for processing of agricultural products (e.g., coffee grinding and roasting machines, cocoa drying machines, durian processing equipment), training on related agricultural practices to ensure quality of processing inputs, and training on packaging and marketing of products.

An example of a hybrid approach is **W2 Indonesian Institute for Energy Economics'** (IIEE) logic model which assumed that providing a community with a new micro hydro plant (MHP), and support in the form of training on coffee cultivation and processing, photocopying, and printing equipment, and a learning center would lead to increased incomes and poverty reduction. The MHP was intended to provide electricity to households and public facilities (including the learning center), as well as to the coffee processing facility, which was set up through community consultation.

3.2. RE Infrastructure Functionality Post-Compact

Overall, most grants achieved their intended outputs in terms of infrastructure and training provision. However, once implemented, there were significant challenges in sustaining optimal RE infrastructure functioning in the four years post-Compact, from addressing major breakdowns to everyday maintenance and use. RE technology associated with 26 percent of grants (6 of 23) were completely non-operational at endline, including two grants that had been non-operational since the end of the Compact. At a cost of $28.7 million, these six grants represent roughly 50 percent of the financial investment in RE being non-operational four years post-compact. In this section, we discuss the functional status of the grant-supported RE-infrastructure and common challenges encountered across the portfolio. Challenges are expanded upon further in the **Sustainability** section.

Grants differed in terms of the number of locations they provided RE technology to. Some targeted one location and provided one type of RE technology (e.g., W2 IIEE revitalized one MHP in one hamlet), some worked in multiple locations providing one type of RE technology to each location (W3A Anekatek provided Solar PV grids to five villages), and others provided multiple types of RE technology to multiple locations (W2 LAKPESDAM-PBNU provided a combination of SHS and Solar PVs in three villages). To capture the variation in functional status of infrastructure, we look at a few different measures of functional status by grant (see Table 9).

RE technology associated with 26 percent of grants (6 of 23) were completely non-operational at endline. These grants implemented a range of RE technologies including large-scale solar grids, SHS, biomass plants, and MHPs, with three grants from the W3A funding window and three from W2. Through grantee and beneficiary reporting, the ET was able to confirm that nine grants (39 percent) were functional across the entire grantee portfolio at endline, but only four grants (17 percent) were considering to be functioning optimally in all locations. These four grants operated in a single location each, provided only one type of RE technology, and at $1.3 million represented approximately two percent of the portfolio's RE financial investment. Technology was considered as operating optimally if it was able to operate without substantial outages and was able to provide RE access to the originally intended set of beneficiaries.[32]

Table 9: RE Infrastructure Functionality at Endline

Grant Name	RE Technology	At least one type of RE infrastructure in one location functional?	All RE types in all locations functional?	All RE types in all locations functioning optimally?
W2 Javlec	Solar PV	✓	✓	✓
W2 Bumi Manira	SWP	✓	✓	✓
W2 LATIN	Biogas Digesters	✓	✓	✓
W2 IIEE	MHP	✓	✓	✓
W3A Sky Energy	Solar PV	✓	✓	⊘
W2 PT CIT	Solar PV	✓	✓	⊘

[32] The ET considered infrastructure to be functioning optimally if it was operational and delivering a basic level of service to intended customers. For grid technologies and SHS systems, this was defined as electricity being available at least 16 hours per day. For SWPs and biogas reactors, this was defined based on user reports of whether the RE infrastructure reliably produced sufficient water and biogas for user needs.

Grant Name	RE Technology	At least one type of RE infrastructure in one location functional?	All RE types in all locations functional?	All RE types in all locations functioning optimally?
W2 PEKA	Solar PV	✓	✓	⃠
W2 LAKPESDAM PBNU	SHS & Solar PV	✓	✓	⃠
W2 KKI Warsi - Jambi	MHP	✓	✓	⃠
W2 Yayasan Dian Tama	Solar PV	✓	⃠	⃠
W3A Akuo Energy	Solar PV, MHP	✓	⃠	⃠
W2 Keling Kumang	MHP & SHS	✓	⃠	⃠
W2 IBEKA	MHP	✓	⃠	⃠
W2 Burung	SWP	✓	⃠	⃠
W2 KKI Warsi - W Sumatra	MHP & Biogas reactors	✓	⃠	⃠
W2 YPK Donders*	SWP & Barsha pumps	✓	?	?
W1 Hivos*	Solar PV & Solar lamps	✓	?	?
W2 Kemitraan	SHS	⃠	⃠	⃠
W2 LPPSLH	MHP	⃠	⃠	⃠
W2 Yayasan Pena Bulu	MHP	⃠	⃠	⃠
W3A Anekatek	Solar PV	⃠	⃠	⃠
W3A Puriver	Solar PV	⃠	⃠	⃠
W3A Charta Putra	Biomass Plant	⃠	⃠	⃠

**Functional status all grant technologies in all locations could not be verified by the ET.*

Major Breakdowns. Across grants, the most common reason RE was not functional was due to major repairs that had not been addressed. In the endline grantee survey, only seven grantees (32 percent) believed communities had adequate knowledge or access to technical support to carry our major repairs[33] and only three of those (14 percent overall) believed communities also had the necessary financial resources to carry out major repairs. Therefore, any major repairs required, particularly in the early years of implementation before financial and management systems were well established, created severe threats to sustainability. While the exact cause of major equipment failure is not certain in all cases, severe weather events are common in Indonesia, and damage due to climactic factors such as lighting strikes, cyclones, and flooding was a common cause impacting technologies associated with nine grants.[34] Outside of climatic events at least four grants experienced unanticipated major quality issues with the provided equipment, particularly solar-powered batteries.[35]

[33] Major repairs were defined as an issue which has resulted in a loss of more than 10 percent of operating capacity.
[34] W2 IIEE, W2 LAKPESDAM-PBNU, W2 Bumi Manira, W2 Yayasan Dian Tama, W2 Kemitraan, W2 Yayasan Pena Bulu, W2 KKI Warsi – Jambi, W2 IBEKA, W1 HIVOS
[35] W2 PEKA, W2 Kemitraan, W3A Anekatek, W3A Puriver

As an example of unexpected quality issues, solar batteries provided for **W3A Aneketek** were anticipated to last 10 years before requiring replacement but started leaking a couple of months after commissioning with widespread failure 1.5 years after implementation. The manufacturer of the batteries was a US based company who set up an office in Indonesia at the time that the grant was implemented. During the interim study, Anekatek grantee consortium members had already noted some concern with the performance of these batteries, but the vendor had been sending technicians on site to remedy the problems. During the time the battery issues became more widespread, causing significant interruptions in electricity provision, the vendor closed their office in Indonesia. Anekatek and the SPV were hesitant to attempt to repair the batteries without the vendor's involvement, as that would void the ten-year equipment warranty. At endline, the vendor was not reachable and the director of the SPV was trying to identify funding to replace these batteries (almost 7 billion IDR, or USD 475,000).

While major breakdowns largely exceeded the ability or willingness of communities to address (see more under **Sustainability**), there are some exceptions. In 2020 a W2 Yayasan Dian Tama beneficiary noted the Solar PV system at one of their production houses failed within months of commissioning. However, with the equipment under warranty they were able to call the vendor who came out and resolved the problem. A W2 Bumi Marnira community respondent noted the SWP stopped functioning within the first year of commissioning. The village government spent six months seeking support and was finally able to secure financing from PAMSIMAS[36] to not only resolve the issue but also to expand the existing pipework. Finally, a W2 Keling Kumang beneficiary noted repairs to the turbine house and generator bearings costing close to $1,000 in the first two years post-commissioning were covered through MHP savings and community contributions. With the exception of W2 Keling Kumang and W2 IIEE, however, these instances relied on existing warranties or outside funding to cover repairs emphasizing the importance of post-implementation subsidization or support.

Community Utilization and Alternatives. Respondents generally cited lack of funding as a main reason why repairs (large and small) had not been attempted, but often other factors contributed. For seven grants, lack of interest in utilizing the RE technology due to availability of an alternative source of electricity or lack of alignment between planned productive use of the technology and market conditions are an additional reason for why some of the grant's RE technology was not repaired.[37]

The issue of lack of interest in utilizing the technology due to availability of alternative sources is most apparent for grants which provided decentralized solar systems (W2 LAKPESDAM-PBNU, W2 Kemitraan, W1 HIVOS). In some locations where decentralized solar systems were provided, an alternative source of electricity became available after the grant, either from PLN or RE provided through government support. Existence of these alternative sources reduced dependence on grant -provided RE

[36] A government program promoting sustainable drinking water known as The National Water Supply & Sanitation
[37] W1 HIVOS, W2 Kemitraan, W2 LAKPESDAM-PBNU, W2 PEKA, W2 Yayasan Dian Tama, W2 Yayasan Pena Bulu, W3A Puriver

and hence reduced the willingness to save and pay for repairs.[38] W2 LAKPESDAM-PBNU and W2 Kemitraan grants tried to encourage households and public facilities to maintain savings for repairs, but these savings mechanisms were not practiced. Therefore, when parts needed to be fixed or replaced, households and facilities did not have dedicated funds to use. In such cases, while the RE was used for an initial period for one to 1.5 years, many are now unusable due to battery or inverter damage or have reduced functionality and are used only as a backup energy source.

The W3A Puriver grant case is a more extreme example of the effect of alternatives, particularly PLN entry, on RE grid utilization. The grant constructed four solar PV grids to serve five villages. During feasibility studies, the grantee noted that PLN entry was not imminent, but by the time grid construction was completed PLN was already serving the community. The intention was to pivot by negotiating a Power Purchase Agreement with PLN, but by that time the grant period had ended, the incoming SPV management had been unable to complete the steps to finalize this agreement. As a result, the infrastructure was never utilized. See the **Sustainability** section for more on the interaction between PLN and RE grids in the portfolio.

In addition to substitution with alternative energy sources, some RE technology fell into disuse after its primary economic purpose proved unsustainable. This is particularly the situation with production houses where market factors, or failure of production equipment, stymied operations (See more under the **Outcomes - Energy Use for Economic Purposes** section).

The example of the **W2 Yayasan Pena Belu** grant is useful for demonstrating how major repairs due to climactic factors, and lack of alignment with intended productive use and market conditions are tied to sustainability of RE technology. The two MHPs constructed under this grant encountered challenges from the outset with neither MHP's output capacity achieving the intended target. The grantee noted that the primary reason for this was timeline delays in approval and payments from MCA-I. Shortly after commissioning, both MHPs faced major technical issues, one due to flooding and the other due to a landslide. By that point, ownership of the infrastructure had transferred to the village government, but the extent of the repairs was outside the village and community's willingness to pay. In addition to providing MHPs, the grant had also provided mini-factories for cocoa drying. Although cocoa farming was endemic to the community, the grantee noted that villagers were more interested in mining rather than cocoa farming, undermining the urgency for repairs. Technology associated with the grant has been non-operational since the close of the Compact, and respondents were not aware of any plans to repair the technology for use.

[38] In W2 LAKPESDAM-PBNU communities, households which received grant-funded SHS and later became connected to other higher-powered sources of electricity (e.g. PLN) noted welfare gains from connection to the alternative electricity source, most notably from being able to charge cellphones and power appliances for domestic use.

In one instance, high demand, rather than low utilization, has also threatened optimal functioning. Under W3A Sky Energy, a combination of higher-than-expected electricity demand and lack of sufficient generation in the rainy season was leading to regular outages at the time of endline data collection.

Ownership. In addition to low utilization, key community level stakeholders from six grants reported lack of clarity on RE infrastructure ownership, these stakeholders included the intended owners (village officials, BUMDes representatives, SPV members etc.).[39] Village officials in particular noted that this lack of clarity was a barrier to funding repairs of RE. Respondents noted that government funding could only be provided to assets that are officially owned by the government and that they had yet to receive any formal handover documentation.

Looking across the portfolio, grants that have performed consistently well on RE Infrastructure Functionality are those that have implemented smaller-scale RE technologies managed by a small group of user households with well-defined economic purposes. These are mostly the grants that implemented SWPs (W2 Burung, W2 Bumi Manira, W2 YPK Donders) and the W2 LATIN grant which provided biogas digesters to a cattle farming group. For SWPs, of the six SWPs functioning across these three grants, all six were reportedly functioning well without notable problems. The W2 LATIN biodigesters are reportedly working as well as they did at commissioning, providing biogas for household use and bioslurry for sale to local farmers. These technologies are relatively less complex than solar grids, biomass plants and MHPs, requiring less intensive O&M to maintain operations and few reported dealing with major repairs to date.

3.3. Outcomes - Energy Sources, Access, Consumption, and Expenditure

In this section we review the principle intermediate outcomes under the portfolio including source substitution, access, consumption, and expenditure.

Effects on Energy Sources

The GP Project Logic assumed that the RE portfolio would reduce dependence on fossil fuels through the provision of renewable energy. Across the portfolio, RE use included the substitution of non-renewable energy sources (48 percent of the portfolio), the improvement and expansion upon existing RE sources in the revitalization of MHPs (9 percent), and generating demand for energy, particularly RE, where none had existed previously in the form of production houses and solar water pumps (26 percent).[40] Four grants (17 percent) deployed multiple approaches, for example, through provision of RE to households (substitution) and construction of production households (generating demand). While examples of source substitution are outlined here as well as in the findings section on the

[39] W2 Burung, W2 IBEKA, W2 LPPSLH, W2 PEKA, W2 Yayasan Pena Bulu, W3A Puriver

[40] Both production houses and SWPs may also substitute for non-RE. Production houses introduced sustainable economic ventures utilizing RE which had the potential to replace economic activities requiring non-RE sources. Without SWPs some beneficiaries noted traveling great distances (using petrol for motorbikes/etc) to access water. However, since these substitutions are not directly transparent we classify these ventures under a third category of increasing demand.

Outcomes - Effects on Greenhouse Gas Emissions, the evaluation found that long-term substitution was limited due to the decreased functionality of most assets at endline.

Substitution of non-RE. In most cases, the RE technology provided by grants was intended to replace existing non-RE sources in lighting, cooking, and small appliance use. Before provision of RE, the main source of lighting in most areas was kerosene lamps or small solar lamps. For cooking, either firewood or Liquefied Petroleum Gas (LPG) gas were primary sources. In some areas, personal or communal diesel generators were also used for a couple hours per day as a source of electricity to power appliances such as televisions or refrigerators. The interim evaluation found a nearly 80 percent reduction in the use of non-RE sources of electricity under the W3A Anekatek grant in East Sumba (prior to the RE technology becoming inoperable). Case study interviews from endline continue to support the idea of substitution in locations where RE technology continues to operate.

A respondent from **W3A Sky Energy** noted *"Before there was SOLAR PV, we used kerosene lamps for lighting at home. If it is difficult to get kerosene, we use diesel fuel. There was generator lighting from the village which is managed by the hamlet head with a fee of IDR 50,000/month. The electricity from the generator was used for lighting with 3 light bulbs and a TV and only ran from 6 PM to 10 PM. After the presence of SOLAR PV, the generator is no longer used."* Similar substitution was seen under the W2 IIEE grant with customers newly connected to the grid switch from kerosene lamps and diesel generators to using RE. Likewise, in areas covered by W2 LAKPESDAM-PBNU, many households continue to utilize SHS to light their homes despite PLN entry. Respondents primarily noted that this was done to save on costs for paying for PLN (there are currently no enforced user fees for the SHS) though SHS was also cited as a back-up for MHP failure.

While almost all substitution cases saw respondents substituting energy sources for lighting, instances of source substitution for cooking were more limited. There was very limited evidence that beneficiaries were able to substitute renewable energy for household cooking given the relative convenience and lower cost of existing sources including firewood and LPG. The one exception was for grants that provided biodigesters (W2 LATIN), where respondents cite that biogas has replaced firewood and LPG gas as the primary source of cooking fuel.

Improving Existing RE Sources. In some instances, investments were aimed at improving or building on existing RE sources. The most common cases were in MHP revitalization, 4 grants[41] revitalized a total of 7 MHPs. In another 2 grants[42], RE provided by the projects substituted for small solar home systems/lighting banks. For these communities the activity provided improved, more reliable RE energy.

[41] W3A Akuo Energy, W2 IIEE, W2 KKI Warsi – Jambi, W2 KKI Warsi – West Sumatra
[42] W3A Anekatek, W1 HIVOS

Generating Demand for RE. Finally, in a third category, RE provided by the portfolio generated new demand for energy by introducing economic activities that required electricity (production houses) or by substituting manual labor (e.g., water collection and distribution) with RE (solar water pumps).

Unsurprisingly, in instances where RE technology has failed there has been a reversal back to non-RE sources, sometimes after productive investments were made by households. W3A Charta Putra biomass plants ran on diesel after the biomass generators broke down. In W2 LPPSLH one village is now utilizing a diesel generator after MHP broke down, and a second plans to purchase a diesel generator in the near future. For W3A Anekatek most families were reverting back to small solar lamps as well as kerosene lighting. In addition, several families began using generators again though with the cost of fuel, primarily relied on solar or kerosene lamps for lighting. In instances where RE technology attempted to generate new economic activity and demand, failure of RE has often led to production houses falling into disuse (rather than being supplied by alternative energy sources).

Electricity Access and Consumption

Across the portfolio, RE technology enabled different levels of access to and consumption of RE which was mostly mediated by the generation capacity and functional status of the technology at endline. 65 percent of the portfolio (15 grants) anticipated increasing electricity access and/or consumption at the household level,[43] though only 39 percent (9 grants) had at least one location providing RE energy to households at endline due to technology challenges.

In this section, we discuss grants which primarily focused on providing RE electricity to households and define access in terms of the level (Tier) of household connection to RE. At the end of this section, we briefly discuss the special case of grants which provided biogas reactors or SWPs to households, and how these technologies might have influenced access and consumption of cooking fuel and water (outputs of RE). Energy for productive use, including the status of grant-established production houses, is discussed in the **Outcomes - Energy Use for Economic Purposes** section.

According to the Compact's closeout Indicator Tracking Table, 9,095 RE users (primarily households) were added by the 15 grants which targeted provision of RE electricity for household use. Accounting for technologies that are no longer functional and utilizing updated numbers for RE users provided by RE managers, the number of users with access to grant-funded RE electricity at endline was less than 3,000 (less than 5 percent of these users are public facilities).[44] This represents approximately a 70 percent reduction in users with access to MCC-supported electricity. Some of the reasons for users losing access

[43] This excludes those that only provided access to production houses (3 grants), public facilities (1 grant), biogas reactors (1 grant), or SWPs (3 grants) which provided an output of RE (water) rather than RE directly.
[44] The ET was unable to calculate the exact number of RE users at endline across the portfolio due to challenges in identifying precise estimates for all locations and technology types, especially for decentralized solar systems where functional status was reportedly variable across systems. Based on estimates available to the ET, the number of RE users with access to electricity at endline was approximately 2,800.

to RE electricity have already been discussed in the **RE Infrastructure Functionality Post-Compact** section and include unresolved major repairs, lack of technology utilization by communities, and lack of clarity on infrastructure ownership.

Where RE infrastructure is functional, the type of access provided to households can be broadly classified into two categories: RE enabling Tier 1 access for lighting and phone charging, and RE enabling Tier 2 access or higher for electricity beyond lighting (including appliances and electric tools). Refer to Figure 3 in the **Country Context and Compact Background** section for ESMAP's definition of the different tiers of electricity access. In addition, technologies associated with some grants were facing operational issues at endline which were also influencing electricity access of connected users (such as unresolved repairs or constrained generation capacity). Table 10 provides an overview of electricity access supported at endline across grants, and whether grant technologies were facing additional limits to providing electricity access.

Table 10: Electricity Access Supported at Endline

Grant Name	RE Technology	Level of access supported at endline for households	Grant technology is NOT facing additional challenges limiting electricity access	Cause of access limitations
W3A Akuo Energy	Solar PV, MHP	Tier 3+	🛇	Technical issues
W3A Sky Energy	Solar PV	Tier 2	🛇	High demand
W2 PT CIT	Solar PV	Tier 2+	🛇	Technical issues
W2 LAKPESDAM PBNU	SHS	Tier 1	🛇	Technical issues
W2 Keling Kumang	MHP	Tier 1 & Tier 2	🛇	Technical Issues & High demand
W2 IIEE	MHP	Tier 3	✓	
W2 KKI Warsi – Jambi	MHP	Tier 2[45]	🛇	Technical issues & High demand
W2 IBEKA	MHP	Tier 1	🛇	Technical issues
W2 KKI Warsi - W Sumatra	MHP	Tier 1	✓	

**Only nine grants are presented in this table because, at endline, these were the only grants with functional RE technology providing electricity for household use.*

RE enabling Tier 1 access. Some grants intended to provide households with Tier 1 access to RE electricity with the primary goal of expanding the availability of quality lighting.[46] For instance, the W2 LAKPESDAM-PBNU grant provided households with SHS with 100-watt peak generation capacity, and four light points. Households that received the SHS systems reported that the quality of lighting from the

[45] The W2 KKI Warsi – Jambi grant revitalized four MHPs and the level of electricity access supported at endline differs for both. The MHP built in Rantau Kermas supports Tier 2+ access for households, while the capacity of the three MHPs in Bergin Tinggi is more limited and support Tier 2 connections for existing customers while all new customers are limited to Tier 1 connections. Tier 2 has been included in the table as the most common connection type supported for brevity.
[46] W2 LAKPESDAM-PBNU, W2 KKI Warsi West Sumatra.

SHS systems was noticeably brighter than lighting from previous sources, such as kerosene lamps and diesel generators. They also noted that initially lighting from SHS could be used for a longer duration than previous sources, sometimes more than 24 hours on a single charge. In addition, households appreciated that the systems were equipped with four lightbulbs, which increased the area that could be illuminated. Access to quality lighting was cited to be particularly useful at night, to extend the amount of time available for domestic tasks, studying and leisure. For other grants, like W2 IBEKA, it is not clear from available documentation and interviews whether the grant intended for RE electricity to be utilized solely for lighting. Our interim evaluation of the W2 IBEKA grant found that, though higher-powered connections were available, most households opted for Tier 1 connections due to low willingness to pay for electricity indicating that there are factors outside of access which determine electricity consumption.

RE enabling Tier 2+ access. A second category of grants provided RE technology that enabled households to access electricity connections that would allow use of appliances and tools. In addition to expanded access to lighting, many households with connections supporting at least Tier 2 electricity access reported expansion in appliance ownership and use. Across grants, the most commonly mentioned appliances powered by RE-electricity were televisions, refrigerators, freezers, and rice cookers. Other common appliances included sound systems, fans, washing machines, water pumps, blenders, irons and carpentry tools, though ownership of higher-powered appliances was limited to households with higher powered connections (Tier 3+). In some cases, appliances were already owned by the household prior to RE electricity provision and powered by an alternative energy source, most common in the case of televisions that households previously powered using diesel generators in the evening. In other cases, appliances were purchased by households after RE provision. During qualitative data collection for endline case studies, respondents often commented that provision of electricity, and ownership of appliances in particular, were especially beneficial for women. Appliances such as rice cookers and washing machines, enabled household chores to be completed in a shorter amount of time and also allowed for multi-tasking. Though many household respondents from the endline case studies noted that RE had enabled appliance usage, a few households from each grant indicated their usage was limited to lighting. The stated reasons for this varied: some asserted that lighting was sufficient for their needs either due to preference or from spending limited time in their homes, while others noted financial constraints of not being able to bear the cost of appliance purchase or higher electricity consumption.

Findings from the IIEE grant on expanded electricity consumption: Household customers of the MHP constructed by the **W2 IIEE** grant noted that the electricity provided from the new MHP is noticeably stronger than the electricity that was generated by the previous MHP. Whereas low voltage and outages were common with the previous MHP, respondents mentioned that electricity from the current MHP is available 24 hours a day and most customers have 900-watt connections enabling Tier 3 access. Changes in appliance ownership varied widely between respondents. Some already had an extensive set of appliances including refrigerators and washing machines that were purchased while living elsewhere or powered with a generator. Therefore, these individuals did not purchase any new items after being connected to the new MHP. Others only had lighting and televisions previously because of the low power of the previous MHP, and had bought items such as refrigerators, rice cookers, irons and blenders after being connected to the new MHP. In addition, a few respondents also acquired higher-powered productive use machinery, including coffee processing equipment, carpentry tools, and blacksmith forges.

Additional limitations to electricity access. As indicated in Table 9, 78 percent of grants with functioning technology at endline are facing challenges, with technical issues or high demand limiting electricity access for existing and new users. Technical issues faced by RE technology have influenced energy access by either making the technology completely non-operational, reducing the hours of operation, or reducing the number of users with access to electricity. In the case of grant technologies facing high demand relative to electricity supply, the influence on access has manifested as restrictions on upgrading to higher powered connection for existing users, restrictions on addition of new connections, and planned outages to manage the supply-demand gap in the most extreme case.

Technical issues and electricity access: A cyclone caused damage to the distribution infrastructure of one of the W2 IBEKA MHPs, resulting in reduction in the number of villages served by RE electricity from four to one. In the case of the W2 PT CIT solar grids, ongoing repair issues at both locations had reduced the hours of electricity available from 24 hours per day to less than eight hours.

High demand and electricity access: For solar grids constructed by the W3A Sky Energy grant, up until the 2021 rainy season (when endline data collection was conducted), electricity was typically available 24 hours per day. However, respondents mentioned that the frequency and duration of outages had notably increased in the past few months. In many sites, the SPV managing the grid would turn off electricity supply during the day to ensure sufficient electricity for nighttime consumption. These outages would extend from six to more than 12 hours per day. In addition, the SPV was no longer accepting applications to upgrade connections from Tier 2 to Tier 3 to limit electricity demand. According to the SPV, these measures were necessary due to higher-than-expected electricity demand combined with reduced charging of the batteries as a result of cloudy weather. In the case of three MHPs revitalized by the W2 KKI Warsi – Jambi grant, due to higher-than-anticipated demand for electricity connections, new households are only provided a connection that is sufficient to power a 10-watt light bulb. Existing customers continue to have 450-watt connections enabling Tier 2 access.

Access to biogas and water from RE. Though the concepts of household access and consumption are most easily applied to RE that provided electricity to households, we also assess how grants that provided biogas reactors and SWPs have influenced access to biogas and water. For the W2 LATIN grant, users noted enhanced access to cooking fuel, and that biogas produced is cheaper and less labor intensive than previous sources (LPG gas and firewood). For grants that provided SWPs, users similarly indicated improved access to clean water, especially those who previously needed to travel long distances in the dry season to fetch water.

Energy Expenditure

Most grants planned for RE users to pay fees to help fund needed O&M for RE technology. Fifty two percent of grants planned for users to make regular payments to access RE (12 of 23) while 17 percent (4 of 23) planned for RE users to make regular contributions to savings schemes to fund future O&M. A smaller proportion of grants, 17 percent (4 of 23), assumed that revenue generated from operating RE (e.g., production houses) would finance operations without requiring additional expenditure by RE users. Lastly, 13 percent of grants (3 of 23) attempted to operationalize a combination of financing systems. Overall, systems for collected regular payments from RE users were largely implemented, though with variable payment compliance by users. Savings schemes were initially attempted but eventually not pursed. RE funded through revenue generation is discussed in the **Outcomes - Energy Use for Economic Purposes** section but was largely unsuccessful as productive activities failed to achieve revenue targets.

Regular payments for electricity service. 61 percent of grants, inclusive of those who implemented a combination of financing systems, (14 of 23) proposed regular payments by RE users to access RE services and to fund ongoing operations and repairs. This system was proposed to communities by grantees where grants constructed RE grids which would be managed by a paid management group in charge of O&M of the technology. At endline, almost all operational grids have a user fee system in place. There are two types of payments systems represented in the portfolio. The most common is a flat rate system where RE users pay a set monthly rate to access RE electricity with rates typically adjusted based on the power of the household's connection. For connections lower than 450 watts (Tier 1 access) tariffs range from IDR 15,000 to 20,000, for 450-watt (Tier 2 access) connection tariffs range from IDR 20,000 to 50,000, and for higher-powered connections the rates vary widely from IDR 30,000 to IDR 100,000. The less common system charges users by kilowatt hour, so expenditure is tied more closely with electricity consumption. For grants with operational grids at endline, the per kilowatt hour tariff ranges from IDR 500 per kWh (W2 IIEE) to IDR 1,460 per kWh (W3A Akuo Energy and W3A Sky Energy).

The ERR calculations for some grants assumed that RE technology would decrease user expenditures on energy due to switching from more expensive fuel-based sources, such as diesel generators. The evidence on effects of RE technology use on energy expenditure for RE grid connected customers is inconclusive and depends on a number of factors, including the previous energy sources utilized by customers and the stringency of fee collection by RE management. For instance, customers who previously used personal diesel generators regularly would be more likely to have experienced reduced energy expenditure than customers who relied on kerosene lamps. Managers also differ in how diligently they collected user payments from customers meaning that in some cases users make regular expenditures on RE electricity while in other cases they do not. The two operational W3A grants employ a prepaid system where users must first make payments prior to accessing electricity. Our interim evaluation found that the cooperative managing W2 IBEKA grant infrastructure experienced significant difficulty in collecting consumption tariffs from connected households with as few as 50 to 75 percent of customers paying the tariff on a monthly basis.

Findings on energy expenditures from the W3A grant: The quantitative evaluation of the **W3A Anekatek** and **W3A Akuo Energy** grants at interim found no change in monthly expenditures on electricity consumption and minimal reductions in expenditures on maintenance and repair of energy sources. At endline, respondents connected to the W3A Akuo Energy grids report spending between IDR 50,000 to IDR 400,000 per month on electricity depending on the number of appliances used, the connection types (e.g., 450-watt, 900-watt), and customer type (e.g. household, small business, combined). Respondents who previously used personal generators noted that current electricity costs were less than before while enabling electricity access for 24 hours, rather than just for a few hours in the evening. Regular users of generators mentioned previously using an average of 2 liters of gasoline per night to power their generators for six hours. At approximately IDR 7,000 per liter, this results in a monthly cost of IDR 420,000. Still, other households who were more infrequent users of generators, or used lower-powered generators, remarked that their current electricity expenditures were slightly higher than before being connected to the grid.

Tariffs are set to comply with village government and other applicable regulations, and in consultation with community members. To address concerns of electricity cost serving as a barrier to access for the most vulnerable households, some management groups have implemented policies of providing free electricity to the poorest households in the community (such as the SPV managing the W3A Sky Energy grids, and the cooperative managing the W2 IIEE grid). In other cases, the monthly tariff rate schedule has been set in consideration of the differences in customers' ability to pay. For instance, the tariff schedule for one of the W2 PT CIT solar grids is set based on the customers occupation, with the highest rate set for salaried workers, followed by farmers and then households without steady income.

Savings schemes for future repairs. Thirty percent of grants in the portfolio (7 of 23) intended for RE users to either contribute to joint savings funds or individually set aside funding for future major repairs and parts replacement. This approach was proposed for non-grid RE technologies such as SWPs, SHS, biogas reactors and standalone Solar PV grids for public facilities, where there is a small, discrete user population and no official RE management group. These were still meant to be regular monthly payments but the funds were intended for future needs, rather than to pay for current O&M services. In practice, savings schemes were not implemented for reasons discussed later in this section. With the absence of savings systems and minimal investment in O&M of technology (see below), it is reasonable to assume that use of RE technology did not increase expenditures for most users and may have decreased expenditures relative to previous sources. However, apart from grants that constructed SWPs and some SHS from the W2 LAKPESDAM-PBNU grant, lack of expenditure by users has likely contributed to technology becoming prematurely non-operational.

For the three grants that provided SHS or biogas reactors to households, savings schemes ran for a couple of months after equipment commissioning but did not continue due to difficulties in managing the logistics of collecting payments, and lack of priority given to saving for future repairs by beneficiary households. Technologies from two of these grants are no longer operational at endline. For the third grant, W2 LAKPESDAM-PBNU, households were initially asked to contribute between IDR 25,000 to 35,000 per month to a savings fund, but this was discontinued after three months. Unlike the other two grants, many SHS systems are still functional at endline but there is limited evidence that users invest in preventative maintenance and repairs. For most households, the SHS has become a backup source for lighting at endline, therefore reducing the prioritization of paying for repairs.

Two grants provided standalone solar PV systems for public facilities. At endline, almost all systems across both grants were not functional. Similar to the SHS case, there is little evidence to suggest that public facilities spent money on O&M of systems. In some cases, facilities became connected to PLN after which the SHS was no longer used. In other cases, facility respondents noted that funds that had been set aside for repairs were reallocated for other, more urgent needs such as COVID-19 relief. One grantee (W2 Kemitraan) asserted that they planned to provide more budgetary and O&M planning support to beneficiary facilities, but due to time constraints this activity was de-prioritized.

For the three grants that implemented SWPs, grants intended for the target user group of farming households living close to the SWP to pay a monthly IDR 5,000 – 10,000 fee to fund future repairs. Community respondents noted that a key difficulty for implementing this system is that the SWPs are regularly used by individuals beyond to originally targeted user group which makes fee collection more difficult. In addition, provision of clean water is viewed as a public good. In some cases, such as SWPs constructed by the W2 YPK Donders grant, local community leaders serving as de facto caretakers of the technology have funded minor repairs using personal funds, noting uncertainty about funding for major repairs. In other cases, the village government as owners of the technology have fully or partially funded repairs and improvements of the technology. For two SWPs under the W2 Burung grant, needed repairs have not been carried out due to lack of clarity on infrastructure ownership but the SWPs are still functional.

3.4. Outcomes - Energy Use for Economic Purposes

As noted in the **Theories of Change** section, 83 percent of grants in the portfolio (19/23) explicitly intended for RE to be used for economic purposes with an aim to achieve the overall GP project goals of increasing income of RE users and reducing poverty through low carbon economic growth. For the balance 17 percent of grants (4/23), though promoting economic activities was not a primary aim of the RE investment, grantees noted that provision of RE could support productivity and income gains. In most cases where RE is still functional, provision of RE has encouraged new income-generating activities and expansion of existing activities in communities though the aggregate effects of these changes have been modest. However, direct interventions made by grants to promote productive use through provision of production houses, equipment and training have been less effective.

3.4.1. Household RE Use for Economic Purposes

Grants assumed that provision of electricity from RE would generally yield economic benefits in targeted communities by extending the potential time spent on income-generating activities (from availability of lighting) and opening new economic possibilities using appliances and tools that could not be powered from lower-capacity sources. For the special case of grants that provided SWPs, water extracted using RE was intended to enhance economic activities through supporting crop cultivation.

Use of RE electricity for economic purposes. At endline, 10 grants had RE technology that was still operational in at least one location and providing electricity via grids or directly to households through SHS. Community respondents confirmed that RE from 90 percent of these grants (9/10) was being utilized for economic purposes.[47] In most cases, the extent of economic activity supported by RE was mediated by the degree of electricity access supported by the RE source. As discussed in the **Outcomes - Energy Sources, Access, Consumption, and Expenditure** section, in some locations RE supported Tier 1 access (lighting and charging) and in other locations RE supported Tier 2+ access (appliances and electric tools).

Where RE was sufficient for lighting, community respondents note that it has extended the available time for economic activities. For instance, respondents from the W2 CU Keling Kumang and W2 PT CIT grants noted that RE had encouraged productive activities using lighting at night, such as weaving and making handicrafts. Another respondent from the W2 KKI Warsi – West Sumatra grant mentioned that lighting from RE had allowed kiosks and stalls to extend their hours of operation, and supported poultry egg hatching businesses. While this represents an improvement from the previous status and indicates that time use patterns for some households had shifted to allow for productive activities to happen at night, the aggregate contribution of RE to improving the local economy is likely minimal as these activities are conducted on a small scale (usually by individuals) and do not produce high value products. Typical economic activities conducted by RE users at night are making food for sale, processing agricultural goods manually, and making handicrafts.

Where RE supported more than Tier 1 access, the most common way it has influenced economic activities is through expansion of products sold by existing kiosks due to access to refrigerators and blenders (e.g., cold drinks, ice creams, ice, preserved fish or meat), or an increase in the number of such kiosks in communities. This aligns with the results from the interim evaluation of the W3A Anekatek and W3A Akuo grants where the measured increase in appliance ownership used to produce goods for sale was almost entirely driven by households selling chilled goods from refrigerators. Customers of these stalls are largely from the local community and products sold are primarily for direct consumption, so these activities are unlikely to significantly change the economic situation of communities. In some cases, other small-scale enterprises such as furniture, carpentry or motorcycle repair workshops have also been opened, which provide higher-value goods and services, though these were less commonly reported.

[47] The one exception is the W2 LAKPESDAM PBNU grant which provided solar home systems to households. At endline, the SHS were being used as a back-up source of lighting because most households had access to an alternative (PLN or an MHP provided by the government). Respondents did not report that the SHS in particular supported any economic activities.

This is likely because a wide range of constraints were reported to influence local economic conditions, beyond availability of electricity, such as availability of financing to start businesses, access to markets, and general disruptions caused by the COVID-19 pandemic.

Findings on economic use effects of grant-funded RE for the W2 IIEE grant:

After commissioning of a new MHP through grant support to replace an older MHP with limited generation capacity, **W2 IIEE** community respondents noted local stalls expanding items for sale to include cold drinks and snacks. In particular, the availability of stalls selling breakfast items was cited, as women were now able to prepare items at night, store them in a refrigerator to prevent spoilage, and easily reheat them in the morning for sale. Other new enterprises included carpentry stalls, motorcycle repair stalls and a blacksmith workshop—all connected to the RE grids. A few respondents also mentioned a desire to open their own kiosks but were constrained by a lack of start-up capital to buy appliances and other needed inputs. According to community respondents, key constraints to improvement of the local economy are the continued reliance on agriculture as a primary source of livelihood and the remoteness of the hamlet's location. The grant attempted to promote tourism initiatives which might have indirectly stimulated the local economy, including setting up a Center of Knowledge to share knowledge of MHP management and constructing a bridge facilitating access to a nearby waterfall. However, these had yet been successful at endline in increasing tourism, potentially due to COVID-19 movement restrictions.

Effects of reduced access to RE

As detailed in previous sections, RE technology associated with multiple grants became non-operational at endline or have faced technical issues which have reduced electricity access. In many cases, access to electricity from RE had encouraged new economic activities in these communities. While electricity alone is not sufficient to stimulate economic activity, the experience of enterprises in these communities is useful for understanding the important role that electricity can play.

W3A Anekatek: Prior to the grids becoming inoperable, a variety of different businesses had opened and expanded in these communities during the two years they were operational such as grocery and snack stalls, furniture and automotive workshops, internet cafés and mobile banking kiosks. After grid shutdown, many of these have now shut down or greatly reduced operations in order to function without electricity. In rare cases, a few enterprises have attempted to remain open using generators for electricity, but profit margins have greatly reduced. Respondents noted that generally the economic conditions had reverted to the previous status (before provision of RE).

W3A Sky Energy: Though grids were still functional at endline, most customers were experiencing frequent and prolonged outages. In particular, businesses selling ice cream or producing ice for fishermen noted that their products were often not cold enough to sell which had started to reduce their revenues. In addition, many fishermen had returned to purchasing ice in the nearby city of Mamuju because of lack of sufficient supply from local vendors.

Use of RE-extracted water for economic purposes. Three grants constructed SWPs and intended for extracted water to be used for crop irrigation, which would in turn lead to increased agricultural sales and improved income for farmers. Across all three such grants, water from functioning SWPs is mostly used for household purposes while some households use it to irrigate vegetable, fruit and/or herbal gardens in the dry season. Produce that is grown is primarily for household consumption, though sometimes surplus is sold. Even without selling produce, it is reasonable to assume indirect effects on income as vegetables grown might substitute for food items previously purchased. Community respondents cite two reasons why water from SWPs is not used more intensively for crop cultivation. The first is related to the design of provided SWPs which were not equipped with pipelines to facilitate access to water, so users have to carry water back and forth from the SWP to their homes or agricultural plots. The second reason is that communities view water provided by the SWP as a necessity and public good rather than a means of livelihoods promotion. Due to water scarcity in grant locations, access to SWP water is not restricted. Therefore, preference is given to ensuring sufficient water to meet the basic needs of all SWP users.

Findings from W2 Burung on economic use of SWP water: The **W2 Burung** grant built five SWPs in five villages. Of the three SWPs that were operational at endline, one had been improved using village funds through addition of pipelines which extended access to a beneficiary housing complex. According to community respondents, this increased the amount of land irrigated by SWP water from 5 hectares to 25 hectares. In the other two villages where pipelines had not been constructed, the total land irrigated by SWP water was estimated to be 5 hectares. In these two villages, distance between the SWP and plots was commonly mentioned as a reason why some farmers did not use the water for dry season vegetable farming.[48] Households that have planted vegetable and fruit gardens due to access to water from the SWPs note the produce is prioritized for consumption but is sold to traders when there is surplus. The magnitude of sales and contribution to overall income is unclear but a few respondents noted that proceeds from vegetable sales helped fund household daily needs and children's school fees.

3.4.2. Targeted Interventions to Promote Economic Use of RE

In addition to general increases in economic activity from availability of RE, many grants aimed to promote specific economic activities. If successful, these activities would serve the dual purpose of improving incomes and livelihoods of RE users, and creating a dedicated customer base for the RE technology. In practice, most of these targeted efforts to promote productive use did not end up being implemented or were halted. Direct interventions applied by grants for this purpose included establishing production houses, providing equipment for processing and packing of products, and training community members on topics such as cultivation practices and/or producing processed products.

Production Houses. Each production house in the portfolio was powered by a Solar or MHP grid, and equipped with machinery needed to produce the planned product. Most production houses were

[48] In one of the grant locations, the village government advocated for pipelines to be added to the SWP by a government program (PAMSIMAS) which extended the network closer to beneficiary homes.

established for processing agricultural commodities such as coffee, cacao and honey. Aside from transforming agricultural goods, a few other production houses were intended to supply purified water and produce ice. Production houses were intended to be self-financing, with revenue from sale of products used for regular O&M and repairs.

In total, 15 production houses were constructed by seven grants, of which only 33 percent (5/15) were being used at endline. Of the 10 production houses not being utilized, two became inoperable shortly after commissioning due to faulty machinery and three were not utilized because community members shifted away from producing the agricultural product the facility intended to process. The remaining five production houses faced common issues of insufficient working capital to purchase raw inputs, producer preferences to sell unprocessed goods, and lack of market linkage to facilitate sale of processed products.

The coffee processing facility established by the W2 IIEE grant: The **W2 IIEE** grant revitalized an MHP, provided coffee farmers with training on coffee cultivation and established a coffee processing facility powered by RE. Efforts to encourage coffee processing yielded some initial success: a unique brand name was developed for the coffee processed at the facility which received a halal certification, and small batches were marketed outside the village. Ultimately, several challenges arose that led to coffee processing not being pursued. To produce high quality coffee for external markets, coffee farmers needed to sort through their coffee beans and only select ripe red beans for processing. Coffee farmers asserted that this process was time intensive, and even though the final product may sell at a premium, farmers preferred to directly sell unsorted coffee in bulk rather than invest the effort into sorting and processing. Though training participants appreciated being exposed to new techniques, they noted that techniques were not practical for them to implement. Also, originally the plan was for the Cooperative which was established to manage the MHP to purchase raw coffee from farmers and centrally manage the processing and marketing. In practice, the Cooperative did not have the working capital to purchase raw coffee from farmers, so this plan was not implemented. Ultimately, community members only used coffee processing facilities built by the grant for processing coffee for home consumption. At endline, this equipment was no longer functional with cooperative management suggesting that profits from coffee processing were minimal, reducing the urgency for making repairs.

Production houses that have realized more sustained success are those which produce purified water or ice (four out of five production houses in use at endline produce one of these products). Given the nature of inputs needed (i.e., water) and products produced, these production houses have been able to overcome the challenges faced by other production houses in the portfolio. Water can be easily sourced by pumping from the ground or a nearby water source, so input supply is not constrained by producer preferences or working capital. Marketing of purified water is also not a challenge as there is sufficient local demand from households and local businesses for potable water. Production houses that produce ice are located in areas where they have a dedicated local customer base of fisherman and traders. As a result, managers of these production houses have not needed to invest substantial effort in finding markets for their products.

Water purifying production houses established by W2 LAKPESDAM-PBNU: The grant set up two production houses for water purification in two separate villages, with each managed by a village cooperative or BUMDes. Managers of these businesses report strong demand from both households and stalls for purified water and have been able to make sufficient profit to handle major repairs and equipment replacement. Beyond benefits from the business, community respondents also appreciated having a local source for clean water, especially in the dry season, noting that in both locations the production house had become one of the primary sources for drinking water in the community. Facility managers in one location did mention that with the recent entry of PLN into the village, others had started water purification businesses, and the competition has led to a reduction in profits.

Other grant-led interventions. Outside of production houses, almost all grants also provided training and equipment for groups to carry out home-based production activities which would use RE. Some examples of activities include banana chip and fish cracker making, durian processing, poultry farming and cake making. Many of these activities could not proceed at a group scale due to seasonality and/or price of inputs, marketing constraints, difficulty coordinating between group members, and lack of interest due minimal profit margins. Multiple grantees also indicated that the project implementation timelines did not allow for sufficient time to be spent on this aspect. However, there is evidence that some participants of these trainings continued activities individually meaning that the trainings may have had a residual effect. One exception is the W2 LATIN grant which provided seven biogas digesters to 20 cattle farming households to be managed jointly. The farmers were also provided training on how to package bioslurry for sale to local farmers. At endline, farmers continue to work together to manage the biodigesters and sell bioslurry produced. Revenue collected is used to finance O&M for the reactors, and profit is shared amongst the families.

Findings on groups trained by the W3A Sky Energy grant: The grant provided training to women on ice cream making and banana chip production. The women's group selling ice cream closed after a year because the group considered it simpler for individuals to purchase and sell brand name ice cream, especially because companies would also supply the freezer to store the product in. The banana chip groups realized some initial success receiving a loan from the BUMDES in 2020 along with additional equipment to support production. When we conducted endline data collection, the group was temporarily inactive because the price of raw materials increased substantially reducing prospective profit margins, the earthquake Mamuju (a nearby city) destroyed their distributor's shop, and COVID-19 generally made marketing more difficult. Despite these challenges, several women continued to make and sell chips on an individual basis.

3.5. Outcomes - Effects on Greenhouse Gas Emissions

One of the GP project's overall objectives was to reduce land-based GHG emissions. The GP Grant facility attempted to attain this objective by reducing reliance on fossil fuels through provision of community-based RE sources. The extent to which grants in the CBOG-RE portfolio have contributed to reductions in GHG emissions is dependent on two factors: whether the grant-funded RE was meant to substitute for non-RE sources, improve existing RE sources, or generate new demand for RE and the functional status of the technology. We find that grants with functional technology at endline that provided RE to substitute non-RE sources or improve existing RE sources are most likely to be contributing to reduced GHG emissions (48 percent of the portfolio, or 11 out of 23 grants). In this section we qualitatively discuss the likelihood that grants have contributed to reductions in GHG emissions. [49]

As discussed in the **Outcomes - Energy Sources, Access, Consumption, and Expenditure** section, RE provision either substituted for non-RE sources, improved upon existing RE sources, or attempted to generate new demand for RE. Implications for how grant-provided RE influenced GHG emissions differ across these three categories.

Substitution of non-RE. Sixty five percent of grants (15/23) provided RE technology intended to substitute for non-RE sources. For most grants, RE substituted for kerosene lamps used for lighting or diesel generators, but the prevalence of generator use varied widely across locations. Where use of diesel generators was prevalent and RE technology is functioning at endline, there is evidence to suggest that RE had contributed to reduced GHG emissions by reducing or completely eliminating the need for non-RE sources. Where RE primarily substituted for kerosene lamps, reductions in GHG emissions are also likely but smaller in magnitude.

Effects on GHG emissions from the W3A Akuo Energy and W3A Sky Energy grants: At baseline, two of the three **W3A Akuo Energy** villages regularly used generators donated through local companies' corporate social responsibility (CSR) funds in the evenings, and outside of these generators 34 percent of households reported owning personal generators. At interim, our household survey in 2019 found that only one percent of Akuo Energy households used at least one non-renewable source, versus 89 percent at baseline in 2017. At endline, households with personal generators in two villages reported using RE electricity as their primary source. Some households reported using the generator in case of grid outages, while others preferred to use solar lamps due to the cost and inconvenience of generator operations. In the third village, at the time of endline data collection in December 2021 the RE grid had not been operational since February 2021 due damage to one of its components and a prolonged repair process. As a result, the SPV had used a diesel generator to provide electricity to its customers for eight to 12 hours per day for almost four months,

[49] We do not attempt to quantify GHG emission effects due to data constraints.

therefore somewhat mitigating the overall reduction in fuel use. During this period, more than 8 drums (approximately 200 liters) of diesel per month was used.

Changes in fuel consumption patterns for **W3A Sky Energy** reported at endline appear similar to W3A Akuo Energy. Prior to the grant, many households received electricity each evening for four hours from communal generators owned by the village. Households which did not have access to these generators, either due to distance or not being able to pay the monthly fee, typically used kerosene lamps for lighting. After commissioning of the RE grids, respondents noted that these generators are no longer used suggesting that the grant likely contributed to notable reductions in GHG emissions.

Improving existing RE sources. Twenty two percent of grants (5/23) provided RE technology intended to improve existing RE sources. The grants with RE technology still functional at endline were the three which revitalized MHPs that had previously served as a primary energy source for target communities. Through the revitalization process, the grants either increased the generation capacity of the MHP or repaired the MHP to improve efficiency. Given that many target customers were already using RE as an energy source, effects of these grants on GHG emissions are likely somewhat less than grants which more intensively substituted for non-RE. However, there is still evidence that these grants contributed to reduced GHG emissions as they enabled more users to be connected to RE and provided improved electricity access and quality reducing the need for non-RE back-up sources.

Related findings from the W2 IIEE grant: The **W2 IIEE** grant revitalized an existing MHP that had been in use since 2007, doubling its generation capacity from 30 kW to 60 kW More than half of the 200 customers connected to the new MHP were customers of the previous MHP, and hence were already using a renewable source as their primary source of electricity. However, due to the poor condition of the previous MHP it needed to be shut down for maintenance for an average of three days per month. During this time, a few households would use personal generators while others would use kerosene lamps. In addition, the increased generation of the new MHP enable the grid to be extended to additional sub-hamlets where households were previously using a combination of kerosene lamps and small solar home systems.

Generating demand for RE. 43 percent of grants (10/23) provided RE technology aimed at generating demand for RE. Seven grants introduced new economic activities that required energy sources through construction of production houses. As discussed in the **Outcomes - Energy Use for Economic Purposes** section, most of these production houses are no longer in use. For the five functional production houses in use at endline, effects on GHG emissions are not fully transparent. These production houses introduced new economic activities rather than directly substituting activities that previously used non-RE, so it is unlikely that they have contributed to GHG emission reduction. Three grants constructed SWPs which did not directly substitute for previous energy sources, but provided clean water sourced using RE. In these cases, the effects on GHG emissions appear mixed. For example, some users of SWPs constructed by the W2 Burung grant reported previously using motorcycles to collect water from the nearest well or spring. With the availability of a clean water source near to their home, they no longer used the motorcycle to fetch water, therefore entailing slight reductions in fuel consumption for these households. Conversely, respondents also noted that individuals from nearby villages also travel to the SWPs to fetch water, with some doing so using motorcycles or small trucks. It is unclear how these individuals sourced their water previously (using fueled transport or by walking). Therefore, the impacts of these SWPs on GHG emissions are not clear, but any impact is likely to be minimal.

Effects of inoperable RE technology on GHG emissions. As noted earlier, RE technology associated with 26 percent of grants (6/23) were completely inoperable at endline. In addition, RE technology was confirmed to be operational across all the entire grantee portfolio (all locations and technology types) for only 39 percent of grants (9/23). For the 14 grants which have some inoperable technology at endline, it is reasonable to assume that the non-functional technology is no longer contributing to reductions in GHG emissions. At the same time, the evaluation team found limited evidence that technology failure has directly contributed to increased GHG emissions (see the two examples described in the text box below). Most locations either reverted back to previous energy sources or received electricity from PLN.

Source switching in W3A Anekatek communities: In the **W3 Anekatek** grant communities, where the solar PV grids have been non-operational since December 2020, most households and businesses have reverted back to using solar home systems to provide lighting and for charging mobile phones, with kerosene as a back-up. A few households were noted to have personal generators, though these were only operated a couple of hours per day to minimize fuel expenses. Patterns of energy use reported by households largely mirrored conditions observed at baseline before the solar grids were commissioned. At endline, the energy situation of these communities is analogous to the situation of nearby comparison communities where qualitative data collection took place. Respondents in comparison communities noted that primary energy sources and the electricity situation has mostly been unchanged since 2017.

Examples of increased GHG emissions attributed to CBOG RE grants

The W3A Charta Putra grant is an interesting case of a grant that may have had the unintended consequence of increasing GHG emissions. As designed, the plants were intended to use biomass (bamboo feedstock) as the primary source of electricity generation. The biomass plants were also equipped with backup diesel generators which only intended to be used when maintenance was being performed on the biomass generators. Due to difficulties sourcing needed spare parts and subsequent damage to the biomass generators, the plants eventually switched over to using the backup diesel generators as a primary source of electricity generation providing electricity to nearby villages through PLN for approximately six hours per day. These plants became non-operational in January 2022 when the district government withdrew funding, but for the one-year period when the plants were mostly running on diesel, they may have contributed to increasing GHG emissions. Grantee documentation notes that previously these communities had mostly used kerosene lamps for lighting, with more limited use of diesel generators and solar home systems.

The W2 LPPSLH grant constructed two MHPs in two villages. Both MHPs were inoperable at endline. The village government in one location had purchased a new diesel generator to fulfill the community's electricity needs in the absence of MHP electricity. In the second location, procurement of a village generator was in process.

3.6. Sustainability

The sustainability outlook for most RE investments is quite low with only two grants identified as having strong revenue streams and management models to maintain and utilize RE for the foreseeable future. The majority of grants consistently meet challenges common to both off-grid and community-based models including constrained access to equipment and limited knowledge required for repairs and maintenance, and limited financing. In addition, the localized efforts limited the extent to which individual grants could influence external factors including tariffs, PLN entry, and market conditions (e.g., for production houses). The general inability of RE managers to overcome these challenges suggest that a key aspect of the GP project logic was not achieved; namely that "power plants would be handed over, operated and maintained by local entities with full community participation" contributing to "***reliable*** community-based RE provision". Sustainability plans developed by grantees were often overly optimistic in regard to anticipated revenue streams and underestimated the likelihood of major equipment failures in the years immediately following implementation.

We begin this section by examining the overall sustainability status of grants in the CBOG-RE portfolio before a discussion of the key factors identified by the evaluation as crucial elements of sustainability. Based on information about the functional and operational status of technologies in each grantee's portfolio, demonstrated ability to manage O&M challenges, and prospects for managing future O&M challenges, the ET developed a qualitative assessment of the future sustainability prospects for each grant using information collected through the desk review, beneficiary verification, and primary data collection conducted for case study grants (Table 11). This assessment was conducted at two points in time, the first in 2019/2020 and the second at endline in 2021/2022.[50]

3.6.1. Sustainability Assessment

At endline, we assess 48 percent of grants to have a "poor" sustainability outlook, 43 percent have a "fair" outlook and only 9 percent have a "good" outlook. The outlook for 26 percent of grants worsened from 2019/2020 to endline, while it appeared to improve for 13 percent of grants. It is important to note that our sustainability assessment aggregates information across sites for grants operating in multiple locations and sustainability may be somewhat different across locations. For instance, the W2 Burung grant constructed 5 SWPs – two were non-operational due to low water levels, two were operational but with uncertain funding prospects due to lack of clarity on ownership, and one was performing better than expected with strong engagement from the village government and user group. In this case, the sustainability outlook is actually mixed depending on location.

***Good Sustainability Outlook*.** The two grants with the strongest sustainability outlooks have demonstrated a strong track record of operations and a system in place for generating sufficient funding for O&M. Managers of the W2 IIEE MHP have independently financed a significant major repair and multiple moderate repairs and appear to have the technical expertise to manage a variety of O&M tasks. Community support for the MHP is also strong and managers have steady revenue from user fee payments. For the W2 LATIN grant, the biogas reactors are reportedly regularly used by beneficiary households, and the household group has maintained steady sales of bioslurry to local farmers. They are confident that revenue from these sales can fund any major repairs, especially because the technology is less complex and does not require expensive parts.

Fair Sustainability Outlook. In some cases, RE technology was functioning well at endline, but still classified as having only a "fair" sustainability outlook, when they do not have a clear mechanism or funding source for dealing with major repairs. For example, W3A Sky Energy was overall operating well but heavily dependent on grantee financial and technical support for repairs. The current high demand appeared to be straining the network and the grantee and community were in the process of seeking alternative energy sources (e.g., PLN entry). Other technologies classified as fair were facing ongoing technical issues at endline.[51] For instance, both solar grids built by the W2 PT CIT grant were facing technical issues related to parts replacement which had reduced availability of electricity to less than eight hours per day. In one case, the RE manager indicated that the issue might require ongoing parts replacement which would impose additional O&M costs. If not resolved, the outlooks for these grants may shift to "poor" in the near future.

Poor Sustainability Outlook. Most grants classified as "poor" in both time periods were those that faced major breakdowns or other O&M challenges as already discussed in **RE Infrastructure Functionality**

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[50] For grants included in the interim study, the first sustainability assessment refers to information gathered in 2019. For all other grants, the first sustainability assessment refers to information gathered during the 2020 desk review. For endline case study grants, the second sustainability assessment was carried out in November 2021. For all other grants, it was carried out in January 2022.
[51] W2 PT CIT, W2 KKI Warsi – Jambi, W2 CU Keling Kumang

Post-Compact.[52] The two exceptions are W3A Akuo Energy and W2 IBEKA, where serious concerns about the operational viability and continued funding of the systems were the primary reason for the designation.

Changes in Sustainability Outlook. Grants which saw a worsening of their sustainability prospects between the two periods were primarily those where the infrastructure become non-operational due to major repairs.[53] Lack of funding was a common reason why repairs had not been addressed, though lack of interest in utilizing the technology due to availability of alternatives or misaligned productive use plans were also a factor for a few grants. One exception is the W3A Sky Energy grant, which previously appeared to have strong sustainability prospects, largely due to the grantee's commitment to remaining involved with the SPVs. While grantee committee and community buy-in remain strong at endline, insufficient electricity supply threatens long-term sustainability, and there were no concrete plans to increase grid capacity (discussed later in this section). Another exception is W2 LAKPESDAM-PBNU which was also previously classified as having a "good" sustainability outlook, as systems were generally in good condition and the communities received ongoing technical advice from a collaboration with a local university. At endline, that collaboration was still in place but the condition of many SHSs had deteriorated due to lack of investment by households in O&M.

Table 11: Sustainability Outlook of Grants in the CBOG RE Portfolio

Grantee	Technology	Ownership	Sustainability Outlook 2019/2020	Sustainability Outlook 2021/2022	Brief Description
(W3A) Puriver Consortium	Solar PV	SPV	Poor	Poor	Never operational due to PLN entry
(W3A) Sky Energy Consortium	Solar PV	SPV	Good	Fair	High demand straining the network, dependent on grantee support
(W3A) Anekatek	Solar PV	SPV	Fair	Poor	Battery failure, all grids offline
(W2) PT Cahaya Inti Trimanunggal	Solar PV	Village Government	Fair	Fair	Operating below capacity due to ongoing technical issues
(W2) Yayasan Dian Tama	Solar PV	Cooperative	Fair	Poor	4/5 production houses non-operational due to limited capital and infrastructure damage
(W2) Javlec	Solar PV	Village-owned Enterprise	Poor	Fair	Has managed to address minor repairs and continue operations
(W2) Peka	Solar PV	Village-owned Enterprise	Poor	Poor	Low demand, equipment failure and PLN entry impacted use
(W2) LAKPESDAM – PBNU	SHS & Solar PV	Mixed Ownership (BUMDES, Government, HHs)	Good	Fair	Mixed – home systems generally not repaired/maintained though some success with production houses.

[52] W3A Puriver, W2 PEKA, W3A Charta Putra, W2 Yayasan Pena Belu
[53] W3A Anekatek, W2 Yayasan Dian Tama, W1 HIVOS, W2 LPPSLH

Grantee	Technology	Ownership	Sustainability Outlook 2019/2020	Sustainability Outlook 2021/2022	Brief Description
(W1) Hivos	Solar PV & Solar Lamps	RESCO	Fair	Poor	Solar lamps broke and were not replaced, only 30% of Solar PV still operating
(W2) Kemitraan	Solar PV	Public Facilities	Poor	Poor	Systems damaged due to lighting and other causes, none are operational
(W2) Bumi Manira	SWP	Village Government	Fair	Fair	Heavily dependent on village funds for repairs
(W2) Burung/ Konsorsium Sumba Hijau	SWP	Village Government	Fair	Fair	Mixed – some locations suffer from low water levels, others with significant community and government buy-in
(W2) YPK Donders	SWP	Farmer's Groups	Poor	Fair	Mixed – some locations are operating well while others are offline
(W2) LATIN	Biogas Digesters	Households	Good	Good	Use continues as anticipated, minimal repairs required
(W3A) PT Charta Putra Indonesia	Biomass Plant	District-owned Enterprise	Poor	Poor	Biomass generators largely offline since close of grant
(W2) LPPSLH	MHP	Village Government	Good	Poor	Quality of infrastructure was poor, could not maintain repairs after initial investments
(W2) Yayasan Pena Bulu	MHP	Village Government	Poor	Poor	Major repairs have not been addressed
(W2) IBEKA	MHP	Cooperative	Poor	Poor	Sub-optimal functioning has limited use, repairs needed
(W2) KKI Warsi – Jambi	MHP	Village Government	Fair	Fair	Operating below capacity, unclear if funds are available for future breakdowns
(W2) IIEE	MHP	Cooperative	Good	Good	Major breakdowns have been addressed, significant community buy-in and local knowledge
(W2) KKI Warsi – Sumatera Barat	MHP & Biogas Digesters	Village Government & Households	Poor	Fair	MHP was repaired and is operational, recently brought under a village-owned enterprise
(W3A) Akuo	Solar PV & MHP	SPV	Poor	Poor	Grantee is still supporting but looking for an exit strategy, poor outlook unless viable subsidization can be found
(W2) CU Keling Kumang	MHP & SHS	Mixed (MHP Management Team / Government / HHs)	Fair	Fair	SHS not operating well, 2 MHPs at lower than anticipated efficiency

In the remainder of this section, we discuss key factors that have influenced sustainability of grants in the CBOG-RE portfolio.

3.6.2. Addressing Maintenance and Repairs

As reported above, RE technology in several locations experienced breakdowns requiring major repairs within four years of the Compact. Dealing with major repairs is often a critical juncture for off-grid RE technologies. In the endline grantee survey, only 32 percent of grantees believed that the current owners had sufficient knowledge or access to technical support to address major repairs and less than half of those (n = 3) believed they also had sufficient finances.

Local Knowledge. Prior experience managing RE technology proved to be an understandable benefit. Of the three grants in the portfolio where MHPs were revitalized, the new management groups included individuals who managed the previous MHPs (IIEE, KKI Warsi – Jambi, KKI Warsi – West Sumatra). These groups have been able to independently handle regular maintenance and major repairs of the technology, liaising with equipment vendors and sometimes carrying out more complex repairs without external assistance. They also, in some instances, were able to leverage savings that pre-dated the Compact.

Major repair challenge handled by W2 IIEE managers: The W2 IIEE MHP was struck by lightning in early 2021 which completely shut down the grid. Management was able to coordinate with the vendor, including sending in parts for repairs, and finance repairs (IDR 20 million) out of savings accumulated over 10 years of managing the infrastructure. Operations resumed within a week of the initial failure.

Accessible Vendors. One way several grants in the portfolio addressed the lack of local knowledge was by using Indonesia-based vendors and ensuring close linkages between RE infrastructure vendors and RE managers in target communities. For grants which used Indonesia-based vendors, sometimes grantees themselves were the infrastructure providers or grantees contracted companies that had previous connections with the target locations. However, other grants have faced much longer delays in carrying out needed repairs, most of which used vendors based outside of Indonesia.

Case studies on vendor use: An example of grantees using local vendors is W3A Sky Energy where Sky Energy was the infrastructure provider for the Solar PV grids. As the manufacturer of the grant infrastructure, Sky Energy is still able to supply the SPV with needed replacement parts at factory prices. In addition, when needed they also send technicians to assist with troubleshooting or to help with installation. Another example is the W2 IIEE grant which contracted the same vendor to construct the new MHP who had constructed the previous MHP operating in the community. RE managers had a long-standing relationship with this vendor since the previous MHP was built in 2007, therefore from the outset there was no need for the grantee to serve as an intermediary between the managers and the vendor to facilitate repairs. This working relationship contributed to W2 IIEE's ability to carry out a major repair in 2021 as noted above.

The W3A Akuo Energy grant provides an example of the challenges of using foreign vendors. When our team visited the W3A Akuo Energy grant communities, the solar grids in one village had been not been operational for eight months due to burn out of one of its components. Due to conditions of the insurance policy on the grids, the damage had to first be inspected in person by an insurance agent – a process that was delayed several months due to COVID-19 restrictions on inter-provincial travel. In addition, Akuo needed to liaise with the Italy and France-based manufacturers to have the needed part sent to Indonesia. At the time of endline, the part had arrived at the village but had not been installed because a certified technician based in Italy needed to be the one to install it. During this eight-month process, electricity was provided to the community by the SPV through diesel generators and the MHP for six months, but the community was completely without power for more than one month. Even the grantee admitted that it is unlikely that the SPV could have handled this repair process without Akuo's involvement, especially liaising with foreign companies.

The problem of sourcing parts is not unique to large, complex grid systems in the portfolio, and is a consideration for all technology types. For instance, community respondents from the LAKPESDAM PBNU grant noted difficulty sourcing needed spare parts for their SHS systems, namely light bulbs. The required type of bulbs was not available on the local market and were considered to be much more expensive than traditional lightbulbs. Local volunteer technicians mentioned there are ways to adapt available lightbulbs for these systems, but that such adaptations are not ideal. As a result of this issue, many households reported not replacing burned out lightbulbs even if only one of the four are still working.

3.6.3. Financing RE

For micro-grids, ensuring a sustainable financial model can be particularly difficult to construct due to challenges in projecting demand, tariff setting and payment enforcement.

Demand. In general, micro-grids tended to overestimate demand, anticipating higher take-up and use of the technology than realized. While 86 percent of grantees in the endline survey noted that demand for the technology was as anticipated, beneficiary and on-the-ground verification revealed multiple instances where demand failed to meet expectations outlined in the grants business model. Lower than anticipated demand threatens operational and financial sustainability through reduced revenue and therefore less money for funding O&M.

Challenges faced by W3A grants due to low demand: For W3A Akuo Energy and W3A Anekatek, there was an expectation that energy demand would increase due to the expansion of home industries, which would increase SPV revenues. However, for Anekatek the grantee noted that, prior to grid shutdown, community demand for electricity was 22 percent of the grid's generation capacity. Anekatek was pursuing external subsidies to cover the shortfall but a request was denied in early 2021 after the district parliament deemed their business model unsustainable. Akuo's SPVs and the grantee also confirmed energy usage was lower than the expected rate, and the grid still had significant excess generation capacity. At endline, Auko's SPVs were still only making enough to cover regular operational costs with Akuo covering the insurance premium cost of between IDR 50 million to 70 million for each of the three villages per year (USD 3,500 to USD 4,800). Akuo is attempting to increase demand for electricity by helping the SPVs explore options to connect their grids with companies in nearby villages or start agricultural processing activities powered by RE, but it is unclear if these will progress beyond the ideation stage. As a result, Akuo is also seeking external subsidies to support the technology moving forward.

While lower than anticipated demand is particularly relevant for grid systems it also impacted RE utilization at production houses. There are multiple instances in the portfolio where production houses were either never used for intended purposes, or barely used before being abandoned. Out of 15 production houses only 5 were still operational at endline. The ability to accurately anticipate market factors was a key challenge for many grantees as noted in the **Productive Uses** section, and improper targeting of the use of the technology greatly dampened overall demand in these instances.

While these cases focus on lower-than-anticipated demand impacting funding streams, cases where demand exceeded projections were not necessarily better off or able to generate more revenue due to capacity constraints. Due to demand exceeding supply of electricity generated by the W3A Sky Energy grids, in late 2021 the SPV started implementing restrictions on increasing power of connections, and prolonged planned outages during the day to conserve battery for nighttime use. At endline, the Cooperative (51 percent owner of the SPV) and the village government were in the process or lobbying the provincial government for PLN entry due to the shortage of electricity supply from the grid. The grantee noted that the installed grid capacity was determined based on results from a needs assessment survey, and in consideration of budget. Community respondents questioned whether the needs assessment survey results should have been more closely scrutinized to understand how realistic the results were.

Tariffs. The ability to increase user fees is constrained by regulatory constraints and by user willingness to pay. Managers of RE grids need to have tariffs approved by the Ministry of Energy and Mineral Resources (*Energi Dan Sumber Daya Mineral,* or ESDM) and any relevant provincial or regional authorities. These authorities rarely allow independent tariffs to significantly exceed the rates allowed for

PLN. Rural electricity tariffs in Indonesia for PLN customers are already highly subsidized and set far below cost recovering rates, with PLN able to recover the difference through tariffs on urban consumers. Managers of independent grids do not have this option to cross subsidize. Even if higher rates could be approved, community consensus would need to be sought.

Payment Collection. Most users of electricity from solar PV and MHP grids are charging user fees, either by kilowatt hour or a flat rate by month. Information from the four endline qualitative case studies which implemented grid systems suggests that non-payment is not a significant issue, though three of the four cases were W3A case studies which use pre-paid systems. Across the portfolio, there are other examples where user fee payments are not always smooth, as is the case with the IBEKA grant where verification respondents noted that the cooperative managing the MHPs were not able to regular collect payments.

For technologies which do not have regular funding through user fees, the situation is mixed in terms of whether lack of funding has been a crucial barrier to usage of the technology. For grants which provided decentralized RE technology to households and public facilities (LAKPESDAM, Kemitraan), evidence indicates that users did not maintain dedicated savings funds and generally did not invest in maintaining these systems by replacing light bulbs, or repairing inverters or batteries. Often identifying funding to fix these issues was deprioritized due to availability of electricity from other sources. Grants which provided SWPs similarly planned for users to contribute through monthly payments. Most SWPs have not faced any major repairs, and minor repairs have been funded as needed by members of the user group. One exception is one of the W2 Burung SWPs, where a large repair of IDR 14 million was co-funded by the user group and village government. In this case, provision of clean water aligns closely with the village development priorities and the government has taken initiative to support SWP operations and even improve the infrastructure.

Role of Subsidization*.* 9 of the 22 grants responding to the online survey noted financial support from the grantee themselves or government for RE beyond initial start-up covered by the project. In many cases, funding from the village or district government is often considered as a source for external funding (or subsidy) for O&M, and the use of village funds was incorporated in some grantee's sustainability plans. The evaluation found examples in the portfolio where government has provided regular funding for operational costs or to fund discrete repairs. This differs from grid models that also tend to be heavily subsidized but with more secure revenue streams. The challenge with this funding at the local level is that it has its own process and rules. For instance, village governments are realistically only able to provide funding if infrastructure is officially the property of the government, which then excludes RE technology owned by independent cooperatives or technology for which the ownership status is unclear. In addition, government funding has its limits. For instance, most village officials mentioned that the maximum disbursement from villages funds to repair RE was IDR 20 million per year, which is insufficient for larger repairs such as wholesale battery replacement.[54] Also, government funding can take time to mobilize and requires submission of formal requests, though processes could be expedited if an official takes initiative or interest. Most importantly, unless the funds are specifically earmarked to support RE grids, funding from government is not always assured. At endline, we heard of multiple instances were funds that had been allocated for repairs were repurposed for COVID-19 relief, including the district

[54] Government officials in areas where W3A Anekatek and W3A Charta Putra operated originally allocated some funding towards O&M before making the determination that the total amount required for investment was not justifiable and subsequently withdrew all funding.

subsidy which was supposed to support the W3A Anekatek SPV though 2024 until the grids could be self-sustaining.

3.6.4. Operating Environment with PLN

During site selection processes for most grants, efforts were made to select locations where PLN entry seemed unlikely in the near term to minimize overlap between PLN services areas and areas targeted for RE provision. One exception are grants which exclusively provided SWPs, and biogas reactors. In these cases, PLN electricity is not in direct competition with intended use.

As noted earlier, despite efforts to minimize overlap between the PLN grid and provision of RE technology, a few grants needed to adjust to PLN grid entry into target communities. In the case of the W2 LAKPESDAM-PBNU grant, due to PLN entry into one of the three target villages prior to grant implementation, the grant pivoted to providing SHS to only the eight most vulnerable households in the community who would not be able to afford PLN electricity. In another village, PLN entered after grant implementation, and SHS systems are now mostly used as a more affordable backup source for lighting. Therefore, the RE technology is still being utilized, though the long-term prospects for use are questionable since users are not investing in O&M of their systems. The W3A Puriver grant is another case where a grant attempted to adapt to PLN entry by selling electricity from the solar grids to PLN. The grant was unsuccessful as incoming SPV management were unable to complete the needed steps to finalize a Power Purchase Agreement with PLN and the infrastructure was never used. While the issue might have been resolved through negotiation and collaboration between the SPV and PLN, SPV members were not capacitated to manage these negotiations, and the grantee did not support after completion of the project period, citing bankruptcy. Only one other grant in the portfolio noted interactions with PLN to potentially set up an agreement. An SPV member from the W3A Akuo Energy grant mentioned that PLN once offered to purchase electricity from their grid at a rate of IDR 1,000/kWh (30 percent lower than the SPV's tariff rate). The SPV declined this offer as it was deemed too low to be considered profitable. PLN stakeholders noted that regulations govern the range of feed-in tariffs they can offer.

For other W3A grants (Anektatek, Akuo Energy and Sky Energy), grantees ensured the legal grounding of the SPVs' sustainability by obtaining business licenses to be the sole providers of electricity within their areas of service for an effective period of 20 years. This means that no other entity, including PLN, would legally be able to serve the areas covered by the mini-grid so long as these business licenses stand. In cases where grant technology is not operating or operating sub-optimally, these licenses have the potential to become a barrier to locations receiving access to electricity. While sole business licenses can be useful for carving out business areas which allow RE a chance to operate without competition, these cases demonstrate the importance of ensuring adequate support for the RE technology so that the license does not serve as a barrier for electricity access if the technology does not operate as planned.

W3A grants and PLN entry: For example, PLN had recently entered villages close to the five villages which were served by the W3A Anekatek RE grids prior to grid shutdown in 2020. Stakeholders note that PLN could have potentially entered Anekaktek areas if the sole business license was not in place. Community members are aware that the SPV has a business license that prevents PLN entry, and that the community has made an investment in the solar PV (by providing labor or land during construction), but still many individuals noted that their priority is to have access to electricity, irrespective of the source.

In another case, due to the prolonged outages due to excessive demand, the W3A Sky Energy cooperative which has 51 percent ownership stake in the SPV, and some village officials have started the process of lobbying to remove the business license and allow PLN to provide electricity to the island.

3.6.5. RE Ownership

The evaluation did not find strong evidence that specific ownership models were more sustainable than others (village government, BUMDes, SPV etc.). Instead, sustainability was more likely to be influenced by how well the grant's business model anticipated and mitigated potential issues post-implementation (technology failure, demand-related challenges, PLN entry, etc.), including the provision of external technical and financial support. However, while the final ownership model itself may have not influenced a grant's sustainability, in certain instances there were challenges in the *transfer* of ownership post-Compact that had implications for sustainability.

At endline, key community level stakeholders from six grants, including the intended owners (village officials, BUMDes representatives, SPV members etc.) reported lack of clarity on RE infrastructure ownership.[55] For village officials in particular, this lack of clarity was cited as the main reason why needed repairs had not been completed. All RE technologies in the portfolio were handed over from grantees to Bappenas who temporarily assumed ownership of assets prior to handing them over to the intended owners (e.g., SPV, village government, BUMDes etc.). In most cases, this handover process was completed by endline, while in a few instances it appears that key stakeholders still lack clarity on infrastructure ownership. For instance, for two of the three Burung SWPs, concerned village officials noted they were unclear about the current status of infrastructure ownership and assumed that the SWPs were the property of the grantee. As a result, they had not carried out minor repairs or made planned improvements to the SWPs to add distribution pipelines. In reality, local grantee staff and district Bappeda noted that the handover paperwork had never been provided to the village officials though it had been prepared.

The W3A Charta Putra grant also faced challenges during the transfer of ownership. Like other W3A grants, the infrastructure was planned to be managed by an SPV, with the grantee retaining 49 percent ownership stake. However, plans were changed when the grantee informed MCA-I that they could not continue their engagement with the project because they had run out of funding. Therefore, sole ownership of the plants was transferred to the district through a district-owned enterprise. According to the grantee, the sustainability of the infrastructure was highly dependent on their continued involvement in operations as biomass plants require more technical expertise to operate optimally.

[55] W2 Burung, W2 IBEKA, W2 LPPSLH, W2 PEKA, W2 Yayasan Pena Bulu, W3A Puriver

The SPV Model under W3A

The relative benefit and viability of the SPV model for infrastructure ownership remains unclear. The SPV model was intended to promote long-term sustainability of the RE systems as well as promoting community buy-in of RE by employing a hybrid ownership model involving village/district-level entities, and the grantee. For W3A grants that are still operational, grantee support has played an important technical and financial role in ensuring ongoing operations. Also, some of the systems set up under the SPV model (e.g., pre-payment) ensured regular revenue streams and helped enforce payment compliance. In addition, SPV members and operators are generally viewed favorably by community members and deemed competent and knowledgeable. This was even the case in W3A Anekatek communities where the grids had not been operational since December 2020.

However, three of the five SPVs were completely non-operational at endline and the two remaining were struggling to recover costs. While difficult to compare W3A grants to others in the portfolio given their scope (W3A grants were, on average, 10 times more expensive than other grants in the portfolio) it is clear that when taken as a group, their end outcomes were not significantly better than the portfolio as a whole.

3.7. Implications for Post-Compact ERR Estimation

The discussion thus far has focused on portfolio-level findings related to guiding evaluation themes. In this section, we focus on the six endline case study grants and comment on what the findings imply for the main benefit streams in the ERR for each grant. We limit the discussion to the endline case study grants as these are the grants for which the ET has the most recent and comprehensive information needed to comment on the implications of endline findings for intended the benefit streams.

Table 12: Perceived Status of *Ex Ante* ERR Main Benefit Streams

Grant	ERR Main Benefit Streams	
W3A Anekatek	Consumer Surplus, Electricity Access	⊘
	Reduced Expenditure, Energy Consumption	⊘
W3A Akuo Energy	Consumer Surplus, Electricity Access	✓
	Reduced Expenditure, Energy Consumption	⊘
	Increased Income/Reduced Cost, Productive Use	⊘
W3A Sky Energy	Consumer Surplus, Electricity Access	✓
	Reduced Expenditure, Energy Consumption	?
	Increased Income/Reduced Cost, Productive Use	✓
W2 IIEE	Reduced Expenditure, Energy Consumption	?
	Increased Income/Reduced Cost, Productive Use	✓
	Increased Income from edu-tourism and MHP Workshops	⊘
	Increased Income, Education Improvement	?
W2 LAKPESDAM-PBNU	Consumer Surplus, Lighting Access	✓
	Reduced Expenditure, Energy and Water Consumption	✓
	Increased Income/Reduced Cost, Productive Use	⊘
W2 Burung	Unknown	?

For the Window 3A grants, the largest benefit is the consumer surplus, as calculated by customer willingness to pay, resulting from increased access to, and consumption of, electricity. Access to electricity has definitively increased in targeted areas for both the Akuo Energy and Sky Energy grants. Qualitative evidence on electricity consumption is mixed with some respondents noting increases in consumption after RE provision, and others noting their consumption has remained constant.

On energy expenditure, findings at interim for Akuo Energy were that energy expenditures had not reduced despite reductions in fuel consumption. Electricity tariffs are unchanged at endline, and respondents did not note any reductions in electricity consumption, so we assume that reductions in energy expenditure have not manifested. For Sky Energy, the evidence is less clear. For most respondents, energy expenditure is relatively unchanged, with some noting slight reductions or increases in spending. On productive use, while marginal expansion of business since interim was noted in Akuo Energy communities, the more intensive productive uses of electricity envisioned in Berau have yet to manifest. In Sky Energy communities, some small business expansion has occurred, but these gains may stagnate in the near future if the capacity of the grid cannot be increased. At endline, a few business owners already mentioned losses due to the daily planned outages, especially those selling frozen goods. Still, given that consumer surplus accounts for nearly all these grants' ERR, the absence of other anticipated outcomes may not prevent them from exceeding the ten percent threshold for justifying MCC investment. Since the Anekatek grids were only functional for less than two years, it is highly unlikely that the grant's ERR will cross the ten percent threshold unless a solution is identified to restore grid operations.

Similar to the Sky Energy case, changes in energy expenditure are unclear for the IIEE case. Those connected to previous MHP report slight increases in energy expenditure, while expenditure changes for those previously unconnected were dependent on previous sources of energy (e.g., generators, kerosene lamps etc.). While benefit streams related to increased income through productive use have likely manifested in some magnitude due to modest expansion in small businesses, the failure of the coffee processing aspect planned by the grant likely calls for a reduction in the estimated magnitude of this benefit stream. The ERR also assumed income benefits starting in year 1 from "edu-tourism" and from MHP workshops held at the Center of Knowledge established by the grant. These activities had yet to start at endline. Lastly, the ERR assumed that electrification would indirectly improve education outcomes for current students due to electrification of the elementary school and improved lighting at home for studying. In the long-term, the ERR assumes this will translate to higher incomes starting in year 12. While the elementary school was receiving electricity from the MHP at endline and pre-school classes were being held at the CoK, the ET does not have enough information to comment on whether the expected benefits are plausible. While benefit streams related to increased income through productive use have likely manifested in some magnitude,

For the LAKPESDAM-PNU grant, the benefit streams related to lighting access and energy expenditure are likely still positive though potentially smaller in magnitude than originally assumed. Though most households now have alternative electricity sources, they still perceive benefits from using SHS as a back-up source (including cost savings). Apparent lack of investment in O&M of SHS indicates that expenditures to maintain these systems have been minimal, but the lifetime of these systems may be shorter than anticipated as a result. In the two locations where solar-powered water purification businesses have been established, community members also noted savings relative to previous clean water sources. The majority of benefit streams related to increased income through production use have not manifested and are unlikely to develop in the future. The grant attempted to promote multiple income generating activities, including water purification, coffee processing, snacks production, chicken egg hatching and briquette making (not RE dependent). Of these, only water purification is ongoing, and the other efforts did not progress beyond a trial period.

Finally, our evaluation cannot comment with the information available on the credibility of the Burung ERR. We were unable to obtain a relevant ERR calculation on which to comment for this grant.

Across these grants, it is plausible that the COVID-19 pandemic played a role in hindering realization of expected benefit streams, especially those related to productive use and the IIEE stream related to edu-tourism. Once pandemic-related restrictions and market slowdowns subside, future prospects for realization of these streams may improve.

For all grants in the portfolio, however, the ERRs generally assume benefit streams lasting 20 years or more based on the intended lifespan of the funded infrastructure. It remains to be seen if these outputs will be sustained for so long. Already at endline, only four years after commissioning, RE technology associated with 26 percent of grants (6 of 23) was completely non-operational, and technologies associated with a further 57 percent of grants (13 of 23) were operating sub-optimally (as discussed in the **RE Infrastructure Functionality Post-Compact** section). The functional status of technologies across the portfolio at endline calls into question whether many of the grants in the portfolio would cross the ten percent threshold to justify MCC investment.

3.8. Synthesis of Findings and Policy Implications

Most grants in the CBOG-RE portfolio share features that are typical for electrification projects based on decentralized RE sources and have important influences on sustainability, as diagnosed in this report. **Decentralized RE projects are often implemented under some sort of market-based paradigm, based on the assumption that this ensures sustainability through creating long-term financial incentives.** Often, realization of these long-term financial incentives is contingent on being able to charge a cost-covering tariff and revenue growth from increasing demand (e.g., from new customers, increased consumption from existing customers for households use, or growth of economic activities using RE). However, even if assumptions related to future revenue growth are sound, these financial gains can take time to manifest. **Hence, reliance on a market-based paradigm assumes that RE managers are able to maintain continuous service delivery by carrying out needed O&M and that the RE infrastructure is able to weather any critical O&M challenges that might arise in the short and medium term.**

Findings from this evaluation related to the functionality of RE infrastructure post-Compact suggest that many technologies in the portfolio have not been able to successfully manage these challenges. Generally, where CBOG RE assets are functioning, it is because grantees continue to provide support for managing O&M (e.g., W3A Akuo, W3A Sky Energy), infrastructure is managed by individuals with prior RE management experience (e.g. W2 IIEE, W2 KKI Warsi), or the infrastructure has yet to face a critical O&M challenge necessitating major repairs (W2 JAVLEC, W2 CU Keling Kumang). With RE infrastructure associated with 26 percent of grants completely non-operational and RE infrastructure associated with just 17 percent of grants fully operational across the grantee portfolio just four years after technology commissioning, it is important to identify common challenges faced across grants and approaches to mitigating these challenges in similar projects in the future.

The implementation context of the CBOG-RE grants is similar to those of other decentralized RE projects. They are located in remote areas far away from the centralized grid (at least during the design phase) and, as a consequence, are also far away from other infrastructure like roads. Access to markets for agricultural products is difficult and non-agricultural incomes are largely absent. **Therefore, decentralized RE projects typically serve a target population with a low ability to pay.** At the same time, transaction costs of running a business in the regions in which decentralized RE projects are typically implemented are very high. Reasons range from underdeveloped financial services, a lack of technically trained staff, lack of spare parts, to high transportation costs and rough weather conditions that often damage the RE infrastructure. **Under these conditions, maintaining the RE infrastructure is challenging.** In addition, demand-side management of collecting is also costly and difficult including collecting user payments and identifying new customers. This leads to a dilemma: under a market-based paradigm these high costs would require very high tariffs to sustain operations, which is at odds with the low ability to pay in the communities and sometimes with government regulations.

Our findings suggest that financing of RE has, indeed, been a major challenge across the portfolio. For RE grids, low tariffs, variable payment compliance and low electricity demand

patterns in the communities, jeopardize the profitability and long-term sustainability of the mini-grid schemes reliant on revenue from users. Even in the best-case scenario of near 100 percent payment compliance, grids are unable to accrue savings, let alone profit. For instance, while the operational W3A grants (Akuo and Sky Energy) have been able to overcome the challenge of enforcing timely payment from customers by implementing pre-paid metering systems, tariff rates have been restricted to not exceed rural PLN rates even though PLN rates are highly subsidized. As a result, SPVs and other operators are only able to collect enough revenue to meet operational costs. For non-grid technologies, intended savings schemes have largely not been implemented and infrastructure functionality is dependent on user groups sourcing funds for repairs on an *ad hoc* basis. Success of this approach is variable. Decentralized solar systems (SHS for homes, standalone solar PVs for public facilities) have largely been used until they become defunct without investments to re-operationalize them, while some SWPs have been actively funded by village government and user groups for meeting multiple objectives (agriculture productivity and clean drinking water). Some grant technologies have received government financing, especially technologies under village government or BUMDes management, but these funding streams have their limitations. **In sum, the financing of RE infrastructure across the portfolio is precarious leading to a situation where technologies are often abandoned when the first O&M challenge cannot be resolved.**

As noted in the Sustainability section, the actual logistics of accessing vendors for major repairs and parts replacement has proven a challenge for many grants, especially those funded through the 3A Window which used foreign vendors. **Lack of availability of needed parts or technicians to resolve O&M problems locally has added to the challenge of maintaining RE technology by introducing extra barriers to accessing needed support.** In these situations, community managers are either reliant on the grantee facilitation, or issues are left unresolved leading to technology operating sub-optimally (or not at all).

The modest results related to productive use of RE across the portfolio largely aligns with literature on the effects of electricity provision on economic conditions in these types of environments (Lenz et al. 2017; Peters et al. 2013; Peters and Sievert 2015). Improving the overall economic situation in a community, particularly in more remote areas, relies on factors beyond electricity provision, and these grants were not designed to alter prevailing market conditions. However, the large number of unused and non-functional production houses funded through the portfolio does suggest a need to refine planning and implementation approaches for this subset of RE interventions. This is particularly important for grants that only establish productive use infrastructure, without additional components aimed at providing RE to the community (W2 PEKA, W2 Yayasan Dian Tama). Grantees often noted needing more time to train and sensitize community members on proposed economic activities to promote behavior change and encourage uptake. Aside from longer implementation timelines, it appears that future grants focused solely on promoting use of RE for economic purposes would need to apply a more intensive market research approach to identify potential opportunities and viable opportunities for market linkage.

Issues faced by CBOG RE grants in financing, accessing vendors and misalignment of productive use plans with context all point to the need to better ensure that grants have a realistic business and operational model in place at the design phase. For financing, this would mean a closer scrutiny of demand, tariff and cost assumptions and inclusion of explicit contingency plans for financing in case expected user revenue does not materialize. For equipment and vendor selection, this might entail building into the initial procurement process a requirement to consider if intended owners of the infrastructure would be able to liaise with selected vendors. The design of grants focused exclusively on promoting RE use through production houses or other small-scale enterprises would likely need to include more intentional interventions for market assessment during planning and market linkage during implementation to encourage use of the technology.

Planning for potential entry of the national grid into areas served by RE technology is another important element to consider. At endline, PLN had only entered areas served by grants which provided non-grid solar systems and RE was either abandoned or still used as backup (W2 LAKPESDAM-PBNU, W2 Kemitraan). Except for the W3A Puriver grant, no other RE grid had encountered direct interaction with PLN. For W3A Anekatek, Akuo and Sky Energy, the sole business licenses established continued to protect these areas from PLN entry. As PLN continues to expand its grid, the potential for interaction between RE and PLN service areas will only increase calling into question what will happen to the RE technology.

Grants in this portfolio employed a range of RE technologies and management models. Though the evaluation did not find any clear patterns on how these choices may have influenced sustainability, a few points are still worth mentioning. The first is that grants that implemented SWPs and group-managed biogas digesters appear to have relatively better sustainability outlooks at endline, perhaps due to the technology being simpler than solar or MHP systems or their usage by a discrete group of users. While these technologies may not meet the objective of electrification, they still show the value of considering certain small-scale RE investments when planning RE programming. The second is that the relative benefit of the SPV management model for mini-grids is unclear. Grantee support has played an important role in ensuring ongoing operations for W3A grids functional at endline. Still, when the five W3A grants are considered as a whole, their end outcomes were not significantly better than other grants.

Though certain grants appear to be more sustainable than others at endline, even the best performing technologies at endline have uncertain long-term sustainability prospects, primarily due to lack of dedicated financing for major repairs. Hence, for future projects, planning for sustainable financing schemes for O&M appears to be of utmost priority. Most mini-grid programs, including the CBOG-RE portfolio, have tried to promote RE use by subsidizing the upfront capital investment costs for infrastructure, sometimes complemented by subsidized O&M activities and/or funding larger repairs on an ad hoc basis. Yet, absent a rigid long-term contractual commitment this does not create incentives or an institutional setting which ensures sustainable operations after 3, 5 or 10 years, especially in a context where those who plan and construct the infrastructure are not the ultimate managers.

However, subsidization of O&M is often not considered at the proposal or design stage of many RE projects. Instead, it is assumed that sufficient revenue will be collected from RE users without pre-determined and secured subsidy streams in case of revenue shortfall. By applying more effective planning tools to scrutinize business plans of potential RE projects, project funders and implementers can proactively identify revenue constraints and adjust project design accordingly (see Peters, Sievert and Toman (2019)).

A potential approach for funding agencies like MCC to consider is to work on sustainable subsidy schemes that not only make possible the initial investment, but also ensure the sustainable operation of mini-grids. Potential "sustainable subsidies" designs should be in the spirit of results-based financing (RBF) approaches, but with 'results' that are based on sustainable mini-grid operations in the mid- or long-term. The RBF would require additional funding from a donor, the government, or any other funding agency. While many energy access RBF schemes incentivize initial connections only, a sustainable subsidy scheme would require an RBF that incentivizes sustained connections. For example, by monitoring the number of connections for 5 or 10 years. Alternatively, some sort of kWh-based subsidy can be implemented, akin to a feed-in tariff, with an important difference in that here we would want to subsize the kWh that reaches a consuming HH or enterprise. Both design options are not easy to implement and require a profound examination in the planning phase. It is also obvious that this will make mini-grid projects more expensive in the first place, but eventually more successful and cost-efficient in the long run. Though MCC's 5-year investment window may make funding long-term subsidy schemes challenging, other options could be considered such as setting up an endowment or securing commitment from the in-country government partner for setting aside funds for subsidies.

4. NEXT STEPS AND FUTURE ANALYSIS

4.1. Dissemination Procedures

This report will be disseminated to MCC and Indonesian stakeholders for review and comment. A finalized version of this report will be made available on MCC's Evidence Platform. In addition, a presentation of findings will be made to stakeholders in Jakarta, Indonesia, including the post-Compact monitoring and evaluation (M&E) partner, Bappenas. A presentation to MCC will follow.

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6. ANNEXES

6.1. Stakeholder Comments and Evaluator Responses

Table 13: Stakeholder Comment and Evaluator Responses

Reviewer Institution / Role	Page Number	Comment	Evaluator Responses
MCC/ Evaluation Lead	iv	In the Evaluation Approach section of the Exec Summary, I think it's important to note that the final design had to shift at the start of data collection due to discoveries about operability. I'd like the reader to understand that we had planned on a quantitative component to this evaluation.	Context on removal of the quantitative component has been added.
MCC/ Evaluation Lead	vii	When discussing key factors for sustainability and O&M, I suggest reflecting on the SPV mechanism of W3A since I was designed to address this. I think this will be a key question from GoI stakeholders and should be answered up front, i.e. what about the SPVs? Update after reading on: You could bring in this statement from page 51 of the report (or something along these lines) into the exec sum: *The evaluation did not find strong evidence that specific ownership models were more sustainable than others (village government, BUMDes, SPV etc.). Instead, sustainability was more likely to be influenced by how well the grant's business model anticipated and mitigated potential issues post-implementation (technology failure, demand-related challenges, PLN entry, etc.), including the provision of external technical and financial support.* Or this from page 52: *However, three of the five SPVs were completely non-operational at endline and the two remaining were struggling to recover costs. While difficult to compare W3A grants to others in the portfolio given their scope (W3A grants were, on average, 10 times more expensive than other grants in the portfolio) it is clear that when taken as a group, their end outcomes were not significantly better than the portfolio as a whole.*	This content has now been integrated into the "Key Factors influencing sustainability" paragraph of the Executive Summary.

MCC/ Evaluation Lead	4	In this sentence: "As MCC later came to delineate GP Grant Portfolios by subject matter rather than funding window, the CBOG RE Grant Portfolio included 24 total grants, including one from Window 1, 18 from Window 2, and five from Window 3A." Please reference MCC and MCA. MCA actually did this categorization more than MCC.	Noted and revised.
MCC/ Evaluation Lead	4	Footnote 19 - similarly, the ITT is technically MCA's not MCC's. Suggest saying the Compact's closeout ITT.	Noted and revised.
MCC/ Evaluation Lead	4	It seems relevant to note that a feature of W3A was also the SPV mechanism. That was a big difference between those OG grants vs the ones in W1/2	Added clarification that another feature of the W3A grants was the SPV approach to ownership.
MCC/ Evaluation Lead	5	Table 2 - please provide the total disbursement for the full portfolio. This figure will need to be referenced in the EB and should also be referenced in the Exec Summary and intro (where you talk about the value of the Compact).	Added total disbursement to Table 2 and included this number to the "Project Background" section in the ES. Also added this number at the outset of section 1.2 in the Introduction.
MCC/ Evaluation Lead	8	I would bring footnote 22 into the main body of the text. The points in the footnote reflect some experiential learning on implementing eval.	Footnote is now in main body of text.
MCC/ Evaluation Lead	27	Refer to the Compact's closeout ITT	Noted and revised.
MCC/ Evaluation Lead	42	Under 3.6 call out, there's a typo: "optimist" instead of "optimistic"	Thank you - typo has been corrected.

MCC/ Evaluation Lead	53	I thought the consumer surplus approach depended on consumption of electricity, not just access. Related to this statement: *For the Window 3A grants, the largest benefit is the consumer surplus, as calculated by customer willingness to pay, resulting from increased access to electricity. Access to electricity has definitively increased in targeted areas for both the Akuo Energy and Sky Energy grants.*	We've now edited the text to indicate that consumer surplus depends on both access and consumption. The updated text also includes clarification that evidence on expanded access is clear, while qualitative evidence on consumption changes was mixed at endline. "For the Window 3A grants, the largest benefit is the consumer surplus, as calculated by customer willingness to pay, resulting from increased access to, and consumption of, electricity. Access to electricity has definitively increased in targeted areas for both the Akuo Energy and Sky Energy grants. Qualitative evidence on electricity consumption is mixed with some respondents noting increases in consumption after RE provision, and others noting their consumption has remained constant."
MCC/ Evaluation Lead	54	Typo: In the two locations where solar-powered water purification businesses have been established, community members **noted** also noted savings relative to previous clean water sources.	Thank you - typo has been corrected.
MCC/ Evaluation Lead	55	Suggest including some/all of this in exec summary: *For all grants in the portfolio, however, the ERRs generally assume benefit streams lasting 20 years or more based on the intended lifespan of the funded infrastructure. It remains to be seen if these outputs will be sustained for so long. Already at endline, only four years after commissioning, RE technology associated with 26 percent of grants (6 of 23) was completely non-operational, and technologies associated with a further 57 percent of grants (13 of 23) were operating sub-optimally (as discussed in the RE Functionality Post-Compact section). The functional status of technologies across the portfolio at endline calls into question whether many of the grants in the portfolio would cross the ten percent threshold to justify MCC investment.*	We've now included this content under a "Summary implications for post-Compact ERR estimation" subsection in the Executive summary.

MCC/Econ		The executive summary lacks a high-level diagnosis or narrative regarding the overall failure of the investments to be sustained over the medium term (or, more broadly, their success or failure). It is well understood that the problems encountered by different investments across the portfolio may be unique, but the evaluation does suggest a number of potential themes without an overall narrative. E.g., what aspects of the program's theory of change might have been flawed in conception or failed in execution? Please see my next comment, which is related.	A key issue that may have contributed to failure may have been the diversity of the portfolio – each of the 23 grants has drastically different budgets, RE technologies, management approaches, and target beneficiaries. As a result, the project logic was high-level and did not capture the nuance of the different outputs, outcomes and assumptions related to ensuring continued O&M of these systems. The logic notes that local capacity for O&M would be improved, RE would be handed over and operated, leading to reliable RE provision. Each grant developed its own tailored O&M approach but it doesn't seem that these approaches sufficiently accounted for common O&M challenges – such as financing and repairs. In the "Key factors influencing sustainability" subsection of the Executive Summary and sections 3.6.2 – 3.6.5 we discuss the high-level themes that emerged from the evaluation that seem to apply to most grants. At the outset of the Findings and Conclusions in the Executive Summary, we've also added the following to explicitly link with the relevant aspect of the GP logic:"Managers of most operational technologies still face significant challenges in maintaining operations, **showing that a key aspect of the GP project logic was not achieved ; namely that "power plants would be handed over, operated and maintained by local entities with full community participation" contributing to "reliable community-based RE provision".**

MCC/Econ	Executive Summary	Regarding the poor sustainability outlook for these RE off-grid investments, more focus needs to be placed on the discussion around low levels of demand and economies of scale for these systems, as this was an early criticism for any approach using mini-grids. For example, on page vi, the evaluation notes that "*Lack of funding was often cited as the primary reason why repairs had not been addressed*" while also noting, in a disconnected manner that "*we find limited growth in businesses providing higher-value goods and services*." The implication one might take away seems to be that without "anchor clients" with "productive economic uses", the infra cannot generate sustained user fees to fund maintenance. Is this SI's conclusion? If so, please say so clearly. If not, please provide a clear hypothesis (with supporting facts).	We do not necessarily conclude that without anchor clients infrastructure cannot generate sustained user fees to fund maintenance. Although we agree that anchor customers could be a significant contributing factor to sustainability, we do not have evidence to unequivocally state that they are a requirement for sustainability. Indeed, we do not discuss anchor customers in this report because it was not identified by respondents as a key sustainability factor for many of the grants in the portfolio. Often, the generation capacity of the RE was just enough to support household users and may have been insufficient for large anchor customers. Also, given the highly remote nature of many communities, anchor customers simply did not exist or efforts to set up anchor customers through production houses did not succeed (as discussed in 3.4.2). Because of these factors, we focus our discussion on the need for sustainable subsidies. In the "Key factors influencing sustainability" section of the Executive Summary, we do discuss the common challenges in financing RE operations that were observed.

MCC/Econ	vii	From **Considerations for future RE programming**: "*Considering the poor functional status of grant infrastructure across the portfolio and ongoing O&M challenges faced by operational technologies, planning for sustainable financing schemes for O&M appears to be of utmost priority when considering designs for future projects. Most mini-grid programs, including the CBOG-RE portfolio, have tried to promote RE use by subsidizing the upfront capital investment costs for infrastructure, with less attention given to subsidization of O&M. Sustainable subsidy schemes, for example using a* ***results-based financing approach, are an option for funding agencies to consider that provide funding for the initial investment, but also ensure the sustainable operation of mini-grids.*** *Such sustainable financing schemes could also indirectly mitigate the other sustainability challenges noted above by incentivizing project implementers to more closely scrutinize their proposed business plans to ensure their practicality.*": This is an interesting suggestion that bears some further explanation (since RBF is just a tool which, by definition, cannot be sustained once the donor leaves). So, could you elaborate? What behavior do you anticipate could be incentivized that would result in improved sustainability? If your position is simply that RE mini-grids need sustained subsidies (as mentioned on p.3 when citing Urpelainen), please say so directly (as such a mechanism cannot be funded by MCC due to the limited 5-year investment window). If there is another mechanism beyond subsidization for ensuring sustainability, please be specific.	Our position is that some sort of sustained subsidy is needed, and RBF is one option that provides funding while also incentivizing managers to deliver quality service to RE users. Behaviors that might be incentivized through RBF schemes are preventative maintenance and other investments into long-run sustainability (such as demand generation). Understandably, due to the limited timeframe for MCC support, ensuring long-term subsidies is challenging. That said, perhaps alternate avenues for ensuring long-term subsidies beyond MCC involvement could be explored such as enabling in-country government partners to disburse these subsidies. Subsidies could be funded by a fund endowed by MCC/other donors. Or perhaps some of the funds contributed by the host country government to the project/compact could be earmarked for long-term subsidies, thereby guaranteeing some long-term support for O&M. If MCC will continue pursuing investments in these types of offgrid energy projects, we believe it will be crucial to integrate provision of long-term subsidies into the design given the findings from this evaluation. When MCC makes investments to support on-grid electricity, country governments often continue supporting these systems by offering subsidized tariff rates so it's not unreasonable for governments to subsidize offgrid electricity. We've added the following to the ES and the Policy Implications section "Though MCC's 5-year investment window may make funding long-term subsidy schemes challenging, other options could be considered such as setting up an endowment or securing commitment from the in-country government partner for setting aside funds for subsidies."

MCC/Econ	vii	Regarding the using of subsidies to improve sustainability, please discuss how this might change based on the consumption "Tier". For example, are systems with that reach higher tiers more sustainable? Which tier of access is necessary to bring in more productive economic uses (if any)? How would these conclusions affect your recommendations? The discussion of consumption Tiers in section 3.4.1 is helpful and it may be beneficial to highlight how these observations impact conclusions.	The evaluation did not collect sufficient evidence to answer these questions on the relationship between consumption tiers and sustainability, and there are numerous factors aside from consumption tier that influenced sustainability in the portfolio making it difficult to extract conclusions or specific recommendations. As discussed in section 3.4.1., we did find that technologies which provided Tier 2+ access seemed to enable greater productive use than technologies that provided Tier 1 access. However, it is not likely that technologies that reach higher tiers would necessarily be more sustainable given the context (rural and remote villages) where demand potential may be limited.
MCC/Econ	Executive Summary	The ES and text make clear that there were some (4-6) successful grants (in the sense of being operational or operating optimally). Within the framework of the evaluation questions, what lessons can be drawn from these successful examples? E.g., what factors do these examples each have in common that might explain the relative success? A table highlighting factors leading to success or failure would be helpful, especially in conjunction with a better narrative.	To clarify, in the "Portfolio-wide sustainability outlook" subsection of the Executive Summary, and section 3.6.1. in Sustainability, we highlight 2 grants that are relative success cases and have strong sustainability outlooks (W2 IIEE, W2 LATIN). These two grants are unique cases from which broadly applicable lessons are difficult to draw. Still, we do describe the specific factors contributing to their success in section 3.6.1. Also, at the end of the "RE functionality post-Compact" subsection of the Executive Summary, we highlight which types of grants have managed to perform relatively well. In general, there are stronger lessons to be learnt from the challenges faced by grants in the portfolio rather than the few relative success cases observed at endline.
MCC/Econ	7	For ease of reference in table 3, could you note which grants are no longer operating or are no longer operating efficiently (or which no longer produce all the anticipated benefits to the extent that this is known).	A column has now been added to the table to clarify operational status of each grant. The categorizations match what is provided in the Evaluation Brief, and in the RE Functionality Post-Compact sub-section.

MCC/Econ	28	"*Our interim evaluation found that, though higher-powered connections were available,* ***most households opted for Tier 1 connections due to low willingness to pay*** *for electricity indicating that there are factors outside of access which determine electricity consumption.*" While it is noted that this was discussed in the interim report, this is an important challenge that undercuts the economic viability of these projects. Given that some readers may only read the final report, perhaps this (and potentially other) lessons from the interim evaluation should be consolidated into a single section and/or discussed in the executive summary.	We've edited the quoted sentence to clarify that this particular finding was from the interim evaluation of the W2 IBEKA grant (not an overall finding of the interim evaluation). In the executive summary, we've added references to findings from the interim evaluation, where appropriate. We've also included a summary of findings from the interim evaluation in as an Annex (see section 6.4), and links to the interim evaluation brief and report.
MCC / M&E Lead	iv	Project background language - suggest adding (i) a footnote to reference the project logic or annex, (ii) the actual objective(s) for GP should be stated to highlight the link to the compact goal	We've added a footnote to reference the GP Project Logic Figure which is in the body of the report, and have included the GP objectives in the text.
MCC / M&E Lead	iv	Evaluation Approach - The evaluation type (performance) should be stated here. The shift from the planned impact evaluation should be noted or footnoted for reference.	Information on evaluation type and context on the shift in evaluation approach have been added.
MCC / M&E Lead	v	Table 1: Suggest adding a column with commissioned dates for reference	We do not have commissioning dates for all RE technologies in the portfolio. Also, grantee documentation often has differing information on handover and commissioning dates. We've added a footnote to specify the date when the final CBOG RE technologies were commissioned, to provide the reader an idea of timeline and exposure period.
MCC / M&E Lead	v - vi	*RE Functionality post compact* - regarding the 6 grants that amount to 50% of RE investments, can we indicate/ specify if these were the same RE technologies or a mix of RE technologies? Based on the breakdown, the 13 grants that are "somewhat operational or non-operational" should also be highlighted in this section in terms of costs and share of the investment portfolio.	We've added additional information in the text to clarify that the 6 non-operational grants implemented a variety of RE technologies. We've also included information on cost and investment share for the balance 13 grants that were partially operational/operating sub-optimally.

MCC / M&E Lead	vi	Outcomes from RE provision for domestic use - given the findings from the interim, could categorize/ describe these as medium to long term outcomes? The interim assumed continued use to follow up at endline, but since they are now contingent on functionality it might help connect the two reports.	We would be hesitant to classify these as long-term outcomes since the endline is only being conducted 4 years after RE commissioning and infrastructure was intended to operate for a longer period (10 -20 years). An example of a longer-term outcomes suggested by the project logic might be increased incomes from productive use of RE. The interim evaluation found evidence of medium-term outcomes from electricity provision for the three W3A and W1 grants evaluated. At endline, the evidence suggests that medium-term outcomes have not been sustained for many grants due to issues with RE infrastructure functionality. We've updated the text to refer to medium and long-term outcomes. We've also included a sentence referencing the interim findings related to outcomes from RE provision for domestic use to help link the two reports.
MCC / M&E Lead	vi	Please double check the ITT and confirm the source of "10,940 RE" users is accurate.	Adjusted the number to 9,095 to match the "Number of customers added" from the closeout ITT.
MCC / M&E Lead	vi	Footnote 2 is missing additional text	Thank you - text has been rectified.
MCC / M&E Lead	1	Suggest adding a footnote to the "MCC funded a five-year 474 million compact" to indicate this was 79% of the original 600 million compact signed.	This footnote has been added.
MCC / M&E Lead	9	Evaluation Questions - suggest stating the EQs here. Alternatively they could be numbered in the EQ mapping table to highlight the references to the baseline/ interim and the expansion from the case studies and portfolio wide review	EQs have now been numbered in the mapping table to facilitate reference to the full EQ text in the Evaluation Questions Annex.

MCC / M&E Lead	18	Limited access to full proposal documentation - was this consistent along the entire portfolio or specific to certain windows or technology types?	This was fairly consistent across the portfolio with no clear patterns based on funding window or technology type. Generally, we were able to obtain more complete documentation for Anekatek, Akuo Energy and the grants that were included as case studies because our team conducted more intensive follow-up with these grantees. For all other grants, access to proposal documentation was grantee-dependent: some had complete documentation which was shared with the ET while others did not.
MCC / M&E Lead	20	Suggest providing additional information on the definition of "optimal functionality"	A footnote has been added to provide more detail on the definition of "optimal functionality".
MCC / M&E Lead	23	Community Utilization and Alternatives - in addition to the reasons cited for lack of interest in RE, were there any observations to suggest improvements in consumer welfare from switching to RE alternatives? Additionally, is there enough evidence to suggest income losses for consumers from investing toward productive use of RE technologies?	Interview respondents from the W2 LAKPESDAM PBNU grant did note some welfare gains from connection to an alternative source. This has been added as a footnote in this section to retain the flow of the narrative. In section "3.4.1. Household RE Use for Economic Purposes", we discuss implications of reduced access to RE on businesses in the "Effects of reduced access to RE " box for the W3A Anekatek and Sky Energy grants. Beyond this, the evaluation did not yield further evidence on potential income losses from productive use investments.
MCC / M&E Lead	44	Sustainability Outlook table: Could this include an additional column for "projection beyond 2022) based on observations and necessary conditions/ steps necessary to maintain or improve projections for the RE technologies where applicable?	The "Sustainability Outlook 2021/2022" column already reflects the ET's assessments of the future sustainability (beyond endline data collection) of grants based on their status at endline and information available to the ET on the prospects of RE condition being maintained or improved. We note at the beginning of the section that the assessment includes information on the "prospects for managing future O&M challenges". We've now included clarification in the text that the assessment is of *future* sustainability prospects.

MCC / M&E Lead	58	General - Based on observations and findings across baseline, interim, and endline, is the ET able to highlight some technologies and locations where current functionality status could be salvaged or reversed through mechanisms such as improvements in ownership models or RBF	A few factors would likely need to be considered to ascertain which technologies and grants could be salvaged through RBF. For instance, failures that require investment into sophisticated hardware (e.g. large solar batteries) may be more difficult to salvage than those that need less expensive parts and labor (e.g. for MHPs, maintenance and repair investments are relatively simpler). However, beyond initial investment to re-operationalize, other factors such as the electricity demand potential, presence of alternative electricity sources (e.g. the national grid), and the competence and interest of the infrastructure owners would need to be equally considered. In the Executive Summary (under "Key factors influencing sustainability"), we now note that the evaluation did not find strong evidence that certain ownership models were more sustainable than others, so changes in ownership by itself are unlikely to alter functionality status. Still, for those technologies where we note that ownership status was still unclear as of endline in section 3.6.5., a clear handover of the technology to intended owners is needed.
Stakeholder Workshop – Open Comments	Presentation	With regard to the significant challenges on sustainability, it was mentioned that there is lack of alignment between planned productive use and market condition. Can you please elaborate further on this? Is it because this issue was not considered during planning or is it more on implementation challenges?	There exists a combination of factors that challenge productive use over time including the sustainability of the technology itself as well as the market conditions. As noted in the report only 33 percent (5/15) of production houses were being used at endline. Of the 10 production houses not being utilized, two became inoperable shortly after commissioning due to faulty machinery and three were not utilized because community members shifted away from producing the agricultural product the facility intended to process. The remaining five production houses faced common issues of insufficient working capital to purchase raw inputs, producer preferences to sell unprocessed goods, and lack of market linkage to facilitate sale of processed products.

Stakeholder Workshop – Open Comments	Presentation	Since this is a CBOG RE which should be excluded from PLN grid, so why PLN become a key sustainable factor as your analyses?	PLN entry into CBOG RE areas effects the sustainability and utility of offgrid technology. In some cases, large investments were never utilized as PLN entered the area prior to commissioning and a power purchasing agreement could not be reached. In other areas, PLN has become a substitute when RE technology has failed and has limited beneficiaries desire for continued RE maintenance or repairs.
Stakeholder Workshop/IBEKA – Open Comments	Presentation	IBEKA Team has previously noted that IBEKA provide RE (Micro Hydro Power) electricity according to rural community needs. With Community Based Micro Hydro Power development, the community can develop productive economic usage of electricity in the afternoon when House Hold electricity demand is at the lowest. It is already implemented at Kamanggih Village, with Knowledge Center and Small Industry building which trains rural community from beneficiary village as well as surrounding village (for rural villager to learns regarding the productive economic usage of electricity)... The available funds were not adequate to establish productive economic infrastructure at each of five villages.	This is noted, thank you.
Stakeholder Workshop/Yayasan Dian Tama – Open Comments	Presentation	The production house is not used optimally for production due to equipment damage but not infrastructure damage. The buildings and installations are still up and running. The only fault is the inverter.	This is noted, thank you.

6.2. Stakeholder Statement of Support or Difference

To be completed following review.

6.3. Evaluator Statement of Independence

No member of the evaluation team or key personnel of subcontract staff have any direct or indirect professional or financial interest in any of the stakeholders whose involvement in the CBOG RE Grant Portfolio is commented upon in this report (such as MCC, MCA-I, grantees, PLN, etc.). All members of the evaluation team responsible for the primary data collection, analysis, and reporting that informs this report are entirely independent of the MCC Indonesia Green Prosperity (GP) CBOG RE Grant Portfolio--meaning that they were not involved in the planning, implementation, or internal monitoring and evaluation of these grants.

In sum, this report has been produced with utmost independence and with the sole objective of providing unbiased, relevant, and well-evidenced responses to its guiding evaluation questions.

6.4. Summary of Interim Evaluation Findings

Evaluation Methods

The interim evaluation included an impact evaluation of the W3A Anekatek grant in East Sumba, a pre-post performance evaluation of the W3A Akuo Energy grant in Berau, and qualitative case studies of 4 other grants (W2 IBEKA, W2 PEKA, W1 HIVOS, W2 Javlec). Respondents were exposed to the program intervention for between 12 and 18 months, depending on the grant.

Findings

Domestic use of electricity

Most of the grants targeted domestic uses of electricity in the short term, with economic uses expected in the long-term, if at all. Such domestic uses included lighting, studying, and powering of appliances and public facilities. These uses were prominent for the Akuo Energy, Anekatek, and Hivos grants. For Anekatek, the mini-grids provided nearly 12 hours per day of additional electricity access and increased the likelihood that domestic appliances would be used. Domestic appliance use was reported to alleviate the burden of domestic tasks typically assigned to women, such as cooking and retrieving water.

Fuel substitution and GHG emissions

In 2017, 89% of Akuo Energy treatment households in Berau and 21% of Anekatek treatment households in Sumba used at least one non-renewable source of energy, while in 2019, only 1% and 3% did so. Reduction in diesel consumption is especially notable—by 1.6 liters per household per month due to the Anekatek grant, and by as much as 7.0 liters per household per month due to Akuo Energy grants. Households that used kerosene for night-time lighting can now use the light provided by mini-grid electricity or Hivos solar lamps. Village-level diesel generators used before the commissioning of Akuo Energy mini-grids are no longer used. Even in Sumber Agung, where the intended economic uses of solar energy have not materialized, the solar power plant is used in place of diesel generators to power village public facilities.

Economic use of electricity

Significant economic benefits pursued by the Anekatek, Akuo Energy, and IBEKA grants were not expected to have materialized at the time of the evaluation (1.5 years after introduction of the mini-grids), and indeed economic benefits appear minimal. There was some evidence of increased time spent on productive activity and of the sale of refrigerated goods, but little evidence of increased income or of new businesses using the source of electricity to power value-adding appliances.

Barriers to financial and operational sustainability

For most of the grants, arrangements to fund operations and maintenance may not be enough to cover a large expense, because electricity tariffs are set below the cost of production and demand is low. The PEKA grant in Berau saw most of its assets fail in 2018 for lack of maintenance. The IBEKA and Javlec grants contend with unclear legal ownership and insufficient revenue. After the grantee subsidy expires in March 2020, operations and maintenance funding for the Akuo Energy mini-grids will be insufficient, and continued sustaining the Anekatek mini-grids will require external subsidy, barring increased demand. The Hivos grant, however, created a renewable energy service company, perhaps ensuring the assets' longevity.

6.5 Endline Case Studies

This section contains findings for each of the six endline qualitative case study grants. As three of the six grants are from the Window 3A set of grants, and these grants have similar theories of change, we start this section by summarizing the Window 3A Theory of Change. Next, we present findings from each of the three Window 3A case studies (Anekatek, Akuo Energy, Sky Energy), followed by the three Window 2 case studies (IIEE, Burung and LAKPESDAM-PBNU).

6.5.1 Window 3A Theory of Change

The Window 3A CBOG RE grants have nearly identical theories of change, which can be summarized as the following: if communities with low access to electrification in remote areas of Indonesia are provided with renewable-energy based micro-grids and capacity building in the proper operation and management of these micro-grids, then (i) the communities will have an increased awareness of RE and sustainable natural resource management; (ii) households in these communities will have reliable and sustainable access to electricity; and (iii) community cooperatives will have the capacity to operate and manage the micro-grids. Supposing these outcomes are realized, and the communities derive sustainable benefits as SPVs continue to provide adequate O&M services, household income will be increased and GHG emissions decreased due to the improved access to, and the utilization of electricity generated from RE sources. In addition to the three outcomes mentioned above, most of the W3A grants additionally posit that increased economic opportunities will result from productive uses of the increased supply of electricity. Although the detailed feasibility study (DFS) or M&E plans for the Window 3A grants typically include some characterization of the TOC previously mentioned, these plans rarely include the underlying assumptions or detailed intermediate steps required for the ultimate goals to be realized.

To highlight key measurement areas for the evaluation, we will now present the relevant findings and key details found in the literature. In theory, electrification is expected to positively affect households and service provision. First, it improves incomes through a decrease in energy expenditures, an extension of working hours, the use of productive motive power, and, eventually, better income opportunities and new and more efficient businesses. Second, it yields better education through extended study hours, improved access to knowledge and information, and improved school services. Third, it leads to improved health from a decrease in polluting lighting sources (kerosene) and improved health services by electrified health facilities. Lastly, it yields positive effects through electrification on security, community participation and (gender) attitudes through improved connectivity and media access (see Lenz et al., 2017).

However, these theorized impacts are contingent upon a handful of key assumptions:

1. **Households are open to using the new technology.** While this is generally not a problematic assumption, it could be violated if there is mistrust between the community and the implementer. An additional barrier is that there might be a lack of optimism in the community that the new technology will be sustainable.

2. **Beneficiary communities will have adequate access to regional and national markets to allow village enterprises to count on more than local demand.** Without this, there may be little incentive to expand or create new businesses. This assumption is likely to be tested more often in agricultural communities that cannot count on the same export base as enterprises in communities that rely on fishing or eco-tourism.

3. **For education outcomes to materialize, schools must be up and running and students must have access to study materials.** This allows households to use electricity in a beneficial way with regards to education.

4. **The capacity building provided for operation and maintenance of the RE infrastructure is given in a sufficient quantity and quality** such that selected community members are capable of properly maintaining the infrastructure and are willing to do so for the long-term. There are no external constraints that would prevent them doing so, such as a dearth of locally available replacement parts or poor-quality O&M contractors.

5. **The TOC assumes that all program components are fit for purpose.** The physical infrastructure and training of community members must be suitable for achieving the purposes set out below. If it is not, the construction of solar arrays may not result in a sustainable source of usable electricity that meets the energy demands of users or contribute to the above stated goals. For example, if energy supply in practice is only sufficient to power small household appliances or lights then new economic opportunities may not be available.

6.5.2 Window 3A Anekatek

Project Background

The $9.2 million “Solar PV Distributed System in East Sumba Project” implemented by PT Anekatek consultatns targeted 909 households and a number of public facilities in the East Sumba Regency for electrification via connection to 11 sub-village (or kampung) level solar PV micro-grid systems with a combined capacity of 492-Kilowatt Peak (kWp). These 11 systems were distributed across five villages: Tawui, Lailunggi, Praimadita, Tandula Jangga, and Praiwitu. The 909 households targeted include all the households in the 11 kampungs that were targeted across the five villages. The underlying TOC for the W3A Anekatek grant largely reflects the simplified Window 3A TOC described above. In addition, the grant conducted activities to encourage electricity consumption and productive use by facilitating an appliance sale and financing program through each BUMDes which intended to provide easier access to electrical appliances and to allow community members to pay for appliances in installments. The grant also conducted trainings with women in each village on cake making to encourage home business development. Specifically, there was a discussion on the use RE through mixers during these trainings.

Figure 5: Solar Panel in Praiwitu

The grant established one SPV, PT Mikro Kisi Sumba, to cover all 11 treatment areas spread across five villages. The implementer's sister company, Electric Vine Industries, had 100 percent ownership of the SPV during the construction phase, after which ownership was split 51 percent to 49 percent in favor of the communities. The communities were represented by a company called Matawai Amahu Energi Sumba. This company, in turn, was jointly owned by the BUMDEs of the five villages, with each village having equal ownership stake.

The evaluation team had previously conducted an interim impact evaluation of this grant in 2019, conducting quantitative and qualitative data collection in the five villages targeted by the grant, and in five comparison villages where RE grids were not provided. [56] Initial findings from the endline qualitative data collection revealed that the Anekatek grids had been completely non-operational since December 2020, with the SPV having stopped operations in March 2020 (a full year before endine data collection). Therefore, rather than moving forward with the impact evaluation, the evaluation team proceeded to

[56] The interim report is available on MCC's Evaluation Catalog. LINK

conduct a qualitative case study to understand the situation of households in Anekatek and comparison communities, and any lessons on sustainability challenges and lessons for future grants (See the **Endline Evaluation Design Changes** Annex).

This case study write-up provides findings from the endline data collection on how outcomes have changed after the grids shut down. Where relevant, we include summary of findings from our interim evaluation for context. A larger portion of the case study is devoted to discussing sustainability and outlining the factors that contributed to the grids becoming non-operational.

Electricity Sources, Access, Consumption and Expenditure

The interim evaluation found that the grant increased the likelihood of households in Anekatek communities using renewable energy source of electricity and decreasing the likelihood of using a non-renewable source compared to households in comparison communities. It also found sizable causal program impacts across important measures of electricity access and consumption such as hours per day of electricity access, lamp-hours per day of electric lighting and the likelihood of a household owning at least one appliance requiring Tier 2 electricity or greater.

Prior to commissioning of the RE grids, most households in these five villages were already using a form of RE, small solar lamps, as their primary source of electricity. Many of these lamps were provided to households for free by the village government or through a CSR program. Households would also sometimes use kerosene lamps as a supplementary source to illuminate areas in their house which were not reached by the solar lamp lighting. Households that did not have access to solar lamps would use kerosene lamps as a primary source, while a smaller proportion of households also used diesel generators to provide electricity for a couple of hours per day. At endline, households reported that they have generally reverted to the same energy consumption patterns from before the grids were operationalized. For most households, solar lamps are now the primary source of electricity providing lighting for an average of three bulbs. Some households reported using the same solar lamps that had been provided through government/CSR support, while others reported purchasing new solar lamps or batteries for their household. Kerosene lamps were also in use to increase the amount of area illuminated in the house, as well as by households without access to solar lamps. Respondents indicated that due to the expense of kerosene and difficulty finding it in the local market, kerosene lamps were less common though still in use. Respondents with school-aged children highlighted that the change in lighting sources had a particular effect on their children’s willingness and ability to study at night since lighting from kerosene and solar lamps is dimmer than lighting from the solar grid.

Generator use was still uncommon and limited to households which had generators prior to grid commissioning, or those that could access generators through relatives. None of the qualitative respondents had purchased diesel generators after the grid shutdown. Many indicated that the key barrier to generator use was the fuel expense. Even those who reported operating generators, noted that they would use the generators only for a few hours per day, and often, the purpose of this use was for productivity—rather than purely for household purposes or leisure (see below). Many respondents were also hopeful that the solar grids would be fixed and operational in the near future, reducing the perceived need to invest in generators.

Respondents in Winumuru and Wanggbewa reported similar energy sources and energy consumption patterns as households in Anekatek communities, with most households using solar lamps as a primary source of lighting. Lamps were either provided through village government support, or purchased by the households themselves. Kerosene lamp usage was reportedly rare and only a few households in each location owned and used diesel generators. According to stakeholders, the electricity situation in these villages was largely unchanged from interim.

Appliance ownership and use had expanded due to access to RE electricity from the grids. At interim, our evaluation found that households frequently purchased something for entertainment purposes (e.g., a television) or to make regular domestic tasks easier, safer, or more efficient (e.g., a rice cooker, iron, or washing machine). Refrigerator ownership also increased significantly, as households reported using them for both household and economic purposes. At endline we found that households had generally kept all appliances that they had purchased after receiving electricity from the RE grid. According to respondents, this was partially due to the hope that the grids would be re-operationalized as well as the difficulty of reselling the appliances. In cases where households were using generators, they would use the generators to power select appliances—for instance, to power a television for a few hours at night. In a few rare instances, respondents reported either selling or giving appliances away to relatives and friends. At interim, communities reported that these appliances were most helpful to and appreciated by women. Many of the tasks obviated or made more efficient or comfortable by these appliances are ones for which women are typically responsible. At endline, respondents corroborated this point and regularly noted that lack of electricity had made the lives of women more difficult as household tasks now had to be done in a manual, more time-intensive manner. For instance, rice that could be cooked in a rick cooker in 30 minutes, now needed be cooked over a fire requiring more time and attention; or clothes that were previously washed using a washing machine now needed to be washed by hand.

Figure 6: Appliances Purchased by RE Grid Customer

Due to the high generation capacity of the Anekatek solar grids, households were able to expand their electricity consumption with the only limitations being their household's ability to pay and preferences. After shutdown, it is conceivable that more households might have tried to switch to non-RE sources with high generation capacity (e.g., diesel generators). However, evidence from qualitative data collection at endline suggests that this has not been the case due to a combination of belief that the grids will be re-operationalized in the near future and low financial capacity to invest in diesel generators and fuel.

Electricity for Economic Purposes

Since outcomes related to use of RE for economic purposes require time to manifest, at interim we expected to see relatively small economic impacts from RE provision, as the grids had only been operational for one year. Still, the evaluation found that women in Anekatek communities were spending over three additional hours on income-generating activities and a significant increase in likelihood that households were using at least one Tier 2 appliance for economic purposes.

Regarding time use effects for women, many female respondents mentioned that after the solar grids had been commissioned, they started to spend a few hours in the evening on income-generating activities, including making snacks and cakes for sale as well as handcrafts. After the shutdown of the grids, some women noted that they had stopped these activities, as making snacks manually would take too much effort or because low quality lighting reduced productivity. A few indicated that they continue to carry on these activities in the evening, but that their productivity and income from these activities had reduced. As one respondent described that "weaving work is mostly done at night because most of the day is spent in the garden. Weaving palm leaves cannot be done during the day because of the nature of the leaves that are easily stiff due to hot weather. When the [RE electricity] was available, in one week I could produce one to two mats depending on size. Mats are sold at a price of Rp. 50,000-200,000 at the nearest market. In a week, I could make 4-5 mats, and sell at a price of Rp. 50,000 per piece. Since the [solar grid] is not lit, the productivity of mats is reduced because the lighting needed for weaving is not good so that weaving cannot last long. Now in one week, sometimes I don't finish working on one mat."

Figure 7: Economic Activities Supported by RE Electricity Prior to Grid Shutdown

Prior to grid shutdown, a variety of different businesses had opened and expanded in these communities such as grocery and snack stalls, furniture and automotive workshops, internet cafés, and mobile banking kiosks. At endline, a variety of changes in business operations were reported by community respondents, including reduction in the types of products sold, shortening of business hours, attempting to maintain operations using generators, reverting to using manual tools, or shutting down completely. For instance, community respondents remarked that since the shutdown of the grids, the general situation in the community had become quieter and less active at night. Even though kiosks could maintain operating hours using lighting from solar or kerosene lamps, the lower foot traffic in the evening reportedly reduced their incentives to stay open later in the evening. Therefore, many kiosks had shortened their operating hours at endline. When the grids were functional, many grocery and snacks stalls had expanded their products to include chilled and frozen blended drinks. Most of these stalls had removed these items from their menu at endline as they did not have access to generators, or the cost of operating generators was not worth the marginal increase in revenue from selling these items. Aside from expansion of food stalls, the other business type mentioned by respondents as particularly benefitting from RE electricity was furniture/woodworking workshops. A few of these stalls were already operating in the community prior to provision of RE electricity, either relying on manual tools or using generators. After the grids shut down, some of these businesses have completely shifted back to use of manual tools due to lack of many for generators, while other use generators for a couple of hours per day to power their tools. Generator use reportedly allows for workshops to handle more and larger orders, relatively to not using any electricity, but reduces profit margins since generators have high operating costs.

Similar to the case of household electricity consumption, overarching findings from the endline data collection suggest that shutdown of the RE grids have brought villages back to the economic conditions from before the grids were commissioned. In comparison communities, respondents reported that the primary economic activity was agriculture and that there were very few other local businesses aside from stalls selling daily necessities. Some respondents were aware that availability of RE electricity in Anekatek villages had encouraged economic activities and expressed a desire that their village could also experience similar economic opportunities.

GHG Emissions

The interim evaluation found that the grant had caused slight reductions in monthly diesel consumption and negligible reductions in kerosene usage for household connected to the grids. These measured changes in fuel consumption patterns translated to reduced GHG emissions due to the grant. As the grids were completely non-operational at endline, we assume that the grant is no longer contributing to GHG emission reduction. As discussed earlier, since our qualitative findings suggest that energy consumption patterns have generally reverted to the prevailing patterns prior to grid commissioning, there does not seem to be strong indications that the failure of the technology has inadvertently increased GHG emissions (for instance, by inducing widespread purchase and use of diesel generators by households and businesses). One or two respondents did indicate that they had started to use generators, when previously they had only relied on solar lamps, so slight increases in GHG emissions are plausible.

Community Buy-in and Sustainability

The primary cause for the grids becoming non-operational was due to widespread leakage and failure of the batteries used by the grid to store charge. In addition, the district-level subsidy that was expected to help support the grids was not provided—initially because the funds were diverted for COVID-19 relief and later because the district parliament did not consider the SPV viable enough to provide funding to.

During our interim evaluation, some Anekatek grantee consortium members have expressed displeasure with the performance of the battery equipment selected by Fluidic, the company responsible for this component of the grants. A few months after grid commissioning, some of the batteries had already started to leak. The root cause of this issue is not clear, some stakeholders question the quality of the batteries themselves while others opined that perhaps the batteries were not designed to be used in such a warm, coastal climate. When these problems first started to surface, Fluidic had made itself locally available and on-call to repair any issues with the batteries as they arose. As the battery issues became more widespread, causing significant interruptions in electricity provision, the vendor closed their office in Indonesia and could not be reached. During this time, Anekatek and the SPV were wary about trying to fix the batteries without the vendor's involvement, as that would void the ten-year equipment warranty. As these battery issues worsened, so did the performance of the solar grids in most locations. Customers were experiencing widespread and prolonged outages as the grids' capacity to store electricity had been severely hampered. Reduced energy generation and hence reduced energy consumption by customers, meant that the SPV's revenue also declined during this period.

The SPV had already been facing financial strain as operating costs far exceeded revenue from customers. At interim, the grantee had reported that major costs to the SPV were largely in-line with the expectations in their business plans, but that sub-optimal tariffs and lower demand than expected were challenging the ability of the SPVs to cover costs, let alone make a profit. In fact, the grantee noted that monthly operational costs for the SPV (including staff salaries) were approximately IDR 120 million while revenue ranged between ID 35 million to 40 million when the grid was optimally operating. The grantee indicated that the largest portion of the operational costs went towards staff salaries, lodging and meals, since some of the SPV were hired from Jakarta. Other significant cost components were transportation for technicians and monthly per meter costs for a service that allowed remote control of the metering system. During the interim evaluation, stakeholders indicated that the plan was for a Perusda (district-owned enterprise) to take over Anekatek's 49 percent stake in the SPV. Anekatek would have then served as an O&M contractor for the SPV. The Perusda had agreed to cover the gap between O&M costs and revenue through injection of district government funds. According to stakeholders, they had reportedly done so with the presumption that increased electricity demand over the next four years would allow the SPV to collect enough revenue to fund these costs without external capital. The timing of ownership transition and acceleration of battery failure coincided with the onset of the COVID-19 pandemic and so the district government funds that were intended to be used to subsidize O&M of the grids was reallocated for COVID-19 relief. By March 2020, the SPV had completely run out of operational funds and there had been no solution to the battery issue so the grids across all five locations were shut off. When Bappenas temporarily assumed ownership of the infrastructure prior to handover to the intended owners (in this case the district government), they agreed to provide temporary funding of IDR 600 million so that the grids could be turned on again until district funding could be secured in 2021. With this funding the grids were turned on for five months at the end of 2020 and customers were provided electricity free of charge. During this time, the SPV started the process of applying for district funding to subsidize the grids using funds from the district government. However, this request was denied as the district parliament examined the SPV financials and projections and the model was deemed unsustainable. In addition, the parliament asserted that the business plan outlining how the breakeven point would be achieved was not detailed enough. According to the grantee, the SPV could reach the breakeven point seven years after grid commissioning, and they were optimistic that this point could potentially be reached sooner given the growth in electricity consumption across the five villages in the 1.5 years when the grids were commissioned.

Currently, the director of the SPV continues to pursue options for funding battery replacement and subsidization for O&M costs. Battery replacement alone would cost almost IDR 7 billion, or USD $475,000. At the time of endline, a solution had yet to be identified, though many options had been pursued including funding from private companies and donors.

From the perspective of community stakeholders, even though the grids had been non-operational for more than a year, respondents were generally supportive of the SPV and held positive perceptions of

SPV members. Though understandably frustrated with the situation, most households viewed the SPV members as professional and competent and had positive perceptions of the overall services provided by the grid and SPV. Similar to findings at interim, the only compliant noted was that the metering system did not allow customers to see their electricity usage. Like other W3A grids, the Anekatek grids used a pre-paid meter system where customers would purchase electricity in bundles. When the allotted amount of kilowatt hours had been consumed, electricity would be shut off unless the customer purchased an additional bundle. Because the meters were not easily accessible, customers remarked that their electricity would often go out before they realized that they had run out of electricity credit.

When asked to choose between electricity from the RE grids and PLN, again most respondents voiced support for the RE grids. Many respondents referenced the investment that the community had already put into constructing the grids, by providing land, cutting down trees, or participating in construction. Respondents also cited that the quality and availability of electricity from PLN would likely not be as good as what the RE grids had previously provided (when operating optimally). In an effort to ensure operational sustainability of the grids, the grant had obtained a business license to be the sole provider of electricity in these five villages for an effective period of 20 years in an effort to minimize competition with PLN. At endline, PLN had extended its grid to villages close to the Anekatek grant villages. PLN had even been requested by the district government to provide electricity to a hospital located in one of the Anekatek grant villages, but PLN did not fulfill the request due to the sole business license. It seems that in the absence of this sole business license, PLN may have been able to extend its grid to serve some of the Anekatek grant areas. Respondents in comparison communities, however, indicated a preference for electricity from PLN. Having heard about the situation of the RE grids in Anekatek communities, they preferred the relatively reliability of PLN (a reversal from interim, when many respondents indicated a preference for electricity from a RE mini-grid). PLN was supposed to start service in Winumuru in 2019, but plans were delayed due to heavy rain with further delays due to the COVID-19 pandemic and cyclone which hit the area in April 2021. At endline, the village government indicated that PLN had planned to revisit extension of the grid to the village in early 2022. The village government in Wanggabewa mentioned there were no near-term plans for PLN entry into the village.

Future plans for restoring electrification in the area are uncertain, as the funding needed to replace the solar batteries and subsidize O&M has proven difficult to source. At the same time, stakeholders have not mentioned any plans to revoke the business license to allow PLN entry. Meanwhile, since the district-level entity was unable to assume ownership of the infrastructure, ownership has now been transferred to the respective village governments. As the original plan was district government ownership, the grant's engagement with village governments was less intense. This further complicates any efforts to identify a solution as there is now a need to coordinate with five different entities rather than a single district-level entity.

6.5.3 Window 3A Akuo Energy

Project Background

The $9.8 million “Off-Grid Power Plants for three Villages in Berau Regency-East Kalimantan Project” implemented by Akuo Energy targeted three villages in the Berau Regency of the East Kalimantan Province: Teluk Sumbang, Long Beliu, and Merabu. The grant constructed three solar grids and revitalized a defunct MHP with a combined generation capacity of 1,273 kWp serving 400 households and a number of public facilities. The underlying TOC for the W3A Akuo Energy grant largely reflects the simplified Window 3A TOC described above. Specifically related to the productive uses of increased electricity supply, the grant assumed that specific businesses such as honey production, boat making, and ecotourism would emerge as a result of availability of electricity from RE.

Figure 8: Solar Panels in Merabu

Like other Window 3A grants, the grids were to be managed by an SPVs with one village-level SPV for each of the three mini-grids. The grant intended that when Akuo Energy transitioned out of its ownership stake of these three SPVs, ownership would transition fully to the villages through their BUMDes, each of which will be responsible for hiring an O&M contractor and saving revenue for replacing key electrical equipment on their own.

At interim, the evaluation team had conducted a quantitative performance evaluation of this grant, as well as qualitative data collection with community members and other key informants. Due to the ongoing COVID-19 pandemic at the time of endline data collection, the quantitative component of the evaluation was dropped (see the **Endline Evaluation Design Changes** Annex). The qualitative component was retained, and findings are outlined below. Where relevant, we also reference findings from the 2019 interim evaluation.

Electricity Sources, Access, Consumption and Expenditure

Qualitative findings from interviews at endline suggest that electricity from the grant-support RE grid is the primary source of energy in all three villages were RE was provided. This is a continuation of a trend observed at interim, where quantitative data from our performance evaluation found that households were more likely to use be using a renewable source of energy rather than a non-renewable source of energy. One area where use of non-renewable energy sources persists is for cooking, where firewood or LPG gas continue to be dominant sources, and for transportation fuel such as motorcycles. Also, community members continue to use diesel generators for lighting when spending the night in temporary dwellings while tending to their agricultural land or mining.

At interim, customers of the W3A Akuo Energy grid reported substantial increases in hours per day of electricity access, lamp-hours per day of electric lighting and aggregate energy consumption. Ownership of Tier 2 appliances also increased, with significant increases in rice cooker, washing machine and refrigerator ownership. At endline, users from Long Beliu and Merabu reported that electricity was usually available with few instances of outages, and that the power of their connections was sufficient to meet their consumption needs. In Teluk Sumbang, where a technical issue compromised the grid for several months, access and consumption were compromised at that time. Before this issue, respondents reported being pleased with the quantity and quality of electricity received. Half of the interview participants noted that they had not bought any new appliances since 2019 and so their energy usage was more or less unchanged. For those who did purchase appliances, the most common ones mentioned were refrigerators, freezers and water dispensers for both household and business purposes. Unlike many other operational grids in the portfolio at endline, the generation capacity of the grids still far exceeded customer demand meaning that electricity supply is not a constraint to access.

Figure 9: Electronics in Customer's Household in Long Beliu

All three SPVs managing the W3A Akuo Energy grids implement a pre-paid voucher system where users are charged per KwH. The rate set by Akuo SPVs is IDR 1,460 per KwH. While installation of new connections was free during the grant implementation period, it now costs between IDR 1 million to install a new connection and between IDR 800,000 to 1 million to upgrade an existing connection. Based on estimates provided by customers during interviews, users typically spend between IDR 50,000 to IDR 400,000 per month on electricity, depending on the number of appliances use, type of connection and whether they are also operating a business at their home. Many of those we spoke to who previously used generators noted that current electricity costs were less than before while enabling electricity access for 24 hours, rather than just for a few hours in the evening. (Regular users of generators mentioned previously using an average of 2 liters of gasoline per night to power their generators for six hours. At approximately IDR 7,000 per liter, this results in a monthly cost of IDR 420,000.) Still, a few others who were more infrequent users of generators, or used lower-powered generators, remarked that their current expenditures were slightly higher than before being connected to the grid.

Electricity for Economic Purposes

The interim performance evaluation found no statistically significant changes in time spent on income generating activities by men or women. The evaluation did find significant increases in households using at least one Tier 2+ appliance to produce goods for sales, almost exclusively driven by households selling chilled goods from refrigerators. Reflecting interim findings, at endline, respondents noted that the most common businesses open or expand due to availability of electricity from RE were food stalls, kiosks selling children's snacks, and households selling ice for meat and fish preservation. The majority of respondents had not perceived growth of any larger-scale businesses or other major changes in local economic conditions. However, a few respondents reported an increased prevalence of higher-value businesses including furniture and wood carving workshops and homestays, though homestay operators noted that business has not been optimal due to COVID-19. Ecotourism was one of the activities that the Akuo logic model assumed would emerge as a result of availability of electricity from RE.

Figure 10: Small Businesses in Long Belui and Merabu

GHG Emissions

For the Window 3A grants, the TOC rests on a critical assumption that households will use electricity from the renewable mini-grid in place of electricity that was previously drawn from fuel-based sources, reducing their consumption of GHG-emitting fossil fuels in the process. Qualitative evidence from endline suggests that use of RE electricity generated by the W3A Akuo Energy infrastructure has likely reduced consumption of GHG-emitting fossil fuels, especially diesel and kerosene.

At baseline, two of the Akuo Energy villages regularly used generators donated through local companies' CSR funds in the evenings, and outside of these generators 34 percent of households reported owning personal generators. At interim, our household survey in April 2019 found that only one percent of Akuo Energy households used at least one non-renewable source, versus 89 percent at baseline in November 2017. At endline, households with personal generators in two villages reported using RE electricity as their primary source. Some households reported using the generator in case of grid outages, while others preferred to use solar lamps due to the cost and inconvenience of generator operations. In the third village, at the time of endline data collection in December 2021 the RE grid had not been operational since February 2021 due damage to one of its components and a prolonged repair process. As a result, the SPV had used a diesel generator to provide electricity to its customers for eight to 12 hours per day for almost four months, therefore somewhat mitigating the overall reduction in fuel use. During this period, more than eight drums (approximately 200 liters) of diesel per month was used.

Community Buy-in and Sustainability

Related to technical sustainability, electricity customers report generally being pleased with the quality and availability of electricity noting that electricity supply was generally available for 24 hours. Respondents from Long Belui did mention one instance of the grid being non-operational for almost a month due to a technical issue that required parts replacement. In Merabu, while no major repairs were mentioned at endline, multiple respondents remarked that during the rainy season sometimes the SPV needed to shut off the grids to ensure sufficient electricity supply for the evening. When our team visited the solar grids in Teluk Sumbang village had been not been operational for eight months due to burn out of one of its components (one of three power conditioning systems). Due to conditions of the insurance policy on the grids, the damage had to first be inspected in person by an insurance agent—a process that was delayed several months due to COVID-19 restrictions on inter-provincial travel. In addition, Akuo needed to liaise with the Italy and France based manufactures to get the needed part sent to Indonesia. At the time of endline, the part had arrived at the village but had not been installed because a certified technician based in Italy needed to be the one to install it. During this eight-month process, electricity was provided to the community by the SPV through diesel generators and the MHP for six months, but the community was completely without power for more than one month. Even the grantee admitted the unlikelihood that the SPV could have handled this repair process without Akuo's involvement, especially liaising with foreign companies. The complexity of the insurance and repairs processes poses a real threat to the long-term sustainability of the grids, especially if Akuo decides to pull back their involvement in the grids. Aside from major repair issues, SPV members noted confidence in being able to manage day-to-day O&M of the grids, including minor repairs. They also continue to contact Akuo for advice and support in case of more serious or complicated technical issues.

Figure 11: SPV Office in Teluk Sumbang

Regarding financial sustainability, respondents general view the tariff as neither expensive nor cheap, but generally reasonable given the level of service provided. A few respondents noted that a small portion of families do find the rates expensive as they do not have steady incomes and sometimes have to go without electricity. There was an expectation that energy demand would increase due to increase and expansion of home industries, which would increase SPV revenues. According to the SPVs and the grantee, energy usage has not increased at the expected rate and the grid still has a lot of excess generation capacity. At endline, the SPVs were still only making just enough to cover regular operational costs with Akuo covering the insurance premium cost of between IDR 50 million to 70 million for each of the three villages per year (USD 3,500 to USD 4,800). Akuo is attempting to shift promote demand by helping the SPVs explore options to connect their grids with companies in nearby villages or start agricultural processing activities powered by RE, but it is unclear if these will progress beyond the ideation stage. The grant intended for SPVs, and the village BUMDes who have ownership stake in the grant, could help stimulate demand by identifying new business opportunities but these entities have mostly appeared to date to focus on the day-to-day operation of the infrastructure rather than on long-term productive use and economic development.

Community perceptions on SPV operations were mixed. Some remarked that they were professional and appreciated how they made themselves available to serve customer requests. Others had fewer positive perceptions indicating that certain members were not always available to serve requests or were not communicative enough about the status of the grid systems. However, respondents universally asserted that electricity had greatly benefitted the community as a whole, and more particularly contributed to a sense of safety at night from availability of lighting, and benefits to women from availability of appliances to make household tasks more efficient. Most respondents indicated a preference for using electricity from the RE grids if given a choice between RE electricity and PLN, citing the higher quality and greater availability of electricity from the RE grids and perceptions of lower cost. Citing technical issues faced by the grids (outages due to rainy season in Merabu and due to the repair issue in Teluk Sumbang), a few respondents indicated a preference for PLN.

Moving forward, key sustainability concerns for the Akuo grids cited by both the grantee and SPV were the ability of the grids to operate without Akuo support. As noted earlier, Akuo has continued their financial involvement in the SPVs by paying the insurance premium on the grids. The grantee made this decision based on an assessment that the SPVs could not shoulder these costs. At endline, Akuo was working to identify potential entities who could take on these insurance payments, including the respective village governments, but the outcome of these conversations was not clear at the time of endline data collection. In addition, the prolonged repair process in Teluk Sumbang also raises concerns that the SPVs would be able to handle similar repair challenges in the future without Akuo assistance. If new business customers can be identified to absorb some of the excess capacity of the grids, there is scope for the SPVs to improve their financial condition. However, by endline, it did not seem that the SPVs were actively seeking new business. PLN reportedly once made an offer to purchase electricity from the Long Beliu SPV for IDR 1,000 per kWh (compared to the IDR 1,460 charged to customers in the community) but the SPV declined this offer as the rate was considered too low to consider.

6.5.4 Window 3A Sky Energy

Project Background

The “Solar Photovoltaic Electricity for Karampuang Island” project implemented by the Sky Energy consortium installed four solar PV systems across Karampuang Island with a combined 598.4-kilowatt generation capacity. The grant’s underlying logic model reflects the overall logic model of Window 3A grants summarized at the beginning of this Annex. More specifically, the grant’s logic model assumed that with increased access to electricity from solar power households would invest in electrical appliance used for income generation and cost savings. It also assumed that general cost savings would manifest from switching from generators to RE, and specific costs savings for fishermen would manifest from purchase of locally made ice. As with other Window 3A grants, the infrastructure was to be managed by a Special Purpose Vehicle.

Figure 12: Sky Energy Solar Grid Systems and Beneficiary Households on Karampuang Island

Most of the assumptions related to increased access to electricity for households and small businesses have held true, though evidence on cost savings is less conclusive. In addition, constraints on electricity supply due to increased demand for electricity pose a long-term threat to sustained realization of outcomes. The SPV, called Karampuang Multi-Power (KMD), was also established as planned with 49 percent shares owned by Sky Energy and 51 percent owned by a village cooperative consisting of RE users.

Electricity Sources, Access, Consumption and Expenditure

Prior to construction of grant RE, most households and businesses were reliant on communal generators provided by the government and shared by 20 to 30 households. Generators would be turned on each evening from 6:00 p.m. to 10:00 p.m. For connected households, electricity provided by these generators was only sufficient to power a couple of lightbulbs and television. Aside from generators, households would use battery-powered lights or kerosene lamps for lighting. Households who did not have access to communal generators also used battery-powered lights or kerosene lamps as a primary source for lighting.

With provision of RE through the grant-funded solar grid, almost all households, businesses and public facilities are connected to the grid and use RE as a source of electricity. At the end of the grant implementation period, the grid served 722 households and 33 public facilities (including street lighting). At endline, this number had increased to 799 due to addition of new households, and the KMD was in the process of adding additional households at endline.

After connection to the RE grid, households report expansion in their electricity access and consumption. Respondents noted benefits to having access to bright lighting throughout the day, rather than just four hours of unstable lighting from generators. Households also reported some expansion in appliance ownership and use, specifically purchase of refrigerators for personal and business use and other household items such as fans, small sound systems, rice cookers and washing machines. For cooking, households still rely on a combination of LPG gas and firewood. While electricity users perceived general benefits to households and the community as a whole from electricity provision, specific benefits were noted for women due to availability of lighting in the early morning and enhanced access to appliances to facilitate household chores. In addition, households noted changes in time use due to RE provision. Previously the community would become quiet after the generators shut off at 10:00 p.m. with most households going to sleep at that time. With provision of RE, households report sleeping later as they are able to watch TV until later at night and the general atmosphere in the community is livelier due to street lighting.

For the first two years after grid commissioning, electricity was generally available 24 hours per day with limited interruptions, but in the few months prior to the endline most households noted that outages had become more frequent and prolonged. Due to increasing demand for electricity from existing customers and addition of new connections, the electricity supply generated by the grid had become insufficient to meet demand, exacerbated by the rainy season when charging potential for solar systems is reduced.

Recognizing that grid capacity may be insufficient, prior to grid commissioning the KMD conducted sensitization trainings with the community to communicate the importance of using energy-efficient appliances and to limit use of appliances requiring a large amount of electricity. According to community respondents, many households have not adhered to this guidance in practice. Once the grids were commissioned, the KMD took additional steps to control demand while still providing connections to new households. KMD implemented restrictions on the number of connections that could be upgraded from the standard 450-watt connection (Tier 1 access) to a 900-watt connection (Tier 2 access), giving preference to those using electricity for business purposes. (At endline, there were only 20 900-watt connections.) Some households reported that the 450-watt connection was sufficient for their needs because they primarily use electricity for lighting, and they did not feel the need to expand their electricity use. Other households mentioned that the current power is insufficient, either because they need to be mindful of the number of appliances used at one time or because they are unable to purchase additional appliances because the current electricity supply is unable to support them. Despite KMD's efforts, by endline planned outages were a common occurrence with the SPV shutting the grids down during the day to ensure sufficient electricity supply for nighttime usage. Respondents reported that these outages sometimes stretched for 12 hours or more.

During the planning stages, the community agreed on a price of IDR 2,000/kWh as part of initial discussions. However, the district government refused that rate noting it must be the same or lower than PLN. Therefore, the tariff was set to match PLN at IDR 1,460/kWh. During the grant implementation phase, installation of new connections were free, but at endline new connections cost IDR 2,000,000. The system uses prepaid vouchers available in IDR 20,000, 50,000 or 100,000 bundles. Customers using electricity for household purposes report spending IDR 50,000 per month, while previously most households paid IDR 35,000 to IDR 50,000 to use the communal generators. Therefore, for most households, access to RE has not necessarily reduced expenditure on electricity. For those whose energy expenditures have increased or stayed the same, they still note that electricity from the RE grid provides better value as it is more available and allows for greater consumption than previous sources.

Electricity for Economic Purposes

Stakeholders perceive that provision of RE has had an impact on the island's economy. A number of new stalls and small cafes opened up selling cold drinks, ice cream and other perishable snack items requiring refrigeration. Other existing stalls expanded to provide these products as well. In addition, RE encouraged emergence of new businesses including water purification stalls, motorcycle and furniture workshops, and fishing boat construction. Many households have also purchased freezers to make ice. Fishing is a common occupation on the island and fisherman previously had to buy ice from the nearby city of Mamuju to preserve their catch prior to sale. After provision of RE, some fishermen have purchased freezers to make their own ice, or purchase ice locally in Karampuang which has helped them to save both time and money and reduced the amount of their catch lost to spoilage.

The grant also provided training to community members on a variety of income-generating activities including banana chips and snacks production, ice cream making, chicken farming, and sea urchin cultivation (the first two activities directly utilized RE). Of these, the banana chip groups realized some initial success receiving a loan from the BUMDES in 2020 along with additional equipment to support production. When we conducted endline data collection, the group was temporarily inactive because the price of raw materials increased substantially reducing prospective profit margins, the earthquake in Mamuju destroyed their distributor's shop, and COVID-19 has generally made marketing more difficult. Despite these challenges, several women continue to make and sell chips on an individual basis. The other activities promoted by the grant did not proceed past the trial period. The women's group selling ice cream closed after a year because the group considered it simpler for individuals to purchase and sell brand name ice cream, especially because companies would also supply the freezer to store the product in. Chicken farming was not pursued due to lack of coordination and interest of group members, and sea urchin cultivation was not continued because the variety of urchins produced did not match the variety or interest to prospective buyers.

Small business owners universally report that provision of RE has been beneficial to their businesses. Yet with the restrictions on upgrading connections to 900 watts and increased frequency in prolonged outages, some businesses have noted that lack of sufficient electricity has started to become a constraint. In particular, businesses selling ice cream or producing ice for fishermen noted that their products were often not firm enough to sell which had started to reduce their revenues. In addition, fishermen had started return to purchasing ice in Mamuju because of lack of sufficient supply in Karampuang.

GHG Emissions

As noted earlier, prior to the grant many households received electricity each evening for four hours from communal generators owned by the village. Households which did not have access to these generators, either due to distance or not being able to pay the monthly fee, typically used kerosene lamps for lighting. After the commissioning of the RE grids, respondents noted that these generators are no longer used, which suggests that the grant likely contributed to notable reductions in GHG emissions. Due to limited electricity supply from the grid, a few motorcycle and furniture workshops and village offices reportedly switched to using diesel generators as a primary source of electricity in 2021.

Community Buy-in and Sustainability

As noted earlier, the grids are managed by KMD, a SPV owned by Sky Energy and a village cooperative of SPV users. Sky Energy is also one of the few cases where the grantee plans to retain investment for over a decade after the project has ended to help ensure the long-term sustainability of the grids. The SPV joint ownership agreement is anticipated to last for approximately 20 years. After about 20 years, full ownership will transfer to the Karampuang community. SPV staff consist of 12 individuals who manage all four solar grids including 10 technicians responsible for the daily O&M of the system, one SPV coordinator and one public relations staff member. In addition, there is an SPV director who is a former Sky Energy staff member and is not based in Karampuang.

The grant took a number of steps to help ensure the technical sustainability of the infrastructure. Recognizing that battery replacement is often a financial burden that mini grids are unable to handle, Sky Energy was careful to purchase maintenance equipment including a water distillation system and liquid batteries which could extend the battery life up to ten years. In addition, since Sky Energy produces most solar equipment, it is relatively easier for them to identify low-cost but reliable replacements when needed. SPV technicians being in regular contact with Sky Energy in case of technical issues, receiving remote guidance and assistance when needed. In addition, if in person consultant is required, Sky Energy sends technicians to the site under a cost sharing mechanism where KMD pays for transportation and accommodation while Sky Energy pays the technician's salary. The SPV has already managed a number of repairs and replacements, including replacement of inverters and batteries. For larger parts, Sky Energy supplies these to the SPV at factory prices, while sometimes smaller spare parts such as cables or electricity meters are provided for free. Community respondents and SPV members noted with pride that after the earthquake in nearby Mamuju in January 2021, the SPV was able to restore electricity to Karampuang within 12 hours while Mamuju was without electricity for several weeks. This speaks to both the resilience of the infrastructure to climactic events and competence of SPV members.

Community respondents universally noted that they are satisfied with the performance of SPV members who are viewed as kind, professional and competent in managing the solar grids. They are also viewed as responsive when technical issues arise and proactively aim to resolve them. In addition, though customers are asked to come to KMD's office to purchase electricity bundles, respondents were particularly appreciative that many SPV members also take payments from community members directly from their homes and facilitate these payments. Though some RE users expressed frustration with the current situation of persistent electricity outages due to constrained supply, they also noted empathy with the situation of the SPV and understanding that the current situation is not their fault. SPV members themselves expressed confidence in being able to manage the day-to-day O&M of the grids, which technician noting comfort in carrying out electricity installation, maintenance, and minor repairs. Technicians noted that the two-week training followed by three months of practical experience alongside Sky Energy technicians was useful for transferring the needed knowledge and skills. For major O&M issues, technicians were confident in being able to source technical advice and support through contacting Sky Energy staff.

Figure 13: SPV Technician Installing a New Connection

As noted earlier, though the community originally agreed to a tariff of IDR 2,000 per kilowatt hour, this tariff was rejected by the district government noting that the tariff must be the same or lower than the PLN rate. Ultimately, the tariff was set at the PLN rate (IDR 1,460 per kilowatt hour). This tariff is unchanged at endline. During the grant implementation period, costs for new connections were waived, but at endline the SPV were charging approximately IDR 2 million for installation of each new connection. Community respondents view the tariff rates as reasonable given the quality and availability of electricity, especially in comparison to the previous situation where communal generators only provided four hours of electricity per day at a similar price. During endline data collection, the SPV reported that their average monthly revenue from electricity sales was approximately IDR 52 million while expenditures were between IDR 40 to 45 million (including SPV staff salaries and regular O&M costs). While the SPV noted that they do regular reserve a portion of the profit for emergency repairs, they admitted that the amount of funds available for major repairs is insufficient. During the 2020 desk review process, the grantee mentioned that there were plans for the SPV to advocate to the district government for an increase in the tariff rate, but process had yet to be started at endline. This is perhaps due to the operational issues being faced by the grid, and efforts by the village government and cooperative to lobby for PLN entry (discussed below).

The biggest sustainability challenge facing the KMD, and solar grids is insufficient electricity supply caused by increasing demand from existing customers and addition of new customers to the grid. This issue was particularly acute at the time of endline data collection due to further constraints on supply generated due to the rainy season. Though higher than expected demand for electricity could be viewed as a success for the project, the endline qualitative data collection revealed that this issue could have been caused by a faulty needs assessment survey and budgetary constraints. During the planning stages, a needs assessment survey was conducted with potential RE users to understand their current energy usage, and what they might use electricity for once the grids were installed. Multiple community stakeholders, including SPV members, village officials and RE users, were incredulous about the validity of this survey because many households mentioned that they would only use the electricity for lighting or low-powered appliances. The enumerators for the survey were members of the community, and some respondents mentioned instances of enumerators priming respondents to downplay the amount of electricity they might use for fear that the project might be cancelled if it seemed too expensive. In addition to potential issues with demand estimation, the grantee also noted that budget constraints also informed the capacity of the grids and that the funds from the grant were insufficient to expand grid capacity further. Due to frustration with the current situation, the cooperative which co-owns the SPV, and some village officials had lobbied the provincial government to allow PLN to enter Karampuang. SPV members and other community respondents noted surprise that the cooperative had not discussed their plans with the SPV prior to taking this step, though some suggested that persisting lack of coordination between the cooperative and SPV director (who is not based in Karampuang) is perhaps one reason. The grant did put in place a sole business license for KMD which means that only KMD can supply electricity to Karampuang, which would prevent PLN from doing so. Regardless, village officials mentioned that the provincial government was in the process of commissioning a feasibility study to understand the feasibility and cost of PLN extending its grid to the island. Previously, construction of the needed undersea cables was deemed prohibitively expensive. Therefore, it is uncertain whether PLN will be able to extend service to Karampuang. Current RE users have mixed opinions about PLN entry. While some perceive that PLN will be more reliable as a public utility entity, most would prefer for the capacity of the RE grids to be increased and to remain KMD customers given the amount of investment already made to construct the grids in the community. However, if outages persist and RE users are unable to expand their electricity consumption, it is unclear if preferences will change. Sky Energy mentioned that expanding grid capacity to meet expected demand would require substantial financial investment (around 50 percent of the cost of the original infrastructure) for which neither the SPV nor Sky Energy have funding.

6.5.5 Window 2 IIEE

Project Background

The $810,000 "Economic improvement through renewable energy-based Center of Knowledge (CoK)" project constructed a micro-hydro plant in the village of Korong Wonorejo with a capacity of 60 kW, which replaced an older, though still functioning plant which had a capacity of 30 kW and was built in 2007. The new MHP was intended to expand household and public facility access to electricity for domestic use relative to the previous MHP. In addition, the project also established a Center of Knowledge (CoK), intended to be a local hub for training and knowledge sharing in MHP plant management and operations, ecotourism, and natural resource management. Within the CoK, the project also set-up coffee processing facilities. Complementary trainings were also provided to local coffee farmers on coffee cultivation and marketing practices. Since the CoK, including the coffee processing facilities, would run off of MHP electricity, the model assumed that income generated from the CoK, and coffee processing would increase community welfare and development. Assumptions related to increased household and public facility access to electricity largely held true, though the CoK and coffee processing facilities housed within it had not been utilized as planned.

Figure 14: Interior and Exterior of MHP Turbine House

Electricity Sources, Access, Consumption, and Expenditure

With the previous MHP, only half of the households in the village (less than 100 households) were able to have access to MHP electricity and connections were limited to 250 watts, which was mostly sufficient for lighting, charging cellphones and televisions, and insufficient for larger appliances. With the new MHP, almost all of the 250 households in the village were connected to the RE grid with higher-powered 900-watt connections. Compared to electricity quality from the previous MHP, electricity users universally noted that electricity access and consumption had improved. With the current MHP, respondents noted that electricity is available 24 hours per day and can be used to power household appliances, while with the previous MHP the current was often unstable, and outages were frequent especially as the number of households and usage increased. Many households had purchased new appliances for domestic tasks and leisure purposes including refrigerators, washing machines, blenders, mixers, irons, rice cookers, and coconut graters. Some households did not report changes in appliance ownership as they previously powered appliances using a diesel generator or had kept appliances from when they lived in another location with access to PLN electricity. Generally, respondents noted that benefits of expanded access to electricity were felt by women whose household chores could be completed more efficiently though time use had not changed notably as time saved was used to multi-task. In other instances, women reported using time saved to help their husbands with farming work.

In addition to households, the RE grid has also improved electricity access for public facilities in the village, namely a mosque, elementary school, village health center, and street lighting.

Electricity for Economic Purposes

Respondents perceived some changes to the village economy after commissioning of the new MHP. A few existing grocery stalls and kiosks expanded their sale items to include cold drinks, ice creams and prepared snacks from having access to refrigeration. In addition to households who purchased carpentry tools for household use, a few others started small-scale carpentry businesses or expanded their existing businesses that were previously dependent on diesel generators. Other emerging businesses included a blacksmith shop which uses a forge powered by MHP electricity, and swallow's nest cultivation which uses RE to power speakers which play bird calls.

Figure 15: Blacksmith Workshop Connected to MHP Grid

For coffee processing, the grant envisioned that the Cooperative that owns the MHP would purchase raw coffee beans from local farmers. After processing and packaging the coffee would be sold for a profit that would be used to support O&M of the MHP with some portion distributed to Cooperative members. In practice, the Cooperative did not have the working capital to purchase coffee in-bulk from producers so this idea could not be realized. Also, most users of the coffee processing facility used the facility to roast and grind beans for their own home consumption, rather than processing beans in bulk for sale. The grant provided trainings to coffee farmers on cultivation, roasting, grinding, and packaging through a coffee entrepreneurship organization. While coffee farmers noted that the trainings were useful in exposing them to new techniques for cultivation, most noted that the techniques were too intensive to be executed in practice requiring inputs such as fertilizers, and time to regularly trim back coffee plants and sort to select on only ripe red beans. Farmers typically sell raw, dried beans to middlemen who come to the village. If farmers were to implement the cultivating and post-harvest processing techniques taught during trainings, the resulting product (i.e., roasted and ground coffee using the highest quality red beans) would sell at a premium versus unprocessed, unsorted beans (IDR 50,000 per kilogram versus IDR 20,000 per kilogram). Yet beyond the time and effort to implement these techniques, respondents also noted that the middlemen that they depend upon as buyers would not purchase processed coffee, as their interest is to buy raw coffee. Therefore, marketing is another key constraint. There were some early grant-supported efforts to market processed coffee grown in the village. A brand name was developed which received a "Halal" certification and small batches of coffee were sold through marketing support from the coffee entrepreneurship organization and through online shops, but these did not continue due to reduced demand due to low interest amongst producers to produce processed coffee and market disruptions due to COVID-19. In addition to these issues, the coffee processing machinery at the CoK had been broken since the end of 2020. Due to low utilization of the facility by farmers and slim profit margins from providing the processing service, the Cooperative had yet to take steps to fix the machinery, and they noted the low incentives to do so as the processing is a small portion of their overall income. The estimated cost for machinery repairs is IDR 2 million while the annual profit to the Cooperative from coffee processing services is estimated at IDR 200,000. Also, coffee producers now have access to coffee processing machinery from farmer's groups and so the CoK would no longer be the only source for these types of services.

Though the CoK-based coffee processing business promoted by the grant has not yielded expected outcomes, some community members have started using MHP electricity for smaller scale coffee processing enterprises. An individual in the community recently started a coffee business from his home, buying raw coffee from farmers, processing it using equipment at home powered by RE, and selling the coffee online. Other community members have noted a desire to start similar coffee processing and marketing enterprises as well.

GHG Emissions

Approximately half of the households connected to the new MHP were connected to the previous MHP, therefore were already using RE as a primary energy source. Given the low power of electricity from the previous MHP and frequency of outages, it is possible that there has been reduced GHG emissions from these households from reduced use of kerosene lamps and reduced use of diesel to power larger appliances. For households that were not connected to the previous MHP, some relied on kerosene lamps for lighting, while a few others used small solar lamps or personal generators. Therefore, it is reasonable to assume additional reduction in GHG emissions from these households.

Community Buy-in and Sustainability

The MHP and CoK are owned and managed by a Cooperative whose leadership consists of individuals who managed the previous MHP. The Cooperative was established because of the grant so that infrastructure could be handed over to an official entity. The grantee noted that an alternative would have been to hand over the infrastructure to be managed through a BUMDes under the village government, but the community opted for a cooperative structure. At endline, the cooperative consisted of three units including the MHP management unit, the business unit overseeing activities at the CoK, and a new savings and loans unit. The overall cooperative is headed by a chairman, secretary, and treasurer. Additionally, each unit has a separate manager, and the MHP unit has two additional technicians. Each of these personnel are provided an honorarium for their work.

Management and technicians appear to actively monitor the technical status of the MHP grid, conducting regularly weekly maintenance on the system, adjusting the voltage distributed via the grid twice daily to regulate electricity flow, and turning off the system during thunderstorms as a preventative measure to protect against damage due to lighting. The vendor who constructed the new MHP is the same vendor who constructed the previous MHP and is located only four hours away from the village. Therefore, management and technicians can access technical support when required and coordinate with the vendor to resolve problems relatively quickly. For instance, the MHP was struck by lightning in early 2021 and parts needed to be sent to the vendor for major repairs. Management and the vendor coordinated to resolve the issue within one week. During this time electricity was not available, but customers report this

this is the only time when there had been a major outage since the new MHP was commissioned. It seems that the high level of experience and knowledge of MHP management and technicians coupled with their close connection with the infrastructure vendor has helped to ensure that the grid is maintained well. There are signs that growing demand from existing customers and new households may be putting strain on the system. Respondents living in the locations furthest from the MHP have noted that recently the electricity voltage has started to fluctuate more frequently, particularly in the evening when demand is highest signaling that the grid's capacity to distribute electricity to its furthest points may be diminishing due to high demand. Even customers living closer to the MHP have noticed a change in electricity quality. According to MHP management, current demand is at 90 percent of the MHP's generation capacity, and that demand will outstrip supply within one to two years.

The tariff structure for the previous MHP was a flat monthly fee of IDR 25,000. After construction of the new MHP, each household has an electricity meter installed and the tariff is IDR 500 per kilowatt hour. Electricity users also pay a monthly cooperative subscription free of IDR 15,000. Inclusive of the subscription free, reported monthly payments range between IDR 35,000 and IDR 100,000 though most households do not pay more than IDR 70,000 per month unless there is unusually high electricity usage due to holidays. Though monthly payments are higher than the previous MHP, customers still view the tariff as affordable, especially in view of the additional consumption the new MHP allows for and the relatively higher price of plan (IDR 1,400 per kWh). The cooperative provides streetlighting and electricity to the mosque free of charge as a form of social service to the community. While the elementary school and village health center are supposed to pay fees, the fee collection from these facilities is apparently not smooth. As noted previously, the coffee processing aspect of the CoK is no longer operating. Even when operational, it did not contribute significantly to Cooperative revenues. Other initiatives through the CoK to raise revenue also have not been successful, including printing and photocopying services and digital camera rentals. As a result, the primary revenue stream for the Cooperative to fund O&M of the MHP is fee collection from customers. On average, monthly fee collection amounts to IDR 8 million and regular O&M costs are IDR 4 million, so the Cooperative can regularly set aside funds as savings but Cooperative management assert that the current tariff may be too low to be sustainable. The major repair in early 2021 cost IDR 20 million and most of the savings accrued by the Cooperative went towards paying for the repair. Some funds that had been allocated to the new savings and loans unit under the Cooperative had to be repurposed to pay for the repair. Cooperative management are concerned that if another major repair arises in the next couple of months before they are able to rebuild their savings, then there will not be any funding to resolve it. In addition, because the cooperative is a standalone entity, unlike a BUMDes which is connected with village government, sourcing government funding is more complicated.

Despite the fact that the income generating aspects of the CoK had not been successful, the CoK was still appreciated by community members as a community asset. Pre-school classes were regularly held there, improving access to early childhood education and the center was regularly used for community gatherings. There were no specific plans for how to realize the idea of using the Center of Knowledge to promote edu-tourism, so it would serve as a hub of knowledge for MHP management (as envisioned by the grant). However, some respondents did indicate optimism that tourism potential would improve after the COVID-19 pandemic.

The Cooperative appears to have strong engagement with the community. Beyond the usual tasks of communicating about MHP status, they also seem to operate transparently by holding annual meetings, providing cooperative members with information about the financial condition of the cooperative, and holding elections when there are changes in cooperative management. Community members also express a strong preference for electricity from the MHP over PLN, citing that the MHP provides service that is similar to PLN but at a much cheaper price. Before the new MHP was constructed, PLN offered to provide service to the community, but the community rejected the offer due to perceptions of poor-quality electricity supply and price. The main sustainability challenge is the constrained capacity of the MHP as demand will outstrip supply in the near future which may compromise electricity quality. Upgrading the infrastructure to increase generation will be dependent on availability of sufficient water flow and would require funding the cooperative does not have.

Figure 16: Interior of the Center of Knowledge Established by the Grant

6.5.6 Window 2 Burung

Project Background

The CBOG-ER component of the $1.6 million "Enhancing community livelihood and conserving environment" project aimed to train farmers on agroforestry and sustainable agriculture, including the provision of crop irrigation and fertilizer, in order to provide communities with food security and increased income in a sustainable manner. The project was implemented by the Sumba Hijau Consortium, led by Burung Indonesia (BI). The grant included three RE components: Biogas energy for cooking fuel, the distribution of solar lamps for households, and the construction of solar water pumps (SWPs) for crop irrigation. BI noted that due to challenges in the administrative and communication process with MCA-I, approval for biogas energy came too late and the activity was canceled. BI did hand over 283 solar lamps to Pendamping Desa, a community development program. However, due to limited time, recipients were not trained by BI on the use and maintenance of those lamps, and BI could not comment on their current status. SWPs were built in the five villages in Central and East Sumba for direct use by 237 households and 16 plantation owners with the intention to irrigate 55 hectares of gardens, plantations and rainfed rice fields (a sixth SWP was cancelled due to limited groundwater). The endline evaluation of the Burung grant focuses on the SWP component.

The grant assumed that availability of water from SWPs, coupled with complementary trainings on sustainability agriculture practices, would increase crop diversity and quantity. This would in turn improve farmer income through increased sales. The grant also assumed that provision of clean water would improve general well-being of SWP users by providing a source of clean water for household needs.

Of the five SWPs constructed by the grant, two stopped functioning a year after commissioning due to low water levels from a sustained drought. This problem has been persistent since 2019 and in one case led to the neglect of the infrastructure, and the solar panels were stolen. According to the grantee, there are plans to relocate one of the SWPs to a more suitable location and the village government had been seeking approval from the district at endline.

The subsequent discussion focuses on the three SWPs still operational at endline. These SWPs were located in the following villages: Umbu Mamijuk (Central Sumba), Manorara (Central Sumba) and Bidi Prang (East Sumba).

Water Sources, Access, Consumption and Expenditure

Across all three villages, respondents report that water is regularly used for household consumption (i.e., drinking, sanitation and hygiene, and cooking) throughout the year, while it is used for crop irrigation only in the dry season (discussed further below in **Water for Economic Purposes**). In the rainy season, some households utilize water from other sources for household consumption, such as personal or communal dug wells, primarily using the SWP as a primary water source only in the dry season. For other households, the SWP is a primary source of water throughout the year. Due to water scarcity in the region, individuals from neighboring villages also come to these SWPs to take water, primarily for personal/household consumption. Previously, households mostly relied on dug wells to source water for household needs. When these wells would dry up in the dry season, most would travel one to three kilometers to springs or drilled wells to source water once or twice daily.

Across all three villages, respondents reported that the SWPs provide reliable access to water during the day, and that only on cloudy days the flow from the pump is reduced. The SWPs do not have batteries so are not functional at night, but respondents did not note that this posed a barrier to accessing sufficient water. Only in Bidi Praing, the SWP was non-functional for four months at the end of 2020 due to a technical issue with the engine (discussed further below in **Community Buy-in and Sustainability**).

In addition, to providing SWPs, the grant also equipped each SWP with a reservoir for storing pumped water. Two of the three SWPs had received improvements aimed at promoting better access to water. In Bidi Praing, the village government took the initiative to build a second reservoir to triple storage capacity from approximately 5,000 liters to 15,000 and extend the pipe network 1.3 km to a beneficiary household complex using money from the Village Fund Allocation after advocating the district government. In Manorara, the village advocated the district government and received funds from PAMSIMAS to build add a pipeline from the SWP to facilitate access of water by public facilities (an elementary school, village offices and a health facility) and households near these facilities. This pipeline was broken by community members within a couple months of being built and the village government had not made repairs at endline due to lack of clarity on infrastructure ownership (discussed further below in **Community Buy-in and Sustainability**).

Figure 17: SWP in Bidi Praing and Green Reservoir Added through Village Funds

Access to the SWPs is not restricted to household living closest to the infrastructure or households from the village. Given the common understanding that water is scare in the region, water is freely accessible. In addition, no limits are placed on the quantity of water that can be taken.

At project conception it was originally agreed that beneficiaries would pay a monthly fee of IDR 10,000. However, this fee collection has not been implemented in any of the three villages and water is accessed for free. BI attributes this to the fact that water is accessed and enjoyed by the community, at large, not just the direct beneficiaries. BI also noted that because the MCAI administrative procedures took longer than anticipated, they did not have sufficient time to sensitize communities on the importance of fee payments for sustainability of the infrastructure. Few SWP users noted using paid sources of clean water previously, therefore provision of SWPs has not had any direct effect on household expenditures. However, for households who use the SWP for cultivating herbal, fruit, or vegetable gardens, it is reasonable to assume that the provision of the SWP has reduced household expenditure on these products as they are now produced at home. If grown vegetables are more nutritious than previous food consumed, it would be reasonable to expect indirect nutritional benefits as well. As discussed in the next section, some households also reported routinely selling produce from their SWP-irrigated gardens, therefore suggesting some increase in household income as well. A few respondents also indicated that the availability of water was particularly beneficial for school children, as they could now bathe more easily prior to going to school. In Bidi Praing, where the village advocated for addition of pipelines, respondents noted additional time saving benefits from the SWP, given that they could now access water from a closer source than before. As respondents in Manorara and Umbu Mamijuk indicated that they previously had to travel long distances during the dry season to source water, it is plausible that they have also experienced time savings, however this was not mentioned by respondents. Also, in Bidi Praing, availability of water from the SWP was attributed with improving the overall sanitation situation in the village as it provided an accessible water source for toilets and washing facilities that were built by the village government in early 2021.

Water for Economic Purposes

Initially, the grant hoped that the water from the SWP could help irrigate rice and corn fields farmed by beneficiaries. Since these fields were rain-fed, traditional crops could only be planted and harvested once a year. With access to water from the SWP, the idea was that these crops could be planted and harvested multiple times a year. This could not be implemented in practice as these fields had highly absorbent soil requiring large quantities of water and the community's desire to ensure availability of sufficient water for household use.

Instead, households living closest to the SWP in each village started cultivating vegetable and fruit gardens after the SWP was installed. During the dry season (April to October), these households cultivate vegetables such as chilis, eggplant, long beans, cabbages, and tomatoes. A few households also cultivate tropical fruits like bananas, papaya, and jackfruit. Respondents noted that produce was primarily for household consumption, but any surplus is typically sold in the market or to local vegetable traders. The magnitude of sales and contribution to overall income is unclear, but a few respondents noted that proceeds from vegetable sales helped fund household daily needs and children's school fees. In addition, in Manorara and Umbu Mamijuk, households with agricultural plots closer to the SWP allow other households who live further away to use their plots to plant vegetables during the dry season. A few respondents noted that distance from the SWP is one barrier to using the water for agriculture. Since two of the three SWPs do not have pipelines attached, most users must carry water from the SWP to their plots using buckets or jerry cans, which is inconvenient when travelling longer distances. In some instances, households living closer to the SWP have purchased houses to attach to SWP taps, but this is not a feasible option for households living further away. In Bidi Praing, the installation of the pipeline network increased the area of land irrigated using water from the SWP to approximately 20 hectares, compared to 5 hectares in Manorara and Umbu Mamijuk.

In addition to vegetable and fruit gardens, availability of water from SWPs also encouraged cultivation of "living pharmacy" gardens—an initiative promoted by the district government to encourage cultivation of herbs with medicinal properties such as turmeric and ginger that could be used for cooking and for curing common illnesses. These herbs are primarily grown for home consumption rather than being sold.

The grant also inspired a few other productive use ventures. In Bidi Praing, a women's group has formed to farm a shared plot of land and started a business selling casava and sweet potato chips. While the plots are not irrigated using water from the SWP, the business was started after training provided by the grant. Also, respondents noted that provision of the SWP led to time savings due to availability of a nearby water source, which allowed the women to have the time to devote to the group. Also, at endline, individuals in Bidi Praing and Umbu Mamijuk had started experimenting with using water from the SWP to create ponds to cultivate fish. If successful, they noted there are future plans to train other community members on fish cultivation with the intention of selling fish in the local market.

Figure 18: SWP-irrigated Herbal and Vegetable Gardens in Umbu Mamijuk

GHG Emissions

RE provided by SWPs is not a direct substitution for non-RE sources, though some indirect effects were noted. While some SWP users reported previously walking 2-3 km to fetch water from the nearest wells or springs, some also reported using motorcycles for this purpose. With the availability of a clean water source near to their home, they no longer used the motorcycle to fetch water, therefore entailing slight reductions in fuel consumption for these households. Conversely, respondents also noted that individuals from nearby villages also travel to the SWPs to fetch water, with some doing so using motorcycles or small trucks. It is it isunclear how these individuals sourced their water previously (using fueled transport or by walking). Therefore, any impacts of these SWPs on GHG emissions are not immediately transparent. However, any impact that occurs is likely to be minimal.

Community Buy-in and Sustainability

According to BI, they attempted to help ensure the technical sustainability of the infrastructure by opting for SWPs that do not have batteries since battery maintenance, repair, and replacement is expensive. In addition, respondents from Manorara and Umbu Mamijuk noted that the grant-supported SWP was the most reliable SWP in their village as it consistently provides water, even during the most severe drought conditions, which is likely due to site selection and depth of the pump. To ensure a sense of ownership over the SWP, BI identified groups in each village to look after the SWP. In Manorara and Bidi Praing, these were farmers groups while in Umbu Mamujik the group was a community-based non-governmental organization (NGO) that was part of the BI consortium. Respondents in each village noted that they did not receive any special training from BI on SWP operations, beyond simple operations such as turning the pump on an off and would contact BI in case of any issues with the infrastructure.

In practice, community ownership and prospects for long-term sustainability differ across the three villages based on degree of village government engagement and clarity regarding infrastructure ownership. One commonality is that community members, especially those living closest to the SWPs, expressed a sense of joint accountability towards the SWP given the importance of clean water. Households closest to the SWP in all three villages report voluntarily looking after the security of the infrastructure and encouraging users to queue in an orderly manner for water during busier periods.

Bidi Praing

The village government of Bidi Praing took an active interest in the grant from the outset and, at endline, indicated clarity that the SWP was owned by the village government. As noted earlier, they used village funds to add improvements to the SWP (an additional reservoir and pipeline system). At endline, there were plans to make further additions to the SWP to add pipelines that would connect 25 households in a neighboring village to the SWP. The Bidi Praing village government was in the process of developing an agreement with the neighboring village to execute this plan. In addition, the village government had designated a member of village government staff to informally serve as the operator of the SWP—to help community members oversee SWP operations and coordinate with the government and BI in case of any issues. This staff member also handles smaller repairs on a regular basis using village government funds, such as leaking faucets or damaged pipes.

The SWP in Bidi Praing is the only one that had faced a major repair challenge where the pump engine stopped functioning. The village government first coordinated directly with the SWP vendor in Jakarta who quoted a high cost for the repairs (IDR 70 million), after which they contacted BI for support to find technicians who could complete the repair for a cheaper price. Ultimately, BI helped to identify a technician and the repair was carried out for IDR 14 million. A large portion of this was from village funds, while a small portion was from contributions collected by the village government from the user group. After this experience of managing a major repair, the village government and community discussed the need to implement a monthly payment scheme (as originally envisioned by the grant) to ensure some amount of dedicated savings for SWP repairs. At endline, the fee payment plan was in the process of being approved by the district government and would be put in place post approval.

Based on the success of the grant-supported SWP, the village government has now constructed two additional SWPs in the village equipped with pipeline networks to ensure that all households have access to clean water. Both were partially funded through community contributions with remaining funding provided from village government funds and PAMSIMAS funding. According to village government respondents, the grant-supported SWP was used as a model for these additional SWPs. One SWP used the same vendor, and both used the same water management system and pipeline network model.

One potential reason why the SWP has been so successful thus far is that it aligns well with village government priorities of providing clean water and improving sanitation. Village government respondents noted that these are the two highest priority areas for village development and that many of their current interventions are aimed towards addressing these areas.

Manorara

In Manorara, key stakeholders did not have clarity on the status of infrastructure handover and respondents noted uncertainty about whether the SWP belonged to BI, to the community, or to the village government. While the handover documentation had been prepared, it had not yet been provided to the village government. [57]

While the SWP was being constructed, BI had identified a group of individuals from the community to informally manage the SWP, including collection of fees from users. Once the SWP was operationalized, this group did not run as intended because many group members worked outside the community or mentioned they did not have time to devote to SWP management. The individual who donated land for the SWP continues to serve as the informal operator and caretaker for the infrastructure. When the SWP requires small repairs, this individual carries out the repairs using personal funds. At endline, the SWP had yet to face any major technical issues, but the operator noted he would source needed funds from the community if such a repair should arise.

Unlike the Bidi Praing case, community respondents did not sense any involvement of the village government in SWP operations, even though the village government were the intended official owners of the infrastructure. The village government, under the previous village head, had advocated for PAMSIMAS funding to add pipelines to the SWP to carry water to a public facility complex. Though these pipelines had been broken by community members, the village government had yet to take steps to repair the damage citing that the infrastructure was not under village government ownership. The village government asserts that the government is unable to allocate funds for repairs and further improvements unless the infrastructure is officially handed over. Post-handover, officials noted plans to repair these pipelines and institute a monthly user fee system (as originally planned by the grant).

Umbu Mamijuk

Similar to Manorara, key stakeholders were not aware of the current ownership of the SWP and assumed that it was under BI's ownership. In addition, BI had tasked one of their consortium partners, a local NGO, to look after the safety of the SWP until the handover process to the village government was complete. The SWP was built on land close to the NGO director's home and the NGO's office. As per community

[57] During endline data collection, the ET learned that the handover documentation for both the Manorara and Umbu Mamijuk SWPs had been prepared and submitted to the district Bappeda office for review. This process coincided with a busy administrative period due to local elections, so the handover documentation was not reviewed and there was no follow-up from other stakeholders (the village government or the grantee). During the endline data collection process, the district Bappeda office retrieved the documents and intended to hand them over to the grantee for subsequent handover to the respective village governments.

respondents, the relationship between the NGO and the current village head was contentious further disincentivizing village government involvement with the SWP.

Due to lack of clarity regarding ownership, several repairs had not been carried out on the SWP including replacement of a missing faucet and repair of cracks in the water reservoir. The SWP still operates regularly without these repairs, but water is now directly pumped from the ground to the taps since the reservoir cannot be used and water flows freely due to the missing faucet leading to wastage. Respondents noted that repairs had not been carried out because the NGO does not have funds, and for fear of causing further damage to infrastructure that is not officially the NGO's property. According to respondents, the community had also requested the village government to add pipelines from the SWP to beneficiary housing complexes, but this request had been denied due to the ownership issue. Unlike the other two villages, there were no plans for instituting any user fee mechanism to ensure future financial sustainability. Perceptions are mixed as to who should bear the cost of needed repairs and there does not appear to be any coordination between stakeholders for future planning. At endline, it seemed that the SWP continued to run because it has not faced any major repairs that would hamper operations rather than O&M efforts made by concerned stakeholders.

Across the three villages, prospects for long-term sustainability appear strongest for Bidi Praing where the village government has already invested in improving the SWP, have led a major repair process in coordination with the community and BI, and have developed concrete plans for implementing a user fee system in the future. For Manorara and Umbu Mamijuk, it is unclear whether the village government will take an active role even after the handover paperwork is provided. In both cases, the current village government is different than the village government that was in place during grant implementation. Both SWPs continue to function because they have not faced any significant O&M challenges, and it is unclear whether there are mechanisms in place to handle major repairs if they do arise. In Manorara, the village government seems to have more concrete plans for the SWP once handover is complete which suggests that engagement may improve post-handover. Conversely, intrapersonal dynamics in Umbu Mamujik may hamper long-term sustainability prospects.

6.5.7 Window 2 LAKPESDAM-PBNU

Project Background

The CBOG-RE component of the $1.3 million "Improvement of poor household income through green business practices" project implemented by LAKPESDAM-PBNU assumed that through the provision of renewable energy (standalone solar systems), as well as productive assets and training one could raise incomes within a community. Unlike other village level solar projects, LAKPESDAM - PBNU focused on a decentralized approach in which systems were installed at households, public institutions, and production houses. The project also provided training, and at times, equipment, for business opportunities that include water purification, egg hatching, banana chip and fish cracker processing, and coffee cultivation.

The project was originally approved for installation of decentralized solar systems at households and public facilities in two villages in Jambi (Rawasari and Sunga Rambut) and a hamlet in West Sumatra (Tandai Bukik Bulek). However, prior to the start of the program it was found that PLN planned to enter Sungai Rambut village. As a result, systems were only installed at the eight most vulnerable households which would struggle to pay PLN tariffs as well as at a production house. Plans to install solar PV systems at public facilities were cancelled as these facilities received electricity from PLN. In the other two locations 272 households, four production houses, and 13 public facilities (i.e., schools, mosques) received solar systems.

The grant planned for a hybrid model of infrastructure ownership with SHS systems installed at homes under the responsibility of respective households except in Sungai Rambut where SHS systems are under the ownership of the village government, and with solar PVs at public facilities under the responsibility of each facility. The solar PVs installed at production houses were planned to be managed by the entity managing the production house, which differed by location: village BUMDes (Rawasari), village cooperative (Sungai Rambut), or village government (Tadai Bukik Bulek). In addition, the project recruited volunteers at each location to serve as SHS technicians. These volunteers received training on SHS installation, O&M and common repairs, and were intended to serve as a resource for beneficiary households in case of technical issues with their systems.

Electricity Sources, Access, Consumption and Expenditure

SHS provided by the grant was intended to serve as a source for lighting, and each system was equipped with four light bulbs. The effects of the SHS systems on household energy consumption were mitigated by the presence of alternative electricity sources in each location. We discuss each location separately in this section.

Sungai Rambut

As noted earlier, in Sungai Rambut the grant pivoted to only provided SHS systems to eight poor households after realizing PLN had entered the village. At endline, a few of these households had been connected to PLN through support of other family members and were using the SHS as a backup source. Other households were still using the SHS as a primary electricity source for lighting. SHS users report that initially the systems provided bright lighting compared to previous sources such as kerosene lamps and diesel generators. One respondent noted that the bright lighting was particularly useful for his children's studies, as previous sources were comparatively dimmer and less reliable. Another respondent noted changes in time use. With availability of lighting from SHS, she slept later because her family would routinely come visit in the evening to spend time with her. However, after two years of use, respondents reported that the performance of the systems started to decline. Of the four light bulbs, one or more were broken or blown out at endline for all systems. Many systems also had reduced battery functionality increasing the time required for full charging. At endline, most households reported still using the SHS as a primary lighting source despite these issues, but that the lighting quality was dimmer than before and sometimes could not last the entire night. A few households had PLN electricity installed through support of relatives to provide better quality lighting. Due to the poor economic conditions of households receiving SHS support, the SHS systems in Sungai Rambut are under village government ownership. As a result, households had not reported incurring expenses for O&M of their systems. Therefore, relatively to previous sources used by these households, including diesel generators and kerosene lamps, the evidence indicates that expenditures on electricity have likely declined. When requested, volunteer technicians check SHS systems to troubleshoot issues, but these technicians do not receive any compensation for their work. In fact, technicians report sometimes paying for repair expenses themselves (e.g., paying IDR 30,000 for light bulb replacement). The village government reportedly set aside funds for battery replacement in 2021, but these had yet to be disbursed when the team conducted endline data collection.

Rawasari

In Rawasari, PLN entered the village in February 2020 and almost all the 224 households that had received the SHS had become connected to the PLN. These households now used the SHS as a backup source in case of PLN outage or to save on electricity costs. Prior to provision of the SHS from the grant, respondents reported using either kerosene lamps for lighting or a communal diesel generator. After provision of the SHS, respondents reported using it as a primary source of lighting before PLN entry. SHS lighting enabled productive time use at night by different members of the household (e.g., children could study more effectively, women could spend more time in the garden during the day and make snacks in the evening). Similar to Sungai Rambut, households experienced decline in SHS quality after two years of use due to light bulbs burning out or reduced battery function. By that time, most households had installed electricity from PLN, so the SHS became a backup source or a source to use at night to reduce PLN costs. At endline, most households interviewed indicated that as long as at least one light bulb was functional, they would not purchase replacement light bulbs or conduct other repairs on their systems. The use of PLN as a primary lighting source is one reason for deprioritizing of repairs, while the difficulty of sourcing replacement parts (especially light bulbs) was another reason cited. While households sampled for the qualitative data collection had not spent any money on maintenance of their systems, the volunteer technician reported that a few households had invested in replacement of parts, including new batteries. Due to the high price of spare parts, technicians reported identifying cheaper and locally available alternatives that could be retrofitted to work with the systems.

Figure 19: PLN and SHS User Household in Rawasari

Tandai Bukek Bulik

In Tandai Bukek Bulik, many of the 48 households that had received SHS systems were now connected an MHP that had been in the community since 2005. Some of these households were previously not connected to the MHP because their houses were not located close enough to the distribution lines. Other households had previously been living in distant farmhouses in the hamlet when the SHS were distributed. They later relocated the SHS to their main houses which were already connected to MHP electricity. A few households living in more remote locations reportedly still use the SHS as a primary source of electricity for lighting, though the condition of these systems was variable with a few households having switched back to using kerosene lamps because their SHS were no longer operational, or the batteries had been stolen. For households with functioning SHS, the systems are used as backup lighting in case the MHP is not functioning. In fact, at the time of endline data collection the MHP had not been operational for one week, so households were using the SHS for lighting. Unlike in Rawasari where households also regularly used SHS to save on PLN costs, households in Tandai Bukik Bulek did not report using their SHS for this purpose because the MHP tariff was a flat monthly payment. The reported condition of SHS systems varied across households, with some indicating that the systems were functioning almost as well as when they were installed, while others noted similar issues as respondents in Rawasari (blown out light bulbs and declining battery capacity). Respondents did appreciate that the quality of lighting from the SHS was superior to previous lighting from kerosene lamps and the current variable lighting quality from MHP electricity. While households with functioning SHS were grateful for a backup source of lighting, the evaluation team found limited evidence that households invested in O&M of these systems. As in Rawasari, most suggested that they would not purchase replacement bulbs or make repairs to other parts as long as their systems had at least one functioning light bulb.

Solar Systems for Public Facilities

Only two locations received solar PV systems for public facilities. In Rawasari, solar PV systems had been installed at 10 public facilities including schools, mosques, and health centers. With the entry of PLN, all these public facilities use electricity from PLN at endline. According to community respondents, the conditions of these systems is also quite poor with extensive damage to batteries, therefore only one of the mosques uses the system as a backup in case of PLN outage. For the 1.5-year period after solar PV installation and before PLN entry, the evaluation team was unable to confirm how the systems influenced energy consumption. In Tandai Bukek Bulik, solar systems were provided to three mosques, though the evaluation team was unable to confirm whether these were still in use.

Electricity for Economic Purposes

Households did not specifically report that availability of lighting from SHS encouraged economic activities. Though the grant expected that lighting from SHS might yield some productivity gains by enabling households to conduct some economic activities at night, the grant more directly promoted use of RE for economic purposes through establishing production houses and conducting trainings with community members.

In Rawasari and Sungai Rambut, the grant attempted to establish three small scale industries: banana chips and fish cracker making, water purification, and poultry farming. Of these, only the water purification business continued beyond the initial trial period. Participants of these groups noted that primary reasons why these activities were pursued where lack of availability of required inputs (bananas and fish), lack of working capital to purchase inputs when available, and the minimal profit from sales relative to the amount of energy expended to produce the products. These groups also faced challenges in obtaining required permits and certifications to sell products outside of the village. For poultry farming, respondents mentioned that after the first set of chicks died, the activity was no longer pursued.

In both locations, water purification continues to be carried out at grant-established production houses. In Rawasari, the water purification enterprise is owned and managed by the village BUMDes, while in Sunga Rambut this responsibility lies with a village cooperative. Both businesses report strong demand for water produced from the village and neighboring villages. In Sungai Rambut, facility management report that they sell between 10 to 200 gallons of purified water a day for between IDR 4,000 – IDR 5,000 per gallon (the average number of gallons sold daily is 50). The facility sells to both individuals and stalls. In Rawasari, an agreement was made to only sell purified water to stalls, rather than directly to households, to support local businesses. Facility management report regularly supplying 13 stalls with purified water at IDR 4,000 per gallon. In both cases, facilities have accrued enough savings to carry out moderate repairs, and in Rawasari was also able to purchase a new water purification machine from accrued savings at a cost of IDR 12.5 million. Both facilities have made additional investments using revenue collected to support their business including buying boats and motorcycles to facilitate product delivery. At endline, managers of both facilities did report that revenues had started decline in the past year. In Rawasari in particular, the entry of PLN has encouraged competition from others in the community who had started water purification businesses powered by PLN electricity. To expand into a new market, facility management in Rawasari indicated plans to scale up the business to produce higher-grade bottled water, though noted barriers related to sourcing sufficient funding and obtaining needed permits.

Figure 20: Water Purification Production House in Sungai Rambut

In Tandai Bukek Bulik, the grant established a production house for coffee processing and making of jenkol chips (chips made from a type of seed) under official ownership of the village government. The jengkol chip activity did not proceed beyond the initial trial period. While lack of working capital to purchase and marketing were constraints, group members also noted that lack of coordination with the group and perceived lack of transparency of how finances were maintained were additional factors contributing to the activity not being pursued. To support the coffee processing activity, the grant facilitated linkages between coffee producers and the "Solok Rajo" cooperative who would help to market the processed coffee produced. While a few small batches of coffee were initially sold through this mechanism, the activity was not pursued. The primary reason was that the grade of coffee the cooperative required necessitating sorting of raw coffee beans to select only ripe red beans for processing. However, the traditional practice of coffee farmers is not to sort beans but to pick them in bulk, dry them and then sell to wholesale traders. The process of sorting beans was viewed as too cumbersome by farmers, especially because the potentially benefits were uncertain (i.e., the ripe beans would first need to be processed, marketed by the cooperative and sold prior to farmers receiving any revenue). In addition, the cooperative requested bulk orders of processed coffee while the actual production capacity of farmers was much lower given the small scale of their plantations. At endline, the production house was no longer in use and had been damaged due to a tornado.

GHG Emissions

While the SHS systems were being used as a primary source of lighting (before PLN entry to Rawasari, and before many beneficiary households were connected to the MHP in Tandai Bukek Bulik), there is some evidence that their use contributed to GHG emission reductions. Households previously used kerosene lamps for lighting, while some also reported using diesel generators. At endline, contributions to GHG emissions have likely reduced as the systems are used only as a backup for primary lighting sources, as well as at night to save on PLN electricity costs. In Sungai Rambut, a few of the eight beneficiary households continue to use the SHS as a primary source while others have switched to PLN. Regarding public facilities, at endline it appears that none of the facilities provided solar PV systems in Rawasari and Tandai Bukek Bulik are using these systems. The evaluation team was unable to confirm the extent to which facilities previously used these systems and what that usage may have entailed for GHG emissions.

As the production houses in each location attempted to establish new economic activities rather than replace existing activities that utilized non-RE, the expected contribution to GHG emissions reductions is minimal. In Sungai Rambut and Rawasari, for water consumers (households and stalls) who may have previously purchased water from neighboring villages or fetched water from distant sources, there may be some indirect effects if fueled transport was used to source this water. With the installation of PLN as a backup source at the Rawasari production house, this may entail slight increases GHG emissions Since the production house in Tandai Bukek Bulik is damaged and not in use, it also is not making any contributions to GHG emissions.

Community Buy-in and Sustainability

SHS

The grant attempted to promote sustainability of the SHS systems in a number of ways. First, in each location, volunteer technicians were identified who were provided with training on installation, O&M, and common repairs of SHS systems. These volunteer technicians were also responsible for helping to install SHS at beneficiary households, and technicians noted appreciation for the opportunity to gain practical experience in this aspect. In at least two of these locations, technicians were individuals who had prior relevant experience and knowledge due to having served as technicians for diesel power plants or micro-hydro plants. Volunteer technicians were intended to serve as a resource for beneficiary households in case they encountered issues with their systems. Most households we spoke to during qualitative data collection were aware of these technicians, and a few had availed of their services to either inquire about replacement parts (in the case of light bulbs) or to diagnose batter-related issues. Respondents generally perceived technicians to be competent and capable of helping to provide guidance and suggestions on common issues. For the most part, households indicated that they had not contacted technicians yet as their systems were at least partially functioning (i.e., had at last one functioning lightbulb, or the battery could still store charge). Technicians reported that they still routinely contact individuals at University Gajah Mada (UGM) for Energy Studies (a member of the grant consortium) which provides remote technical and managerial assistance to managers via phone or text. An additional sustainability plan which included monitoring and technical assistance by a local vocational school could not be pursued as the plan would require coordination with the provincial government and identification of associated funding. To promote financial sustainability, the grant attempted to institute a group savings mechanism where SHS users in Rawasari and Tandai Bukek Bulik would contribute between IDR 25,000 and IDR

35,000 per month. This mechanism would ensure that dedicated funds were in place to address repairs and purchase replacement parts, especially battery replacement which the grantee noted would be necessary after five years of use. In practice, this mechanism only ran for a couple of months after SHS handover. Community respondents provided two reasons why this savings scheme did not continue. First, some SHS users were unwilling to allocate money for future repairs that may or may not be needed, preferring instead to use that money for more immediate needs. In addition, since the SHSs are owned by the respective households, the need to contribute to a joint scheme was not entirely clear to households. Others noted that coordinating the actual logistics of fee collection was the key challenge (who would visit each household to collect the money or follow-up in case of non-payment etc.).

Public Facilities

As solar PVs at public facilities were not functional or not in use at endline due to presence of alternative sources, it seems unlikely that these will be used in the future. The grantee noted that the original sustainability plan for solar PVs installed at public facilities in Rawasari and Tandai Bukek Bulik was for O&M costs to be paid by the respective village governments, though there was no written agreement or statement to that effect. Since all systems are reportedly broken or not in use, it does not seem that facilities prioritized or invested in O&M of the systems. Volunteer technicians noted that, while they were comfortable troubleshooting issues with SHS, they were much less confident on O&M of the solar PV systems installed for public facilities and production houses. Their trainings had focused more on SHSs.

Productive Activities and Production Houses

Regarding the group-based productive activities, though participants appreciated these trainings and the opportunity to gain new knowledge, it seems unlikely that these activities will be restarted given the challenges related to inputs, finances and group coordination noted earlier. Similarly, with the damage to the coffee production house in Tandai Bukek Bulik and no plans for repairs or repurposing of the infrastructure, it does not seem that this infrastructure will be revitalized and used. Sustainability prospects for the two water purification businesses are decidedly more positive as both have been able to sustain operations, have steady demand for their product, and have demonstrated an ability to deal with O&M thus far. However, with the recent decline in revenues, management did not some uncertainty that extensive major repairs or parts replacement could be independently funded in the future.

The long-term sustainability of SHSs across all three locations is threatened by the fact that these systems have become a backup source of lighting for most households. As a result, we found that many households had not invested in O&M of their systems or replacement parts, opting to continue utilizing them with reduced functionality as long as they provided some lighting. Contributing to this is the fact that the required replacement parts are not readily available in local markets, which means that technicians have to coordinate with UGM to source lightbulbs in bulk and ship them to the village or parts need to be purchased online. At endline, there was limited evidence that these efforts had been made, perhaps because SHSs are not a primary source of lighting for most households and the parts were perceived to be expensive. As noted earlier, technicians in some locations did note that they have attempted to identify workarounds to parts availability by purchasing locally available alternatives and fitting them to the SHSs. In Sungai Rambut where the village government has taken responsibility for the SHS systems, there is no indication that any funds have been disbursed for O&M or replacement parts. Village government representatives had only noted that funds had been allocated in 2021 for the purpose of battery replacement. Therefore, though households were universally appreciative of the systems, there is not strong evidence to suggest that households will maintain their systems in the long-term. Given that few households have made even small investments in parts replacement, it seems highly unlikely that larger investments, like battery replacement, will be made.

For production houses, despite the recent reported declines in sales, it seems likely that the water purification facilities in Rawasari and Sungai Rambut will continue to operate. Community members cited benefits from availability of clean water and appreciate the convenience and lower cost of water produced. Since the production house in Rawasari is an operating unit of the village BUMDes, its sustainability outlook is somewhat stronger than the production house in Sungai Rambut. Managers of the facility noted that they could source financing from the village government through the BUMDes in case major repairs or investments are needed that the facility cannot afford. In contrast, since the production house in Sungai Rambut is owned by a cooperative (a standalone entity without government affiliation), access to government funding is more challenging. The village government has offered to incorporate the cooperative into the BUMDes to enable more financial security, but cooperative management noted reluctance due to concerns that existing members of facility management might be fired.

6.6 Literature Review

For ease of reference, this literature review is pasted directly from Social Impact's Evaluation Design Report.[58]

6.6.2 Summary of Existing Evidence

Micro-grids play a crucial role in efforts to provide universal access to electricity by 2030 around the world, as proclaimed by the United Nations (UN) initiative Sustainable Energy for All (SE4All) and the Sustainable Development Goal 7. The International Energy Agency (IEA) estimates that 42 percent of the additional electricity generation capacity to reach universal access can most economically be achieved through micro-grids (IEA 2010).[59]

The academic literature is inconclusive about the impacts of rural electrification on rural development, and there are only few rigorous studies to provide compelling evidence. For example, in India, Bangladesh, and Vietnam respectively, Van de Walle et al. (2015),[60] Khandker, Barnes, and Samad (2012),[61] and Khandker, Barnes, and Samad (2013)[62] find evidence for positive effects on job market indicators, household income, and educational performance as a result of electrification. Parikh et al. (2015)[63] find positive effects in particular for women from infrastructure provision, including electricity, in Indian slums on literacy, income and health. Grimm, Sparrow and Tasciotti (2015)[64] and Peters and Vance (2011)[65] show that electrification contributes substantially to the fertility decline in Indonesia and Côte d'Ivoire respectively. In addition, some positive evidence on firm productivity comes from India, Kenya, Nicaragua, and South Africa (Rud 2012;[66] Gibson and Olivia 2010;[67] Kirubi et al. 2009;[68] Grogan and Sadanand 2013).[69]

There is, however, a set of more sobering findings. While research indicates that lighting is a high priority for people and is in fact used also for purposes considered to be beneficial from a development perspective, impacts on productive activities, however, are often much less pronounced than expected

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[58] Social Impact, Inc (2019). Evaluation Design Report: MCC Indonesia Green Prosperity Project: Grant Facility Community-Based Off-Grid Renewable Energy Grant Portfolio v.3. See https://data.mcc.gov/evaluations/index.php/catalog/207
[59] Birol, F. (2010). World energy outlook 2010. International Energy Agency, 1(3).
[60] van de Walle, D., Ravallion, M., Mendiratta, V., & and Koolwal, G. (2015). Long-term impacts of household electrification in rural India. World Bank Economic Review, forthcoming.
[61] Khandker, S. R., Barnes, D.F. & Samad, H.A. (2012). The Welfare Impacts of Rural Electrification in Bangladesh. The Energy Journal, 33(1), 187.
[62] Khandker, S. R., Barnes, D.F. & Samad, H.A. (2012). The Welfare Impacts of Rural Electrification in Bangladesh. The Energy Journal, 33(1), 187.
[63] Parikh, P., Fu, K., Parikh, H., McRobie, A., & George, G. (2015). Infrastructure Provision, Gender, and Poverty in Indian Slums. World Development, 66, 468-486.
[64] Grimm, M., Sparrow, R., & Tasciotti, L. (2015). Does electrification spur the fertility transition? Evidence from Indonesia. Demography, forthcoming.
[65] Peters, J., & Vance, C. (2011). Rural Electrification and Fertility – Evidence from Côte d'Ivoire. Journal of Development Studies, 47 (5), 753-766.
[66] Rud, J.P. (2012). Electricity provision and industrial development: Evidence from India. Journal of Development Economics, 97(2), 352–67.
[67] Gibson, J., & Olivia, S. (2010). The effect of infrastructure access and quality on non-farm enterprises in rural Indonesia. World Development, 38(5), 717-726
[68] Kirubi, C., Jacobson, A., Kammen, D. M., & Mills, A. (2009). Community-based electric micro-grids can contribute to rural development: evidence from Kenya. World Development, 37(7), 1208-1221.
[69] Grogan, L. & Sadanand, A. (2013). Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua. World Development, 43(0), 252–265.

(Bernard 2012;[70] Peters, Vance and Harsdorff 2011;[71] Neelsen and Peters 2011;[72] Grimm, Hartwig and Lay 2013;[73] Banerjee et al. 2011;[74] Lenz et al. 2017;[75] Peters et al. 2013;[76] Peters and Sievert 2015;[77] Oakley et al. 2007;[78] Obeng and Every 2010).[79] A recent large-scale evaluation of a rural electrification program in Tanzania,[80] for example, finds reductions in some traditional energy source uses and positive effects on land prices and lighting usage as proxies for well-being. However, there are no impacts on non-agricultural employment or firm creation. The reason is often that in most rural areas electricity is not the only bottleneck that impedes business development. In the absence of roads and market access, electricity can only be used for productive purposes that serve the local demand, which is often small. Moreover, households and enterprises in rural areas typically have a very low ability to pay. As a result, typical household electricity demand is very low (see for example D'Agostino et al. 2016;[81] Grimm and Peters 2016;[82] Bensch et al. 2016).[83] Electricity in rural areas is often only used for lighting, charging mobile phones and operating radios and sometimes TV (television)-sets (see for example IEG 2008,[84] Lenz et al. 2017).[85]

The impacts of electrification on GHG emissions and the environment depends on the source of electricity that is supplied and the initial energy sources that are being replaced. Currently, RE sources make up

[70] Bernard, T. (2012). Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa. World Bank Research Observer, 27(1), 33–51.
[71] Peters, Jörg, Colin Vance, and Marek Harsdorff. 2011. "Grid Extension in Rural Benin: Micro-Manufacturers and the Electrification Trap." World Development, 39(5): 773–83.
[72] Neelsen, Sven and Jörg Peters. 2011. "Electricity usage in micro-enterprises — Evidence from Lake Victoria, Uganda." Energy for Sustainable Development, 15(1): 21–31.
[73] Grimm, M., Hartwig, R. & Lay, J. (2013). Electricity Access and the Performance of Micro and Small Enterprises: Evidence from West Africa. European Journal of Development Research, 25, 815-829.
[74] Banerjee, S. G., A. Singh, and Samad, H. (2011). Power and people : the benefits of renewable energy in Nepal. Washington D.C., World Bank.
[75] Lenz, L., A. Munyehirwe, J. Peters und M. Sievert. 2017. Does Large Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program. World Development 89 (17): 88-110.
[76] Peters, J., M. Sievert and C. Vance (2013), Firm Performance and Electricity Usage in Small Manufacturing and Service Firms in Ghana. In: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (ed.), Productive Use of Energy – PRODUSE - Measuring Impacts of Electrification on Small and Micro-Enterprises in Sub-Saharan Africa. Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. 75-94.
[77] Peters, J., & Sievert, M. (2015). The provision of electricity to rural communities through Micro-Hydro Power in rural Indonesia: Micro Hydro Power pilot programme within the national programme for community development (PNPM) supported by the Netherlands through energising development (No. 88). RWI Materialien.
[78] Oakley, D., P. Harris, et al. (2007). Modern energy - Impact on micro-enterprise. A report produced by the Department for International Development. R8145. DFID. AEA Energy and Environment. March 2007.
[79] Obeng, G. Y. and H. D. Evers (2010). Impacts of public solar PV electrification on rural microenterprises: The case of Ghana. Energy for Sustainable Development 14(3): 223-231.
[80] Chaplin, D., Mamun, A., Protik, A., Schurrer, J., Vohra, D., Bos, K., ... & Cook, T. Grid Electricity Expansion in Tanzania by MCC: Findings from a Rigorous Impact Evaluation, Final Report (No. 144768f69008442e96369195ed29da85). Mathematica Policy Research.
[81] D'Agostino, A.L., Lund, P.D. and Urpelainen, J., 2016. The business of distributed solar power: a comparative case study of centralized charging stations and solar microgrids. Wiley Interdisciplinary Reviews: Energy and Environment.
[82] Grimm, M., & Peters, J. (2016). Solar off-grid markets in Africa. Recent dynamics and the role of branded products. Field Actions Science Reports. The journal of field actions, (Special Issue 15), 160-163.
[83] Bensch, G., Grimm, M., Huppertz, M., Langbein, J., & Peters, J. (2016). Are promotion programs needed to establish off-grid solar energy markets? Evidence from rural Burkina Faso (No. 653). Ruhr Economic Papers.
[84] Independent Evaluation Group (IEG). 2008. The Welfare Impacts of Rural Electrification – An IEG Impact Evaluation. Independent Evaluation Group, World Bank.
[85] Lenz, L., A. Munyehirwe, J. Peters und M. Sievert. 2017. Does Large Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program. World Development 89 (17): 88-110.

between 15 percent and 20 percent of the world's total energy demand. In the case of solar PV and micro-hydro plant installation, the energy provided is from non-depletable fuels solely and consumption does not emit GHG (Akella et al. 2009).[86] The more these new systems replace initial reliance on oil, coal, and natural gas, the better the environmental impacts of the intervention. One example is dry-cell batteries and LED lamps, which have replaced kerosene in many parts of the developing world (see Bensch, Peters and Sievert 2017).[87] Electrification can hence help to reduce e-waste in rural areas. Furthermore, high emission reductions can in particular be expected when rural households replace diesel-driven machinery use or biomass-based cooking and heating by electric appliances. Biomass use for cooking and heating is a major cause of climate-relevant emissions (for example Shindell et al. 2012;[88] Ramanathan and Carmichael 2008;[89] Bailis et al. 2015).[90] While typically electricity is rarely used for cooking in developing countries, in Asia the use of electric rice cookers is very common.

There are very few rigorous studies on the sustainability of micro-grid programs, partly because only few examples of sustainably working micro-grid programs exist that have matured beyond the installation of just a model micro-grid. There are a few potential reasons for low sustainability. First, institutional and political challenges often impede cost-covering electricity consumption tariffs that would make investments into micro-grids attractive. In most countries, rural electricity tariffs - even for the national grid - are not cost recovering (see Trimble et al. 2016),[91] but highly subsidized by governments or in the best-case cross-subsidized by urban consumers. Accordingly, typically regulatory bodies or the incumbent utility will not readily approve higher tariffs that are needed to make micro-grids cost covering (Peters and Sievert 2015).[92] In addition, payment enforcement may be hampered by low ability to pay (D'Agostino et al. 2016)[93] and irregular, seasonal income flows that are typical among agriculture-reliant populations. Furthermore, there may be a low willingness-to-pay, as the costs of renewable energies (solar, hydro, wind) are not directly visible for the population given its local generation (as compared to, for example, the case of generators).

Mini-grids can be operated by public-private partnerships or by communities. For micro-grids operated by the community, the two key challenges are tariff setting and payment enforcement (Peters and Sievert

[86] Akella, A.K. 2009. Social, economical and environmental impacts of renewable energy systems. Renewable Energy 34: 390–396.
[87] Bensch, G., J. Peters und M. Sievert (2017), The lighting transition in rural Africa — From kerosene to battery-powered LED and the emerging disposal problem. Energy for Sustainable Development 39: 13-20.
[88] Shindell, D., Kuylenstierna, J. C., Vignati, E., van Dingenen, R., Amann, M., Klimont, Z., ... & Schwartz, J. (2012). Simultaneously mitigating near-term climate change and improving human health and food security. Science, 335(6065), 183-189.
[89] Ramanathan, V., & Carmichael, G. (2008). Global and regional climate changes due to black carbon. Nature geoscience, 1(4), 221.
[90] Bailis R., Drigo R., Ghilardi A. and O. Masera (2015). The carbon footprint of traditional woodfuels. National Climate Change 5:266–72.
[91] Trimble, Christopher Philip; Kojima, Masami; Perez Arroyo, Ines; Mohammadzadeh, Farah. 2016. "Financial viability of electricity sectors in Sub-Saharan Africa : quasi-fiscal deficits and hidden costs". World Bank Policy Research Working Paper.
[92] Peters, J., & Sievert, M. (2015). The provision of electricity to rural communities through Micro-Hydro Power in rural Indonesia: Micro Hydro Power pilot programme within the national programme for community development (PNPM) supported by the Netherlands through energising development (No. 88). RWI Materialien.
[93] D'Agostino, A.L., Lund, P.D. and Urpelainen, J., 2016. The business of distributed solar power: a comparative case study of centralized charging stations and solar microgrids. Wiley Interdisciplinary Reviews: Energy and Environment.

2015).[94] Incentives and obstacles to enforce payment rigorously are different for a community member than for outsiders working for a commercial operator. Most importantly, social entanglements may complicate rigorous enforcement. In theory, the same mechanism can also work the other way around, where social cohesion might lead people to feel more obliged to pay their contributions. Lastly, payment for operational staff may seem dispensable in rural subsistence communities where paid labor is rather an exception than the rule. This, again, may lead to too low tariffs and bad payment discipline.

6.6.3 Gaps in Literature

This evaluation can provide evidence on three gaps in the literature. In particular, three design features of the Window 3A projects are highly interesting from a global learning point of view.

First, as outlined above, despite high costs attached to electrification, there is generally no consensus on the impacts of electrification on rural development, and less so for the case of micro-grids. Given that micro-grids play an important role in the SE4ALL goal of universal electricity access, evidence is highly required.

Second, a comparison of different micro-grid management or financing systems does not exist in the literature. The only examination has been done in Indonesia for non-private micro-grids run by the community and fully subsidized by the government (see Peters and Sievert 2015).[95] Evidence on the impacts of the management system on the sustainability of micro-hydro plants is not available and, more concretely, there is no understanding of the dynamics that may hamper or foster payment enforcement among local customers and O&M practices among the local community operators.

Third, there is no study that assesses the impact of providing electricity access paired with productive use promotion. The exception is one study on microfinance and electricity (Khandker and Koolwal (2010).[96] Given high impact expectations from electrification and productive use aspirations, but often limited income effects in practice, learning on combined interventions is highly relevant. The trainings on productive use, as provided by the Window 3A projects, in conjunction with electricity provision therefore serve as a unique opportunity to fill this gap.

6.6.4 Policy Relevance of the Evaluation

The electrification rate in Indonesia has been increasing at a steady pace, expanding from approximately 43 percent in 1995 to 84 percent in 2015.[97] There are, however, great disparities in electricity access across regions, ranging between 36.4 percent in Papua and 100 percent in Jakarta. Generally, electrification is disproportionately provided in the centers of Java and Bali, while the eastern provinces

[94] Peters, J., & Sievert, M. (2015). The provision of electricity to rural communities through Micro-Hydro Power in rural Indonesia: Micro Hydro Power pilot programme within the national programme for community development (PNPM) supported by the Netherlands through energising development (No. 88). RWI Materialien.
[95] Peters, J., & Sievert, M. (2015). The provision of electricity to rural communities through Micro-Hydro Power in rural Indonesia: Micro Hydro Power pilot programme within the national programme for community development (PNPM) supported by the Netherlands through energising development (No. 88). RWI Materialien.
[96] Khandker, S.R., Koolwal, G.B. (2010) How Infrastructure and Financial Institutions Affect Rural Income and Poverty: Evidence from Bangladesh. Journal of Development Studies, Vol. 46 (6), p.1109–1137.
[97] https://www.cia.gov/library/publications/the-world-factbook/geos/id.html.

are characterized by the lowest electrification rates. In 2012, the provinces East Kalimantan (W3A Akuo Energy Solar/Micro-Hydro, Berau) and East Nusa Tenggara (W3A Anekatek Solar, East Sumba) had electrification rates of 64 and 44 percent respectively, lagging behind the average electrification rate of 75 percent of that year.

The country has an installed electricity generating capacity of 51.92 GW (gigawatts), of which the vast majority is generated from fossil fuels (83.2 percent), with coal being the predominant type of fossil fuel. 11 percent of the capacity is generated by hydroelectric plants. The remaining 5.8 percent comes from other renewable sources.[98] The country produces high levels of GHG emissions. The use of fossil fuels, in particular in the power sector and transportation, is expected to more than double the country's energy-related CO_2 emissions in the coming 25 years, rising to more than 800 million tons by 2035.[99]

The GoI political agenda pursues as major objectives the increase in electricity access, an expansion of RE use and green growth. The country was one of the first to ratify the United Nations Framework Convention on Climate Change and to adopt the Kyoto Protocol.[100] The *National Energy policy* (KEN) aims at increasing the country's usage of new and RE from four percent of all energy usage in 2011 to 23 percent by 2025 and 31 percent by 2050.[101] Simultaneously, the *2015-2019 National Medium Development Plan* sets the goal of reaching an electrification rate of 96.6 percent by the end of 2019 with a particular focus on disadvantaged communities and remote, undeveloped regions.[102] In an attempt of bringing together these multiple goals, the GOI and the state electricity company PLN have launched several rural electrification plans. Among them stands out the longer-term solar development plan *Thousand Islands Program,* which aims at expanding the solar installed capacity to 620-megawatts by 2020.[103]

However, the government faces several challenges in reaching the remaining 16 percent of its population that lacks electricity access. This population group is the most costly and timely and technically more difficult to serve, given the lower population density and ability to pay. Moreover, the mountainous topography of the archipelagic nation represents a challenge for the expansion of electricity access. Electricity supply in the provinces East Kalimantan (W3A Akuo Energy Solar/Micro-Hydro, Berau) and East Nusa Tenggara (W3A Anekatek Solar, East Sumba) is particularly costly.[104]

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[98] Tharakan, Pradeep. "Summary of Indonesia's Energy Sector Assessment." Www.adb.org, Asian Development Bank, 10 Nov. 2017, www.adb.org/publications/summary-indonesias-energy-sector-assessment. pg. 8.

[99] Tharakan, Pradeep. "Summary of Indonesia's Energy Sector Assessment." Www.adb.org, Asian Development Bank, 10 Nov. 2017, www.adb.org/publications/summary-indonesias-energy-sector-assessment. pg. 9.

[100] ESDM. "ESDM - Kementerian Energi Dan Sumber Daya Mineral Republik Indonesia." *ESDM*, ESDM, www.esdm.go.id/.

[101] Tharakan, Pradeep. "Summary of Indonesia's Energy Sector Assessment." Www.adb.org, Asian Development Bank, 10 Nov. 2017, www.adb.org/publications/summary-indonesias-energy-sector-assessment. pg. 31.

[102] Current policies in the RE sector include the Ministerial Decree No.38/2016, which aims at expediting electricity access in remote Indonesia. However, the Ministerial Decree No. 12/2017 by the Ministry of Energy and Mineral Resources regulates tariffs of electricity generated from RE, and Decree No. 4 and 5/2017 by the Ministry of Industry set quality requirements for the content of solar PV modules. Both may hamper investments into RE (see https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2017/06/ACEF-2017-Session-18-Info-sheet-02-06-2017.pdf).

[103] Asian Development Bank. "Achieving Universal Electricity Access in Indonesia." *Www.adb.org*, Asian Development Bank, 2016, www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf. pg. 35.

[104] Asian Development Bank. "Achieving Universal Electricity Access in Indonesia." *Www.adb.org*, Asian Development Bank, 2016, www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf. pg. 46.

Concerning off-grid electrification programs, the ADB summarizes the experience made by PLN and several governmental agencies to be "mixed at best".[105] Private sector efforts are small in number and are described as ad hoc. In addition, they seem to be hindered by project-specific regulatory requirements. Off-grid efforts by line ministries and regional governments (Pemerintah Daerah) often only fund initial installation of plants, but do not ensure financial and technical sustainability, resulting in high failure rates. PLN would be better placed to assure sustainability, but has little experience with renewable technologies, is in a bad financial situation and has a high workload in conventional grid extension.

As a result, many initial attempts of the *Thousand Islands Programs* have been delayed due to financing or technical difficulties. The following problems have been encountered in the implementation of off-grid electrification projects:

- Failure to assess full present and future electricity needs of the target population.
- Poor design, materials and workmanship, compromising technical performance and sustainability.
- Lack of financing mechanisms to trigger payment discipline among customers to finance O&M.
- Lacking human resources to operate and maintain the plants.
- Pricing that is inconsistent with ability to pay of the target population.
- Limited scale-up opportunities due centralized focus on PLN and too little mobilization of local governments, NGOs, the private sector, and community.

The Window 3A project approaches coincide largely with current and future (governmental) efforts of providing electricity to the remaining unconnected 16 percent of the Indonesian population, which are characterized by residence remoteness, low ability to pay, and limited productive activities. Thereby, the projects and the evidence that Window 3A project create on sustainability and worthwhileness are relevant and timely. In addition, the project design incorporates several features to tackle past challenges in sustainable off-grid electricity provision outlined above. First, the community-based operation approaches (Evaluation Question [EQ] 4: Special Purpose Vehicles and the primary-secondary cooperative scheme) may serve as examples of how to trigger payment discipline, thereby financing O&M and assuring sustainability of the plants. Second, the implementation of income generating trainings (EQ 2) might represent a positive example of complementary activities to unlock growth potentials of electrification interventions. Based on these experiences, learnings from this evaluation may inform the design of a (still lacking) coordinated, sound policy instrument to foster sustainable off-grid provision in rural areas. Third, this evaluation will provide evidence on electricity consumption patterns in the typical unconnected areas (EQ 1), which can improve assessment of present and future electricity needs of the unconnected 16 percent of the population. Lastly, an assessment of off-grid electrification impacts on households, GHG emissions (EQ 3), and the local economy can confirm or adjust theoretical impact expectations and provide evidence on potential bottlenecks to unlock them in practice.

[105] Asian Development Bank. "Achieving Universal Electricity Access in Indonesia." *Www.adb.org*, Asian Development Bank, 2016, www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf. pg. 46.

6.7 Endline Evaluation Design Changes

6.7.1 W3A Anekatek Impact Evaluation and W3A Akuo Energy Performance Evaluation

Revisions to the primary data collection approach for the IE and PE at endline reflect precautions to ensure the safety of the evaluation team and respondents in response to the COVID-19 pandemic and information about the non-operational status of the RE grids associated with the Anekatek grant.

Primary changes to approach:

1. **Dropping the quantitative data collection of the pre/post performance evaluation of W3A Akuo Energy Solar/Micro-Hydro, Berau:** The household survey and enterprise survey components were dropped from the Performance Evaluation in Berau at endline. This decision was made based on an assessment that the potential risks posed by face-to-face interaction between respondents and enumerators outweighed the additional learning gains from retaining quantitative analysis for the PE at endline. Qualitative data collection was conducted and captured endline perspectives related to outcomes across all EQs from stakeholders at different levels.
2. **Substitution of Community Beneficiary FGDs with KIIs:** Focus group discussions (FGDs) with community beneficiaries have been replaced with KIIs with community beneficiaries due to the risk posed by conducting group meetings during the COVID-19 pandemic. As with previous rounds, a convenience sampling methodology will be employed to identify respondents. For each grant, at least 24 KIIs will be conducted, stratified by village (12 with male respondents, 12 with female respondents).
3. **Dropping the quantitative data collection of the impact evaluation of W3A Anekatek Solar, East Sumba:** The household survey and enterprise survey components were dropped from the Impact Evaluation in East Sumba at endline. Due to information that the W3A Anekatek grids had not been operational since December 2020 and efforts to reduce in-person interactions during the COVID-19 pandemic, the quantitative component of the evaluation was dropped at endline and the qualitative component for the W3A Anekatek grant was expanded to cover all five villages were the grids were constructed, rather than just two. The objective of expanding the qualitative data collection was to understand if there was any variation between villages in experiences after grid shutdown.

6.7.2 Endline Case Study Selection Criteria

At endline, due to the strong demonstrated interest from various stakeholders in learning across the entire CBOG RE portfolio, all 17 grants not previously covered under the evaluation were considered for in-depth, qualitative case studies. As it is not feasible to visit all 17 locations, the evaluation team considered the following criteria in shortlisting grants for endline case studies. The criteria focus on areas identified during the desk review that play a significant role in either hindering or promoting long term sustainability.

1. **Understanding the role of PLN (grid) entry** – The desk review revealed key challenges to micro-grid operations when PLN entered a community. While there is opportunity to pivot and

inject generated energy into the grid through a feed-in-tariff, the level of planning and coordination to do so appears to be outside project scope where PLN entry has occurred.

2. **Understanding how various business models account for unplanned events** – Several communities encountered large, unexpected repairs shortly after commissioning. This can be especially common in areas susceptible to climatic shocks, including heavy flooding and lightning. How grants prepared and adapted to these shocks, including the planned level of commitment and buy-in from external sponsors (government, NGOs, anchor customers), seems to play a role in long term sustainability.
3. **Understanding the role of anchor customers** – Off-grid RE is typically targeted in rural, hard-to-reach locations where households are the primary consumer. However, household energy use can be erratic and concentrated in the morning and evening hours, requiring costly solutions for storage during the day which includes peak generation hours for investments such as solar energy.[106] One solution to this issue is to identify an anchor customer within the community that can provide a steady use of energy throughout the day, such as schools, government offices, processing facilities, or cellular towers. The CBOG RE portfolio presents an opportunity to investigate a variety of approaches involving anchor customers including grants that (1) worked with an established customer that may have been switching from diesel generation to RE, (2) generated a new customer within the community (e.g., through the construction of agriculture processing facilities), (3) proceeded without an anchor customer.
4. **Understanding variation within the CBOG RE Portfolio** – The portfolio provides rich variation in the type of RE investment, funding mechanism, location, and level of success or failure to date. While accounting for the three criteria above, the endline case studies aim to capture this variation and contribute to overall learning across the portfolio.

A fifth criteria for case study selection, though not explicitly included above, is logistical feasibility of accessing the grant's location. While at interim, there was a focus on choosing grants within the same areas as the impact and performance evaluations, at endline the ET also considered grants outside of these geographic areas (East Sumba and Burau). However, the final recommendations account for travel and cost to these locations.

Expansion Case Study Recommendations: SI recommended proceeding with the following grantees for case studies: Sky Energy, Burung, IIEE, LAKPESDAM – PBNU. These cases studies were recommended based on the unique learning opportunities they provide, while still contributing to the overall portfolio narrative.

- *Sky Energy* – Successful solar grid model which appears to have generated increased economic opportunity and community in-migration as a result. Community buy-in appears to be high and the grantee has the longest period of planned, sustained investment (two decades prior to full community handover). Tariffs are controlled by the government and do not meet standards for cost-recovery. The grantee has noted continued negotiations with government to increase tariffs moving forward.

[106] F. C. Robert, Sisodia, G. S, and S. Gopalan. 2017. The critical role of anchor customers in rural microgrids: Impact of load factor on energy cost. 2017 International Conference on Computation of Power, Energy Information and Commuincation (ICCPEIC), Melmaruvathur, 2017, pp. 398-403, doi: 10.1109/ICCPEIC.2017.8290401.

- *Burung* – Solar water pumps owned by the village government and maintained through voluntary labor. Presents an opportunity to understand both the successes of local government in advocating for RE infrastructure (pipe expansion, additional reservoirs) and the challenges and setbacks when local ownership is transferred due to elections.
- *IIEE* – Hydro plant revitalization in a well-targeted community (one that purportedly refused PLN entry in the past). Project established a new anchor customer through the Center of Knowledge and coffee processing that appears to have had strong success.
- *LAKPESDAM – PBNU* – Large-scale solar home distribution was chosen over the solar grid model allowing the project to pivot in one village upon PLN entry. The decentralized choice presents challenges for ongoing maintenance and repairs but given the large investment it appears to be doing better than other grants with smaller SHS distribution. Villages are also connected to a university that is said to provide ongoing technical support and learning.

Covering a range of solar and hydro investments, these four case studies are reflective of the distribution of RE investments under the CBOG RE portfolio.

6.7.3 Evaluation Questions

This annex contains the full text of the Window 3A, Case Study and Portfolio-level evaluation questions.

OR1.) **Original** How have energy consumption patterns changed among beneficiary households and businesses in response to the provision of a renewable source of electricity?

a. What are the implications of these changes for household expenditures?

OR2.) Has the electricity provided through the RE infrastructure been used for economic purposes at the community or household level?

a. Has the productive uses/profit-generating component of the grant been effective; and has it helped the SPV be sustained?

OR3.) To what extent do any changes in energy consumption patterns favor reduced GHG emissions?

a. Are there any other ways in which the grants contribute to the objective of reducing or avoiding GHG emissions?

OR4.) Has the Special Purpose Vehicle been an effective intervention to improve community buy-in and sustainability of the infrastructure?

Case Study

CS1.) **Theory of Change:** How did each grant intend to deploy renewable energy resources in target communities? How did each intend for target communities, households, and enterprises to use the new renewable energy source(s)?

a. Were these intents achieved or not? Why, or why not? If not, does it appear that the original Theory of Change could be plausible in other circumstances? (e.g., with what we know post-implementation, do these ToCs seem valid or are there important missing elements?)

b. How, if at all, did the grants' theories of change diverge in their hypothesized mechanisms to reach shared outcomes? (e.g., if grants had the same outcomes in mind, did they have the same strategy for achieving these outcomes or did they use different approaches?)

CS2.) **Sustainability:** How did the grants approach achieving sustainability of the RE infrastructure in each community? What are the relative advantages and disadvantages of these approaches (SPV, RESCO, village-owned enterprise, etc.), given the geographic and social settings in which they were deployed? What lessons can be learned from these approaches for future off-grid RE programming?

a. Were there any ways that productive uses of renewable energy were intrinsically linked with the model for achieving sustainability?

CS3.) **Outcomes:** What changes do households, enterprises, and leaders in target communities perceive to be caused by grant outputs? Do these changes map onto planned outcomes for the grants? Do perceived outcomes appear to be consistent with quantitative changes observed in the Akuo and Anekatek grants? Do perceived outcomes vary across different RE technologies, different management arrangements, or different geographic settings?

a. What are the different ways that RE outputs are being used for productive purposes?
b. Are there any other ways that RE outputs are being used aside from domestic or commercial/productive use (e.g. use in public facilities)?
c. Were there any perceived outcomes from grant outputs that targeted improvements in RE-related knowledge, market demand, or other social themes?

Portfolio-level

The following evaluation questions were added to the endline evaluation scope to guide the inquiry of portfolio-level grant performance:

PR1) To what extent are off-grid RE assets funded within the grant portfolio functioning as intended three years following Compact closure?

PR2) What challenges to sustainability have these assets experienced three years following Compact closure? What are the prospects for the long-term sustainability of each grant?

PR3) What lessons does the Green Prosperity off-grid RE grant portfolio offer in terms of promoting the sustainability of off-grid RE programming?

6.7.4 Detailed Sample Information

W3A Anekatek

Respondent Type	Location	Female	Male	Total
District-level Bappeda	East Sumba	1	4	5
District PLN	East Sumba	0	3	3
Village Government	Tawui South	0	1	1

Respondent Type	Location	Female	Male	Total
Village Government	Lailunggi	0	1	1
Village Government	Praimadita	0	2	2
Village Government	Praiwitu	0	1	1
Village Government	Winumuru*	1	0	1
Village Government	Wanggabewa*	0	1	1
RE Management – ex SPV members**	East Sumba	0	4	4
RE Management – BUMDes Members	Praimadita	0	1	1
RE Management – BUMDes Members	Tandula Jangga	0	1	1
RE Users – Household	Tawui	3	3	6
RE Users – Household	Lailunggi	3	3	6
RE Users – Household	Praimadita	3	3	6
RE Users – Household	Tandula Jangga	3	3	6
RE Users – Household	Praiwitu	3	3	6
Community Member	Winumuru*	3	3	6
Community Member	Wanggabewa*	3	3	6
Grantee	NA	0	1	1
Total Respondents – W3A Anekatek				**64**

**Winumuri and Wanggabewa are comparison villages near to where the W3A Anekatek Solar PV grids were built. These villages were part of the interim impact evaluation sample, including the qualitative data collection conducted at interim.*
***The W3A SPV was not active at the time of endline, therefore the evaluation team spoke to ex-SPV members who were available for interview.*

W3A Akuo Energy

Respondent Type	Location	Female	Male	Total
District-level Bappeda	Berau	0	1	1
District PLN	Berau	0	1	1
Village Government	Long Belui	0	1	1
Village Government	Teluk Sumbang	1	0	0
Village Government & RE Management – SPV Member*	Merabu	0	1	1
RE Management – SPV Members	Long Belui	0	2	2
RE Management – SPV Members	Teluk Sumbang	1	2	3
RE Users – Household	Long Beliu	4	4	8
RE Users – Household	Teluk Sumbang	4	3	7
RE Users – Household	Merabu	4	4	8
Grantee	NA	1	2	3

Respondent Type	Location	Female	Male	Total
Total Respondents – W3A Akuo Energy				**35**

**This individual was both a member of village government and a member of the SPV, therefore relevant topics from both the Village Official KII guide and SPV KII guide were covered during this interview.*

W3A Sky Energy

Respondent Type	Location	Female	Male	Total
District-level Bappeda	Mamuju	0	1	1
District PLN	Mamuju	0	4	4
Village Government	Karampuang	2	2	4
RE Management – SPV Member	Karampuang	1	6	7
RE User – Small Business Owner	Karampuang	3	3	6
RE User – Household	Karampuang	3	3	6
Grantee	NA	1	3	4
Total Respondents – W3A Sky Energy				**32**

W2 Burung Indonesia

Respondent Type	Location	Female	Male	Total
District-level Bappeda	Central Sumba	0	3	3
District PLN	West Sumba	0	1	1
Village Government	Umbu Mamijuk	0	1	1
Village Government	Manorara	0	1	1
Village Government	Bidi Praing	0	1	1
Village Government & RE Management *	Bidi Praing	0	1	1
RE Management - Operator	Umbu Mamijuk	1	0	1
RE Management – Operator	Manorara	0	1	1
RE User – Farmer Group Member	Umbu Mamijuk	1	1	2
RE User – Household	Umbu Mamijuk	1	1	2
RE User – Farmer Group Member **	Manorara	1	1	2
RE User – Household **	Manorara	1	1	2
RE User – Farmer Group Member	Manorara	0	1	1

Respondent Type	Location	Female	Male	Total
RE User – Women's Business Group Member **	Manorara	1	0	1
RE User – Household	Manorara	1	1	2
Grantee	NA	0	3	3
Total Respondents – W2 Burung Indonesia				**25**

**The W2 Burung SWPs are official under ownership of the village government. This individual was both a member of village government and the individual most knowledgeable about the operations of the SWP.*

W2 IIEE

Respondent Type	Location	Female	Male	Total
District-level Bappeda	South Solok	0	3	3
District PLN	South Solok	0	2	2
Village Government	Lubuk Gadang Selatan	1	1	2
RE Management – Cooperative	Korong Wonorejo	0	5	5
RE User – Coffee Processing Facility User*	Korong Wonorejo	2	5	7
RE User – Household	Korong Wonorejo	3	3	6
Grantee	NA	1	0	1
Total respondents – W2 IIEE				**26**

**In addition to targeting RE for household consumption, the grant also targeted coffee farmers to encourage them to use the coffee processing facility which was established by the grant.*

W2 LAKPESDAM-PBNU

Respondent Type	Location	Female	Male	Total
District-level Bappeda	Tanjung Jabung Timur	1	2	3
District PLN	Tanjung Jabung Timur	0	2	2
Village Government	Sungai Rambut	0	1	1
Village Government	Rawasari	1	0	1
Village Government	Tandai Bukik Bulek	0	4	4
RE Management – Cooperative	Sungai Rambut	0	2	2
RE Management – Operator	Sungai Rambut	0	1	1
RE Management – BUMDES	Rawasari	1	1	2

Respondent Type	Location	Female	Male	Total
RE Management – Operator	Rawasari	0	1	1
RE Management – Cooperative	Tandai Bukik Bulek	2	1	3
RE User – Household	Sungai Rambut	3	1	4
RE User – Household	Rawasari	3	0	3
RE User – Household	Tandai Bukik Bulek	5	2	7
Grantee	NA	0	1	1
Total Respondents – W2 LAKPESDAM-PBNU				**35**

6.7.5 Data Collection Instruments

Informed Consent Language

Endline Qualitative Informed Consent

This was the informed consent form template administered with all qualitative data collection respondents across all six endline case studies. For each respondent type, the informed consent script was tailored as per the prompts indicated in the template.

Hello, my name is [moderator name], and I work for Social Impact, a management consulting firm based in the Washington D.C. area. We are evaluating the Renewable Energy Portfolio of the MCC Indonesia Green Prosperity (GP) Project, which aims to combat environmental degradation and alleviate rural poverty. Our study is funded by the Millennium Challenge Corporation (MCC), a U.S. agency that provides assistance to other countries' development projects.

The GP Project is designed to support the Government of Indonesia's commitment to a more sustainable, less carbon-intensive future by promoting environmentally sustainable, low carbon economic growth. The evaluation will aim to measure impacts of the GP Facility program. Ultimately this study will produce a report that will help MCC, MCA-I and the Government of Indonesia understand how to best improve rural electrification programs in Indonesia.

- [FOR COMMUNITY BENEFICIARY GROUPS] You were selected to participate in this interview based on your status as a community member who uses energy produced by the [mentions specifics of RE infrastructure – solar panels, micro-hydro etc.], and is knowledgeable about the implementation of this system in your village. If you agree to participate, you will be involved in one of 90 such interviews that we will be conducting. These interviews are expected to take around 60 minutes to complete.

- [FOR INDIVIDUALS WHO MANAGE THE RE INFRASTRUCTURE] You were selected to participate in this interview based on your status as an individual who manages/operates the [mentions specifics of RE infrastructure – solar panels, micro-hydro etc.], and is knowledgeable about the implementation of this system in your village. If you agree to participate, you will be involved in one of 25 such interviews that we will be conducting. These interviews are expected to take around 60 minutes to complete.

- [FOR VILLAGE OFFICIALS] You were selected to participate in this interview because of the [mention specifics RE-infrastructure] that were installed in your village through support from this project, and we would like to hear your perspectives on this infrastructure/project and whether it fits into the broader strategy for the village. If you agree to participate, you will be involved in one of 25 such interviews that we will be conducting. These interviews are expected to take around 60 minutes to complete.

- [FOR GOVERNMENT OFFICIALS] You were selected to participate in this interview because RE infrastructure was built in your province/district under this project, and we would like to hear your perspectives on this infrastructure/project and whether it fits into the broader strategy of your department. If you agree to participate, you will be involved in one of 15 such interviews that we will be conducting. These interviews are expected to take around 60 minutes to complete.

- [FOR GRANTEE STAFF] You were selected to participate in this interview because grants that your organization implemented were selected to be included in the endline evaluation, and we would like to hear your perspectives on the implementation of the RE infrastructure. If you agree to participate, you will be involved in one of 6 such interviews that we will be conducting. These interviews are expected to take around 60 minutes to complete.

Any information you provide that can identify you will be kept strictly confidential by the parties conducting this study, including MCC and MCA-I employees, and the researchers, to the maximum extent permitted by the laws of the United States and the laws of Indonesia. The personally identifiable information you provide will be stored in a secure, password-protected location, and individuals external to the research team will be unable to access it. The information we receive from you will be used for research purposes only. The final report that summarizes this research *may* contain quotations from the sessions we conduct. However, we will not include names or any information that will identify individual quotations. A list of positions and organizations that participated may be included in the report annex but will not be connected to individual statements.

- [FOR GRANTEE STAFF AND GOVERNMENT OFFICIALS]: Despite these steps to protect your identify, there is still a possibility that indirect identifiers retained in reporting combined with other information such as role or name of organization, could be used to potentially re-identify you as a respondent.

Your participation is voluntary and you may choose not to answer any or all questions for any reason. In other words, you have the alternative not to participate and there will be no consequences for nonparticipation. You may ask questions at any time. If you choose to participate in the interview, you may decide to stop participating at any time and the interview will be terminated. This study poses no risk to participants.

- [FOR COMMUNITY RESPONDENTS ONLY] To thank you for your time, you will be provided with [in-kind incentive] for completing this interview.

- [ALL OTHER RESPONDENT GROUPS] There is no direct benefit to your participation in this interview aside from the knowledge that the information you provide may help improve the design of future rural electrification programs in Indonesia.

COVID – 19: Given the COVID-19 pandemic there are several reasons you may choose not to participate in the study. If you or someone in your household or workplace has been feeling sick including having a cough or high temperature in the past two weeks we ask you not to participate for your safety and the safety of others. Also, we plan to use safety protocols when we talk such as wear masks and maintain social distancing, but if you are worried that these measures are not possible or not enough protection, you may not want to participate.

Recording: With your permission, we would like to record this interview. This is mainly because we are doing so many interviews at once, and we want to ensure that we do not misunderstand or misrepresent anything. These recordings will be used to generate a transcription of the interview, and to verify detailed notes taken by interviewers. Audio files will be password protected, only available to the evaluation team, and deleted at the conclusion of the study.

You may contact [CONTACT NAME], Social Impact's Senior Qualitative Analyst for the evaluation at [EMAIL AND PHONE NUMEBER], [SI CONTACT NAME] at Social Impact at [EMAIL], or the Institutional Review Board at Social Impact Inc., at irb@socialimpact.com. If you have any questions, concerns or complaints about the study or your rights as a participant, please feel free to contact us at any time.

Do you have any questions?

By saying "yes," and participating in this study, you are indicating that you have heard this consent script, had an opportunity to ask any questions about your participation and voluntarily consent to participate.

Will you participate in this research study? You may answer yes or no.

_____ Yes, I am willing to participate _____ No, I am not willing to participate

Do you give your consent to this interview being recorded?
_____ Yes, I give my consent ____ No, I do not give my consent

SPV Leadership KII Protocol

This protocol was administered with SPV leadership of the W3A Anekatek Solar/East Sumba grant, the W3A Akuo Energy Solar/Micro-Hydro, Berau grant, and SPV leadership of W3A W3A Sky Energy Solar, Karampuang Island.

This KII should be issued *at minimum* with the following roles (or equivalents) of SPV leadership:

1. SPV Head
2. Secretary
3. Treasurer
4. Other division heads (e.g., O&M, sales and collection, finance and administration, environment/community officers)

Questions	EQ	KII	Theme
What do you understand the SPV's responsibilities to be as a whole with respect to [grant] and the Solar PV facility in your area? What are the specific responsibilities of your role on the SPV? Do you feel that the SPV's responsibilities now are different from what they were two years ago?	4	All	Sustainability
What is your role in your community? Do you hold any other leadership positions in the community? Have there been conflicts with community members due to your role in the SPV?	4	ALL	Sustainability
Has COVID-19 effected the SPV or mini-grid operations in any way? How?	4	Head	Sustainability
Is the SPV better prepared to provide electricity to the community in the long-term than PLN or a private enterprise? Why (not)?	4	ALL	Sustainability
How would you describe your existing relationship with [grantee] to this point? Are they still engaged with the SPV following the grant? What is their role?	4	All	Relationship with grantee/contractors

Questions	EQ	KII	Theme
How are routine and preventative O&M tasks handled for this mini-grid? What about complex O&M tasks or repairs? Are these handled by the SPV, through a contract with an O&M provider, or both? Please describe how the SPV responded to any significant O&M challenges to the mini-grid in the past year, and how often these challenges occur. Are you confident the SPV will be able to respond to significant O&M challenges in the future? For instance, do you think there is sufficient funding or support to make a major repair next year (2021), if one were needed? A major repair is to address an issue which has reduced capacity by more than 10%. Do you think there is sufficient funding or support to make a minor repair next year (2021), if one were needed? A minor repair is on an issue that has reduced capacity by less than 10 percent and that, if *not* addressed, in *not* expected to cause further problems.	4	O&M	Sustainability
How easy and affordable is it to find replacement parts when they are needed? How long has it taken for replacement parts to arrive? If you use external technicians for repairs or maintenance, how long does it typically take from when you request service for service to be completed?	4	O&M	Sustainability
Do you feel that operators are adequately trained to handle their responsibilities in O&M? Has there been any need to pursue additional training to the training provided by the grant? Are the people who received training from the grant the same ones currently responsible for O&M, or has there been turnover? *(If there has been turnover)* Were these new SPV members trained? How and by whom?	4	O&M	Sustainability
Have there been other significant challenges for the SPV, like political, social, or financial challenges? [If SPV includes cooperation among treatment units] How have [treatment units] cooperated with one another?	4	All	Sustainability, optimism, cooperation with other villages

Questions	EQ	KII	Theme
Is the micro-grid ever discussed during community meetings? If yes, then what type of discussions (ex. Complaints, technical issues, positive messaging about the RE infrastructure being an asset)	4	Head	Sustainability
What sorts of enterprises have taken advantage of the new renewable energy resource? Have community members started new businesses since the micro-grid was commissioned? If so, what kinds of businesses?	2	Head	Productive uses
How would you compare the performance of the mini-grid relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future? Have you been satisfied with the quality and reliability of the electricity supply from the mini-grid?	4	All	Optimism
How are responsibilities within the SPV distributed between females and males?	4	ALL	Sustainability
How were responsibilities in day-to-day operation and maintenance be handed over to you? Was this process reasonable?	4	O&M	Sustainability
Has your training prepared you for your role in the SPV? What part or parts of your training have seemed the most useful? Are there any situations you have encountered for which you felt you were not adequately prepared? Did you receive your training from the grant or from another source?	4	All	Sustainability, relationship with grantee/contractors
How much are community members charged to use electricity from the mini-grid? Have members of your community been willing and able to pay this amount?	2, 4	All	Sustainability
How has your SPV chosen to use surplus electricity or revenue, if a surplus exists?	2	Head, Treasurer	Productive uses
Have you experienced any challenges in payments or sustainability of the system? How often do people fail to pay their bill, or elect not to use any electricity due to financial hardship? Have you had any issues with fraud, or tampering with meters? How do you deal with these problems? Have these challenges stayed constant over time (i.e. were there more issues in the beginning or are there more now?)	2,4	All	Sustainability
What actions have your SPV taken to ensure gender equality and social inclusion in benefits from the new RE systems? Were these actions successful? Why or why not?	4	Head, Community Officer	Gender

Questions	EQ	KII	Theme
How confident are you that the SPV is prepared, in terms of capacity, equipment, and legal status, to operate the infrastructure in the long term?	4	Head	Optimism
More generally, do you think there are opportunities to expand demand for mini-grid electricity (either by adding new households, enterprises, or any nearby entities that consume a lot of energy) ? What are the opportunities? What are the challenges?	4	Head	Sustainability
How likely is it that the mini-grid will still be functioning 1 year from now? 5 years? 10 years? What are some of the reasons for your opinion? - Very likely - Somewhat likely - Not likely - It will not be operating - Unsure	4	All	Sustainability
Does the SPV receive any external support (from regional government, other organizations)? What type of support does the SPV receive? Does the SPV receive any support from the community? In your opinion, what support does the SPV still need to ensure that the mini-grid continues to operate in the future?	4	Head	Sustainability

6.7.5.1.1 Village Official KII Protocol

This protocol was administered with village officials in areas covered by the six endline case studies.

Questions	EQ	Theme
Has health service quality been affected by access to RE? If so, how? What about for the health and wellbeing of pregnant women in particular?	1, 2	Community details
Has school service quality been affected by access to RE? If so, how?	2	Productive Uses, Community details
What did you learn from grant trainings about renewable energy and using RE in your community? Was the information in grant trainings new information for you? Do you think Renewable Energy is better for the environment than alternative electricity sources? Explain.	1, 4	Sustainability
We would like to understand from you any effects that COVID-19 might have had on the mini-grid or the electricity situation in the community. To your knowledge, has COVID-19 effected mini-grid operations? If so, how? Do you think household electricity consumption has changed in any way due to COVID-19 ? If so, how? For households in your community, has the pandemic effected their ability to pay for electricity? If so, how? Has COVID-19 had an effect on the economic activities in the community (on existing business, on opening of new business)? If so, how?	1,2	Consumption patterns, productive uses
Do you feel that the mini-grid requires your support? In what way? Are community members supporting the mini-grid? How?	1, 4	Sustainability
Is the mini-grid discussed during community meetings? If so, in what ways is it discussed? Do you interact with SPV members? How often and in what way?	4	Sustainability
Are there economic activities in this community that have benefitted from access to the mini-grid? What are these activities? How have they benefitted?	2	Productive Uses
Were any grant trainings especially helpful for increasing economic activities in your villages? Please describe these trainings and how they were helpful.	2	Productive Uses

Questions	EQ	Theme
Have any community members started new businesses using electricity from the mini-grid? Do you know of any that are planning to start a business, but have not done so? What is stopping them?	2	Productive Uses
What are typical productive activities pursued by women in your community? Have these been affected by the mini-grid or grant trainings in any way? How so?	2	Productive Uses, Gender
Have the general living conditions (particularly poverty level) in the sub-village changed within the last 2 years? How so? Do you think the new RE mini-grid has affected this situation?	4	Sustainability
Has safety and security in this community been affected in any way by access to electricity?	4	Community details
What do you understand the SPV's responsibilities to be as a whole with respect to [grant] and the Solar PV facility in your area?	4	Sustainability
What challenges do you anticipate will occur with the SPV given your knowledge of your community? Have there been any significant challenges with the SPV or mini-grid to date?	4	Sustainability
To your knowledge, have there been any problems with households paying for or being able to afford electricity from the mini-grid? Do households ever resort to fraud or tampering with meters to afford electricity? Are you confident households will be able to afford electricity from the mini-grid in the long-term?	4	Sustainability
What about major challenges with outages or malfunctioning of the mini-grid? How long does it typically take for these to be repaired? How have these issues affected your community?	4	Sustainability
How would you compare the performance of the mini-grid relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future? Have you been satisfied with the quality and reliability of the electricity supply from the mini-grid?	4	Sustainability
More generally, do you think there are opportunities to expand demand for mini-grid electricity (either by adding new households, enterprises, or any nearby entities that consume a lot of energy) ? What are the opportunities? What are the challenges?	4	Sustainability

Questions	EQ	Theme
How likely is it that the mini-grid will still be functioning 1 year from now? 5 years? 10 years? What are some of the reasons for your opinion? - Very likely - Somewhat likely - Not likely - It will not be operating - Unsure	4	Sustainability

6.7.5.1.2 Grantee KII Protocol

This protocol was administered with grantees for the six qualitative case studies.

**Note: Some questions in this protocol may be skipped based on the informant's role in the implementing organization, or the implementing organization's role in an implementing consortium. For example, engineering firms will not be asked about community engagement plans for SPVs, unless they are somehow involved.

Question	EQ	Theme
1. Please describe your role on this grant.	4	NA
2. Please describe the grant's status in [village name; regency name] at the end of the Compact. Was there any outstanding work that needed to be completed after Compact closure? Does [grantee] have any role with the SPV or mini-grid still?	4	Project Details, Sustainability
3. Were SPV members adequately prepared to fulfill their roles and responsibilities at the end of the Compact period? Were any additional trainings required to prepare SPV staff? To your knowledge, are the individuals trained by the grant still the ones in their respective roles with the SPV or has there been turnover?	4	Project Details, Sustainability
4. Please describe any changes made to the business plan you were pursuing in creating the SPV(s) for this project since November 2017. What is the governance process in terms of managing cash flow and assets? Have dividends been reinvested in the community and, if so, how?	4	Project Details, Sustainability
5. What is the final selling price for electricity in each village/kampung? Please describe how you arrived at this figure and, if it has changed, why.	1	Energy Consumption
6. How did you transition ownership to the SPV after construction was completed?	4	Sustainability, Sustainability
7. Has PLN expanded into the villages/kampungs targeted by this grant? Describe how the SPV mitigated this, if it came to fruition.	1 and 4	Sustainability
8. Have you tapped into additional resources besides those provided by MCA-I to ensure the sustainability of the project? If so, what actions have you taken?	4	Sustainability, Sustainability

Question	EQ	Theme
9. What are the main challenges you see to the Solar PV Facility development? (ask about SPV leadership and role, if not mentioned) What challenges have you observed in terms of sustainability? How does the SPV's actualized sustainability status compare to the expectations of sustainability you had at the project's inception?	4 (though potentially all EQs)	Sustainability, Sustainability
10. In each of the targeted areas, what have been the main outcomes from your project? Have you observed business expansion or the creation of new businesses? If so, what kinds? How long did it take before these businesses developed or expanded?	1-4	Sustainability, Sustainability
11. In your view, what is the outlook for the sustainability of the mini-grid once it is completely left to the SPV to manage? What are the biggest threats to sustainability? If you were to implement this grant again, is there anything you would suggest doing differently to improve grant outcomes or sustainability?	4	Sustainability

6.7.5.1.3 Community Beneficiary KII[107] Guide

This protocol was administered with community members at baseline, interim and endline in study areas included in the impact evaluation, rigorous performance evaluation and qualitative case studies.

Topic: Energy

Question	EQ	Theme
1. What is your HH's main use for electricity (appliances, lighting, productive uses)? Has this changed since you were connected to the mini-grid?	1, 2	Energy Consumption, Productive Uses
2. Please describe a typical day or week in terms of your energy usage. Which energy sources do you use most often, or prefer to use? Are there certain times of day, or certain times of the year, when you use some energy sources more than others?	1	Energy Consumption
3. We'd like to understand how COVID-19 electricity and economic situation in the community. Has your household's electricity consumption changed in any way due to COVID-19? How about the consumption by other households in your community? Has the pandemic effected your ability to pay for electricity? How about other households in your community? Do you think COVID-19 has had an effect on the economic activities in the community (on existing business, on opening of new business)? If so, how?	1,2	Energy Consumption, Productive Uses
4. Are you satisfied with the price per kWh of electricity your family uses currently? What are the main reasons for your satisfaction/dissatisfaction? Please discuss. What is your understanding of the costs of operating the micro-grid?	1	Energy Consumption
5. Are you satisfied with the quality of electricity your family currently receives? What are the main reasons for your satisfaction/dissatisfaction? Please discuss.	1	Energy Consumption

[107] Due to the risks posed by group meetings during the COVID-19 pandemic, community beneficiary FGDs were replaced with one-on-one KIIs at endline.

6. Are you satisfied with the hours per day of electricity your family currently receives? What are the main reasons for your satisfaction/dissatisfaction? Please discuss.	1	Energy Consumption
7. Are you satisfied with the operator of the electricity your family uses currently (SPV/PLN)? What are the main reasons for your satisfaction/dissatisfaction?	1	Energy Consumption
8. How would you compare the performance of the mini-grid relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future? Have you been satisfied with the quality and reliability of the electricity supply from the mini-grid?	1	Energy Consumption
9. Would you prefer other types of electricity? What kinds and why?	1	Energy Consumption
10. Has access to the mini-grid in this village brought growth in economic activities? How?	2	Productive Uses
11. What else is needed in your community to raise economic wellbeing?	1	Energy Consumption

Topic: Equality, Gender, Security

Question	EQ	Theme
1. Who has benefitted most from energy access in your community? Is there anyone who has not benefited from access to the mini-grid?	1	Energy Consumption, Gender
2. Do you think female community members have been affected equally by electricity access as male members? How has electricity access changed the life of women, and their rights and roles within the community?	1	Energy Consumption, Gender
3. Are there any ways that grant trainings were especially beneficial to women in this community?	1	Energy Consumption, Gender
4. Do you think electricity access has affected security in your community? Please discuss.	1	Energy Consumption
5. Do you feel that the way SPV members were selected to manage the mini-grid was fair? If not, why not?	4	Sustainability, Community Organization

Topic: Environment

Question	EQ	Theme

1. Which environmental issue concerns this community the most? Why?	3	GHG Emissions
2. Are there activities for which you used to use kerosene, diesel, or gasoline that you can now do using electricity from the mini-grid instead? Do you think less of these fuels is used in your community now than before the mini-grid was commissioned? If so, how has this change effected your finances, health, or the local environment?	3	GHG Emissions

Topic: Project Details and SPV

Question	EQ	Theme
1. Overall, please discuss your satisfaction with [Project name/grantee name]'s work in your community. Is there any way that they are still engaged with the community?	NA	Project Details
2. Please discuss your satisfaction with the SPV in charge of your mini-grid, and your confidence in their management of the mini-grid in the long term. Do you feel that you understand what the SPV does?	4	Sustainability
3. Has the introduction of the SPV in your community affected interpersonal or social community dynamics in any significant way? How so?	4	Sustainability
4. If PLN were to extend the grid into your community or village, would you prefer to consume electricity from PLN or the SPV? Why?	4	Sustainability
5. To your knowledge, have SPV profits been reinvested in the community in any way? Does the SPV or the community make any arrangement to assist less wealthy households in paying for their electricity?	4	Sustainability

Topic: Conclusion

Question	EQ	Theme
1. In comparison with the situation 2 years ago, have the living conditions in this village improved? If yes, how? If not, why not? To what extent do you feel these changes were caused by the mini-grid? *If not raised independently, probe specifically about changes in firewood consumption, health (headaches from generator or smoke from firewood), security, and media consumption (internet, television, telecommunications)*	1, 4	Sustainability
2. Will the mini-grid will still be functioning 1 year from now? 5 years? 10 years? What are some of the reasons for your opinion? - Yes - No - Unsure	4	Sustainability

6.7.5.1.4 PLN/Mini-Grid Manager Form

This questionnaire was administered with regional PLN offices in study locations at interim and endline.

The purpose of this form is to understand the cost of service and fuel mix for the PLN grid and mini grid(s) in our study areas. Using either secondary documentation or an interview, we would aim to complete the items on this form with these stakeholders.

Fuel Mix

1. What is the installed generation capacity of the [grid/mini-grid] serving [Berau/East Sumba/treatment area]?

________________ kWp/MWp

2. What is the fuel mix for the installed capacity of the [grid/mini-grid]?

Renewable: ___%	Diesel/Oil: ___%	Coal: ___%	Gas: ___%	Other: ___%

3. How much electricity has the [grid/mini-grid] serving [Berau/East Sumba/treatment area] generated in the past year?

________________ kWh/MWh

4. What is the fuel mix for the electricity that has been generated in the past year?

Renewable: ___%	Diesel/Oil: ___%	Coal: ___%	Gas: ___%	Other: ___%

Cost of Service

5. What is the cost per kWh to [PLN/SPV] of generating electricity at peak capacity?

________________ IDR/kWh

6. What has been the average cost per kWh to [PLN/SPV] of generating electricity over the past calendar year?

______________ IDR/kWh

7. How much are (rural) customers charged per kWh to consume electricity? Is this tariff cost covering?

______________ IDR/kWh, Yes/No

Grid Expansion (PLN only)

8. Please describe planned extensions of the PLN grid in [East Sumba/Berau] in the near-term (next 1-2 years), providing supporting documentation if any is available.
9. Please describe planned extensions of the PLN grid in [East Sumba/Berau] in the 3-5 year timeframe if this is known, providing supporting documentation if any is available.
10. Please describe planned extensions of the PLN grid in [East Sumba/Berau] in the 5-10 year timeframe if this is known, providing supporting documentation if any is available.
11. Are you aware of any plans to purchase electricity generated from independent mini-grids encountered during grid expansion? If so, are you aware at what price per kWh this electricity will be purchased?

______________ IDR/kWh

12. What are some of the challenges to expanding the PLN grid into these areas? What are some the issues involved in purchasing power from independent mini-grids in this area?
13. Did COVID 19 have any effect on PLN's operations in the area?
    a. Were there projects that were supposed to happen in 2020 or 2021 that were stalled or delayed? If so, what is the current status of these projects?
    b. Was your team able to carry out regular maintenance on the grid and respond to outages or faults as usual?
    c. Were there any noticeable changes in energy consumption or revenue collection in 2020 and 2021?

Grantee Case Study Protocol

This Grantee Case Study protocol was used to collect information on grants included in the qualitative case studies at interim prior to the start of data collection.

This protocol is meant to be employed iteratively, in a semi-structured fashion, with case study grantees prior to field data collection. It aims to construct or confirm the final, planned version of the grant's theory of change, planned outcomes, and approach to sustainability. It can be employed in email form or through an interview, whichever is most convenient for the grantee. As part of this protocol, it is important to establish for the grantee at the outset which documents we have and when these documents are dated.

Planned Theory of Change

As part of our case study, we need to develop a detailed understanding of the [project] theory of change. To do this, we would like to obtain or construct a logic model that summarizes the grant from main activities through to final outcomes. Ideally, this logic model should include assumptions inherent between major nodes (e.g. outputs and outcomes).

If we already have a logic model from previous documentation (e.g., Hivos):

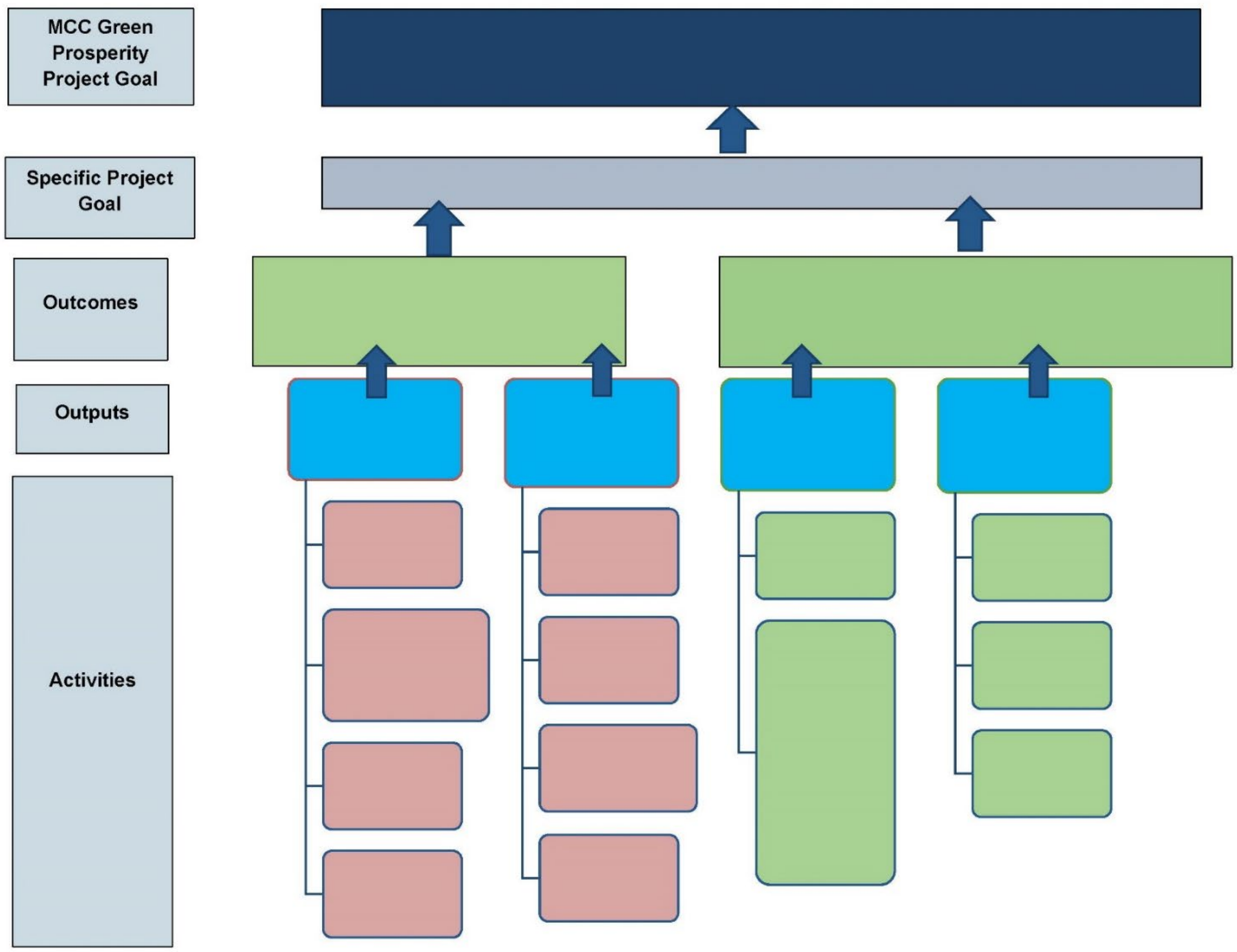
1. This is the most recent logic model we have available for your grant. Is this the final version of the grant's logic model?
    a. *If not*: Is there an updated version of this logic model you could share with us from other documentation?
        i. *If not:* Could you point out specific pieces of this logic model that must be updated to reflect the grant's final, planned theory of change?
    b. *If the logic model does not include key assumptions:* Do you have a document that outlines the key assumptions connecting the key nodes of this logic model?
        i. *If not:* What are the fundamental assumptions that you believe are required for the theory of change outlined in this logic model to be achieved? In other words, if this logic model were to be followed faithfully and desired outcomes were not to be achieved, why do you think that would be?

If we do not have a logic model from previous documentation (e.g., IBEKA):

1. Was a logic model ever constructed for your grant? If so, could you share the final version of this logic model with us?
    a. *If not[108]: [show blank template of logic model, below]* I would like to complete this template with specific reference to your grant so that I can understand how the grant aimed to achieve desired outcomes.
        i. *After completing:* What are the fundamental assumptions that you believe are required for the theory of change outlined in this logic model to be achieved? In other words, if this logic model were to be followed faithfully and desired outcomes were not to be achieved, why do you think that would be?

[108] If no documentation of a logic model is available, triangulate planned ToC with multiple grantee employees, if possible.

Both: To your knowledge, where there anyways that the final results of grant implementation deviated from this planned theory of change? For example, were there activities that were not completed, extra outputs that had not been anticipated, etc.?



Anticipated Outcomes and Targeted Beneficiaries

1. *According to the post-Compact ITT, the final outputs and outcomes for your grant were [the following]. Are there major outcomes that are not included in the ITT?*
   a. *Be sure to specify those that appear in the logic model but not the ITT. Is there any M&E documentation you can share with us where these other outcomes are measured and reported?*
2. *For each of the outcomes specified, who were the beneficiaries targeted? Where are these beneficiaries located?*
   a. *Can you provide a roster of beneficiaries, ideally including names, telephone numbers, and locations? We would use this list to contact beneficiaries for focus group discussions.*

3. *Were there any unanticipated outcomes that you know occurred as a result of the grant? Please describe them.*

Community Ownership, RE Asset Management, and Model for Sustainability

For each of these questions, ask for documentation of these plans first. If the plans cannot be discerned from documentation, ask for references to grantee staff who may be able to describe these plans in detail in an interview or email exchange.

1. *Briefly describe the grant's approach to ensuring grant outputs and outcomes could be sustained over time. Is there any documentation you have available that outlines this overall approach in detail, such as a sustainability plan?*
2. ***Technical Sustainability:*** *Can you share any design documents, design reviews, or commissioning documents for the RE assets funded by the grant? These would include any documents that justify the technology selected, specify capacity, output, and/or functioning requirements of the technology, set expectations for how long the assets are expected to function to specification, and describe the extent to which assets were installed as designed.*
    a. *If not: To the best of your knowledge, why did the grant choose to fund the RE assets that it did compared to potential alternatives? How did you know these were suitable for the local context? What is the output capacity of the RE assets funded by the grant, and for how long are they expected to function? Were the RE assets installed as they had been designed?*
3. ***Operational Sustainability:*** *Can you share any operations and maintenance plans for RE assets funded under the project? In whose possession were these plans when the grant ended? How did the grant ensure that operators and vendors of the assets were capable of executing these plans after the grant period ended?*
4. ***Financial Sustainability:*** Can you share any business plans or documentation that describes user-fees, O&M funding, and management funding for the RE assets? Was the arrangement for revenue collection, capital funding, and profit-sharing from use of the RE assets specified by the grant or developed by local communities? How could the grantee be assured that this arrangement would function after the grant had ended?
5. ***Political/Social/Environmental Sustainability:*** *Is there any documentation available, such as a gender and social integration plan (GSIP) or Landscape-Lifescape Analysis, that analyzes the suitability of the political, social, and environmental context for long-term operation of RE assets? Was there any plan in place to encourage knowledge about and enthusiasm for the use of RE in benefitting communities? Are there records of any discussions between the grantee and PLN about the potential for grid expansion into villages in which the grant was operating?*

Grant Beneficiary Follow-up Protocol

As part of our desk review (conducted after interim, and before endline) we would like to check in with benefitting communities to confirm the status of the infrastructure, economic use, and sustainability projections. **Each grantee provided community contacts for verification or contacts will be solicited from Bappenas**. Ideally contacts will consist of a district or village level official that can speak to all components of the RE infrastructure, even if infrastructure was installed in multiple locations. In some instances, it may be necessary to reach out to multiple individuals.

Review grantee documentation/brief: Prior to reaching out to the beneficiary, review the documentation and brief to re-familiarize yourself with that project. Pay attention to the operational status reported by the grantee, the economic uses of the equipment, and the O&M structure and fill in some of the details below prior to your call.

Contact grantee and introduce yourself: Explain that Social Impact is an independent evaluator hired by MCC to evaluate the effect and sustainability of renewable energy installed under MCA-I on their communities. ***Be specific about the technology you are referring to (i.e. the solar panels installed in your community).*** If needed, acknowledge the grantee did a number of activities but we are specifically interested in those that relate to RE or the use of RE. Let them know we already spoke to grantees and the grantees provided their contact as someone who could verify and provide additional information on the program. Ask if they have time now and are willing to answer some questions or schedule another time to talk.

Grantee Name:	
Respondent Name:	
Respondent Phone number:	
Date/Time:	

1. **Respondent's Involvement**
   a. Before we begin can you please tell me what was your involvement with the project/grantee?

Response:

2. **Confirm Equipment and operational status**
   a. __ [Grantee name]__, provided ____________[technology]___________ to the community. Is that correct?

Response:

   b. The technology was supposed to supply electricity to ____[HHs/Production Houses/Public Facilities/etc.]____. Were these HH/facilities connected to and receiving electricity ***at the end of the grant in 2018***? (Yes/No -> if no, clarify)

Response:

c. Is____________[technology]___________ still operating (providing electricity to the community) today as well, or better, than it did at commissioning? (if not, what has changed?)

Response:

3. **Clarify Ownership**
    a. Who owns the technology? Was there a hand over period from the grantee and/or Bappenas and when was the technology officially handed over to the community?

Response:

4. **Clarify Financing**
    a. *If technology is still operating* → Does the community pay for the electricity and/or use of the technology? How is payment made and how much?
        i. How were the user's fees (tariffs) set? Were they set at the village level or were they impacted by district, provincial or national guidelines?
        ii. Do you believe the tariff was set: (1) To low, (2) Just right, (3) Too high? *(Interviewer: Select one of the three options)*
    b. *If technology is not operating* → Did the community pay for the electricity and/or use of the technology prior to it breaking down? How was payment made and how much?
        i. How were the user's fees (tariffs) set? Were they set at the village level or were they impacted by district, provincial or national guidelines?
        ii. Do you believe the tariff was set: (1) To low, (2) Just right, (3) Too high? *(Interviewer: Select one of the three options)*

Response:

5. **Clarify Operations & Maintenance**
    a. *If technology is still operating* → Who is in charge of operations & maintenance? How were they trained? Are they paid?
    b. *If technology is not operating* → Who was in charge of operations & maintenance? How were they trained? Were they paid?

Response:

c. Has the technology required any large repairs (a large repair is one that has reduced capacity by more than 10%)? Who paid for those repairs?

Response:

d. *If technology is still operating only* → Do you think there is sufficient funding or support to make a major repair next year (2021), if one were needed? A major repair is to address an issue which has reduced capacity by more than 10%.

Response:

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a. *If technology is still operating only* → Do you think there is sufficient funding or support to make a minor repair next year (2021), if one were needed? A minor repair is on an issue that has reduced capacity by less than 10 percent and that, if *not* addressed, in *not* expected to cause further problems.

Response:

---

6. **Economic Use**
   a. Does/did the community use the provided renewable energy for any economic purposes (business, irrigation for crops for sale, etc) or was it only for household use? If so, please provide examples.
      i. Do you believe demand (use) of the technology is (1) Lower than anticipated, (2) Just as anticipated, (3) Higher than anticipated? *(Interviewer: Select one of the three options)*

Response:

---

7. Sustainability
   a. *If technology is still operating* → Why do you think the technology has worked well to date? What is needed if the technology is going to continue operating for the next 10 years?
   b. *If technology is not operating* → Why do you think the technology failed? What is needed if the technology is going to start operating again (and who is responsible for that)?

Response:

---

c. *Ask for all respondents, regardless if the technology is currently operational or not*

1. How likely do you think it is that the technology will be operating well a year from now?

☐ Very Likely ☐ Somewhat Likely ☐ Not likely ☐ It will not be operating

2. How likely do you think it is that the technology will be operating well 5 years from now?

☐ Very Likely ☐ Somewhat Likely ☐ Not likely ☐ It will not be operating

3. How likely do you think it is that the technology will be operating well 10 years from now?

☐ Very Likely ☐ Somewhat Likely ☐ Not likely ☐ It will not be operating

8. **End**

Thank you very much for your time today. Is there anything else you would like to share with me? Is there anyone else you think we should speak to about this technology?

Grantee Online Survey

This online survey was administered to all grantees who were beneficiaries of the GP facility and implemented grants in the CBOG-RE portfolio as part of the Desk Review conducted between interim and endline.

Module A: Introduction and Consent

#	QUESTION	RESPONSES
a1	**Please select the grant you represent.**	☐ 1 Anetatek ☐ 2 Auko ☐ 3 Bumi Manira ☐ 4 Burung/ Konsorsium Sumba Hijau ☐ 5 CU Keling Kumang ☐ 6 Hivos ☐ 7 IBEKA ☐ 8 IIEE ☐ 9 Javlec ☐ 10 Kemitraan ☐ 11 KKI Warsi - Jambi ☐ 12 KKI Warsi - Sumatera Barat ☐ 13 LAKPESDAM – PBNU ☐ 14 LATIN ☐ 15 LPPSLH ☐ 16 PEKA Solar ☐ 17 PT Cahaya Inti Trimanunggal ☐ 18 PT Charta Putra Indonesia ☐ 19 Puriver Consortium ☐ 20 Sky Energy Consortium ☐ 21 Yayasan Dian Tama ☐ 22 Yayasan Pena Bulu ☐ 23 YPK Donders
a2	**Please provide your contact details (NAME)**	*open text:*
a3	**Position/Relationship to the grant (e.g. Manager, Field Coordinator, etc.)**	*open text:*
a4	**Phone number (main)**	# # # # # # # #
a5	**Phone number (alternative)**	# # # # # # # #
a6	**Email**	*open text:*

#	QUESTION	RESPONSES
a7	**Consent Script:** Welcome to the MCC Indonesia Green Prosperity (Indo GP) Renewable Energy evaluation. This evaluation is being conducted by Social Impact, an independent evaluation company based in the U.S. This research will provide important information to MCC, grantees, and policy makers in the energy sector about the outcomes realized under the MCC Compact. We hope that the research will influence policies and programs in the future. We are conducting this online survey with 23 grantees who received funding for renewable energy technology under Indo GP. We are asking you to participate in this evaluation because of your involvement in the program. This survey should take approximately 20 minutes to complete. There is no direct benefit for participating, other than knowing that you are providing information that can help the sector, MCC and the Government of Indonesia better plan for renewable energy programs in the future. There is no risk to participating, other than the time you could spend doing something else. Your participation is voluntary. There is no consequence if you choose not to participate. You may also skip any specific questions within the survey, or to stop participating at any time with no consequence. Your personal identifying information will be kept confidential by the research team, including members of Social Impact and MCC, to the fullest extent possible permitted by local law, U.S. law, and MCC policy. Your personal information, including your name and position, will not be disclosed in any publication and will be stored securely by the research team. The data generated from this interview will be used to write a report that will be made public on MCC's Evaluation Catalogue. While all identifying information will be kept confidential, de-identified data may be combined with other study participants' data and shared publicly for future research purposes. Your views are important and we hope that you will take the time to participate. If you have any questions about the study or your rights as a participant, you may contact [NAME], [LOCAL NUMBER] or Social Impact at irb@socialimpact.com or +1-703-465-1884.	
a8	**Do you agree to participate?**	☐ 1 Yes ☐ 0 No à Module Z, and end of form.

Module B: Technology

#	QUESTION	RESPONSES
b1	**Your grant primarily used *[RE Infrastructure]*, did the grant consider other types of RE Infrastructure?**	☐ 0 No → Skip to b3 ☐ 1 Yes
b2	**What other types did you consider?**	☐ 1 Solar Home Systems ☐ 2 Standalone Solar Power Plant *(Pembangkit Listrik Tenaga Surya)* ☐ 3 Solar Grid ☐ 4 Solar Water Pump ☐ 5 Hydro Plant ☐ 6 Hydro Pumps (Barsha) ☐ 7 Biogas Digester (Home Use) ☐ 8 Biogas Plant ☐ -96 Other, specify *NB: Filter out used technology*
b2_o	**Other (Specify)**	*Other, specify response - open text:*
b3	**What was the main factor in your choice of technology?**	*Open text:*
b4	**What do you consider the main sustainability challenge in your choice of *[RE technology]* for *[grant name]*?**	*Open text:*
b5	**Is the technology currently operating as expected?**	☐ 1 Yes – As Expected ☐ 2 Yes – But at less than optimal ☐ 0 No – Technology is not operating

Module C: Operational

#	QUESTION	RESPONSES
The following section aims to understand the RE technology's ownership model, operations and maintenance, and support. If the technology is not operating, please still communicate its ownership status, and capacity of staff to carry out maintenance and repairs. We will ask about finances (tariffs) in a later section.		
c1	**Please confirm the current ownership model for the RE technology. (Note if the technology has not yet been handed over please indicate the planned ownership).**	☐ 1 Special Purpose Vehicle (SPV) ☐ 2 Village Government ☐ 3 Village Enterprise (BUMDes) ☐ 4 Regional Company ☐ 5 Cooperative ☐ 6 Household or Public Facility (Individual) ☐ 7 Farmer's Group ☐ -96 Other, specify
c1_o	(If c1 = -96) **What is the current ownership model?**	*Other, specify response - open text:*
c2	**What do you consider the key non-financial sustainability challenge of the current ownership model?**	*Open text:*

#	QUESTION	RESPONSES
c3	**Is the current ownership model the same as the model that was originally planned?**	☐ 0 No ☐ 1 Yes → c5
c4	**What was the planned ownership model? *(Select one)***	☐ 1 Special Purpose Vehicle (SPV) ☐ 2 Village Government ☐ 3 Village Enterprise ☐ 4 Regional Company ☐ 5 Cooperative ☐ 6 Household or Public Facility (Individual) ☐ 7 Farmer's Group ☐ -96 Other, specify
c4_o	**What was the planned ownership model?**	*Other, specify response - open text:*
c5	**What was the key factor in your choice of model? *(Select one)***	☐ 1 Financial viability ☐ 2 Presence of farmer/other producer groups ☐ 3 Presence of community groups ☐ 4 Technical knowledge of prospective owners ☐ 5 Community request ☐ 6 Model required by MCA-I ☐ 7 Model required by the local government ☐ 5 No other option seemed viable ☐ -96 Other, specify
c5_o	(If c5= -96) **Other (Specify)**	*Other, specify response - open text:*
c6	**How confident are you that current owners can carry out daily maintenance?**	☐ 1 Very Confident ☐ 2 Confident ☐ 3 Not Very Confident ☐ 4 Unsure
c7	**Do you believe the current owners have adequate knowledge or access to technical support to carry out a minor repair? Please focus only on knowledge/skillset, not financial access (a minor repair is one that has reduced capacity by less than 10%).**	☐ 0 No ☐ 1 Yes
c8	**Do you believe the current owners have adequate knowledge or access to technical support to carry out a major repair? Please focus only on knowledge/skillset, not financial access (a major repair is one that has reduced capacity by more than 10%)?**	☐ 0 No ☐ 1 Yes
c9	**Was any external support *planned* for Operations and Maintenance after the end of the project period? External support would be support/warranty/investment provided by an individual or institution outside of the current owners or beneficiaries. It is typically non-local support. If an SPV model with partial grantee ownership, please select "yes."**	☐ 0 No → Skip to Module D ☐ 1 Yes

#	QUESTION	RESPONSES
c10	**What external support was planned? *(select all that apply)***	☐ 1 Financial Support from the Village, District or Regional Government ☐ 2 Financial Support from a third party (donor, NGO, etc.) ☐ 3 Financial Support from the grantee ☐ 4 Technical Support from a third party (donor, NGO, consortium, university etc.) ☐ 5 Technical Support from the grantee ☐ 6 Technical Support from the vendor ☐ 7 Equipment warranty for replacement or repairs ☐ -96 Other support
c10_o	(If c10= -96) **What other support was planned?**	*Other, specify response - open text:*
c11	**Is any external support ongoing (as of December 2020)?**	☐ 0 No ☐ 1 Yes
c12	**What external support is ongoing (as of December 2020)? *(select all that apply)***	☐ 1 Financial Support from the Village, District or Regional Government ☐ 2 Financial Support from a third party (donor, NGO, etc.) ☐ 3 Financial Support from the grantee ☐ 4 Technical Support from a third party (donor, NGO, consortium, university etc.) ☐ 5 Technical Support from the grantee ☐ 6 Technical Support from the vendor ☐ 7 Equipment warranty for replacement or repairs ☐ -96 Other support
c12_o	(If **c12**= -96) **What other external support is ongoing?**	*Other, specify response - open text:*

Module D: Financial

#	QUESTION	RESPONSES
The following questions seek to understand the financial sustainability of the RE infrastructure as well as long term projections.		
d1	**Did you conduct initial analysis to determine a cost-recovery tariff?**	☐ 0 No → d4 ☐ 1 Yes

#	QUESTION	RESPONSES
The following questions seek to understand the financial sustainability of the RE infrastructure as well as long term projections.		
d2	**Which cost components did you include in calculating the costs that need to be covered by the tariff?**	☐ 0 Fuel Costs ☐ 1 Minor Repair ☐ 2 Major Repair ☐ 3 Parts Replacement ☐ 4 Staffing Costs ☐ 5 Taxes/Permits/Other Fees ☐ 6 Geographic/Climatic Challenges ☐ -96 Other
d2_o	(If d2= -96) **What other costs did you consider?**	*Other, specify response - open text:*
d3	**You noted you did not consider [d2_unselected]. Why were these costs not included?**	*Open text:*
d4	**Do you consider the final tariff for use of the technology (including those with no tariff) appropriate?**	☐ 0 No ☐ 1 Yes → d7
d5	**Why is it not appropriate?**	☐ 0 Too Low ☐ 1 Too High
d6	**Why was a more appropriate tariff not chosen? *(select all that apply)***	☐ 0 Restricted by government guidelines ☐ 1 Resistance from the community members (beneficiaries) ☐ 2 Resistance from community leadership/government ☐ 3 Costs were higher than originally anticipated ☐ 4 Demand was different than originally anticipated ☐ -96 Other
d6_o	(If d6= -96) **Why was a more appropriate tariff not chosen?**	*Other, specify response - open text:*
d7	**Is demand/use of the technology as expected?**	☐ 1 Yes, as expected → d9 ☐ 2 Lower than expected ☐ 3 Higher than expected
d8	(If d7= 2 or 3) **What has changed that caused demand to be different than expected?**	*Other, specify response - open text:*
d9	**Do you believe the owners have adequate savings to cover a minor repair** (a minor repair is one that has reduced capacity by less than 10%) **in the next year?**	☐ 0 No ☐ 1 Yes
d10	**Do you believe the owners have adequate savings to cover a major repair** (a major repair is one that has reduced capacity by more than 10%) **in the next year?**	☐ 0 No ☐ 1 Yes
d11	**In your opinion, how likely is it that the RE technology will be operating 1 year from now?**	☐ 1 Very likely ☐ 2 Somewhat likely ☐ 3 Not very likely ☐ 4 It will not be operating

#	QUESTION	RESPONSES
The following questions seek to understand the financial sustainability of the RE infrastructure as well as long term projections.		
d12	**In your opinion, how likely is it that the RE technology will be operating 5 years from now?**	1 Very likely 2 Somewhat likely 3 Not very likely 4 It will not be operating
d13	**In your opinion, how likely is it that the RE technology will be operating 10 years from now?**	1 Very likely 2 Somewhat likely 3 Not very likely 4 It will not be operating

Module E: Other

#	QUESTION	RESPONSES
The following contains questions about PLN entry into the community.		
e1	**Was any formal agreement made with PLN to delay or avoid entry into the beneficiary area?**	0 No → e3 1 Yes
e2	**How confident are you that this agreement will be upheld?**	1 Very confident 2 Somewhat confident 3 Not very confident
e3	**If PLN enters (or has already entered) the beneficiary community in the next five years, what will happen to the RE technology?**	1 It will be/has been decommissioned → e6 2 It **will be** integrated into the PLN network 3 It **has been** integrated into the PLN network (a formal/written agreement is in place) 4 It will continue to function as planned, alongside, but not part of, the PLN network → e6
e4	**Who was/will be responsible for integrating the technology with PLN?**	1 Bappenas 2 Ministry of Energy and Petroleum 3 Other government entity 4 Current Owners (e.g. SPV, regional company, beneficiaries) 5 Grantee 6 Unsure -96 Other
e4_o	(If e4 = -96) **Who will be responsible?**	*Other, specify response - open text:*
e5	**Will a feed-in-tariff be paid?**	0 No 1 Yes 2 Unsure
The following contains questions about the administration and execution of activities under the Compact.		
e6	**Was the application process with MCA-I clear and easy to implement?**	1 Very Clear 2 Clear 3 Somewhat difficult to implement 4 Very difficult to implement

#	QUESTION	RESPONSES
e7	**Was the review process with MCA-I clear as to next steps and appropriate channels of communication?**	☐ 1 Very Clear ☐ 2 Clear ☐ 3 Somewhat difficult to implement ☐ 4 Very difficult to implement
e8	**Was the timeline for review and approvals adhered to by MCA-I or where their unexpected delays?**	☐ 0 Timeline was as communicated ☐ 1 There were unexpected delays ☐ 2 Unsure
e9	**Did you experience any of the following challenges in implementing the RE component of your grant? (select all that apply)**	☐ 1 Laborious paperwork ☐ 2 Delayed Permissions from MCA-I ☐ 3 Delayed Permissions/Permitting from Local Authorities ☐ 4 Delayed Agreement with the Beneficiary Community ☐ 5 Delayed Identification of the Appropriate Site for the Technology ☐ 6 Need to Revise Location or Technology Choice after DES or FS ☐ 7 Need to Revise Location or Approach due to presence of another grantee or PLN entry ☐ 8 Challenges with identifying an appropriate vendor ☐ 9 Geographic/Seasonal challenges delaying or inhibiting construction ☐ 10 Other
e9_o	(If e9= -96) **What other challenges did you experience?**	*Other, specify response - open text:*
e10	**Are there any areas MCA-I could have provided greater support? (select all that apply)**	☐ 1 Longer timelines for implementation ☐ 2 Assistance with identification of vendor ☐ 3 Assistance with garnering local permissions ☐ 4 Other
e10_o	(If e10= -96) **What other areas of support could have been provided?**	*Other, specify response - open text:*

Module Z: Conclusion

#	QUESTION	RESPONSES
Z1	**Anything else you would like SI to be aware of?**	(open text)

Endline Case Study Protocols – Village Owner/Operator KII Guide

This KII was issued for LAKPESDAM – PBNU and Burung where the technology is considered to be "village" owned even as direct operations and maintenance may fall on households or farmers groups. Operators included individuals identified by the grantee (i.e., trained by the grantee) or community as responsible for maintenance and repairs.

	Questions
1.	What do you understand the *[Village Government]* responsibilities to be as a whole with respect to the *[RE technology]* in your area? What are the specific responsibilities of your role in the *[RE technology]*?
2.	Has the ownership model of the technology changed since the project finished? What was the reason for the change?
3.	How would you describe your existing relationship with [grantee] to this point? Are they still engaged with the [SPV/Co-op/Village Government] following the grant? What is their role?
4.	How are routine and preventative O&M tasks handled for the *[RE technology]*? What about complex O&M tasks or repairs? Who handles these repairs? Please describe how the *[SPV/Co-op/Village Government]* responded to any significant O&M challenges to facilities in the past year, and how often these challenges occur. Are you confident the *[SPV/Co-op/Village Government]* will be able to respond to significant O&M challenges in the future?
5.	Did the grantee issue any guarantee for maintenance and repair of spare parts? If so, for how long? How easy and affordable is it to find replacement parts when they are needed? How long has it taken for replacement parts to arrive? If you use external technicians for repairs or maintenance, how long does it typically take from when you request service for service to be completed?
6.	How were responsibilities in day-to-day operation and maintenance handed over to you? Was this process reasonable?
7.	Have there been significant challenges for the *[SPV/Co-op/Village Government]* aside from O&M challenges, like political, social, or financial challenges? *If applicable:* Does the community seem to be comfortable with the way that the village fund is used to support the facilities rather than other alternatives?
8.	How would you compare the performance of the *[RE Technology]* relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future? Have you been satisfied with the quality and reliability of the electricity *(or water for SWP)* supply?
9.	Has your training prepared you for your role in the *[SPV/Co-op/Village Government]*? What part or parts of your training have seemed the most useful? Are there any situations you have encountered for which you felt you were not adequately prepared? Did you receive your training from the grant or from another source? Are the people who received training from the grant the same ones currently responsible, or has there been turnover?
10.	Please walk me through the revenue and expenditures of the *[RE Technology]*. How much do community members pay for *[use/access]?* What is the cost of operating the *[RE Technology]*? Is the revenue from the users enough to cover all expenses, or is supplementary funding required from other sources (e.g. village fund, district government, NGOs, national programs)?
11.	Do you think *[business generated from the RE technology]* have opportunities for growth in the near future or the long-term? If so, how might it grow? If not, what prevents it from growing?

	Questions
12.	How has the *[SPV/Co-op/Village Government]* chosen to use surplus electricity or revenue if a surplus exists?
13.	What actions has the *[SPV/Co-op/Village Government]* taken to ensure gender equality and social inclusion in access to and the benefits from the new RE systems? Were these actions successful? Why or why not?
14.	How are responsibilities within the *[SPV/Co-op/Village Government]* distributed between females and males?
15.	How confident are you that the *[SPV/Co-op/Village Government]* is prepared, in terms of capacity, equipment, and legal status, to operate the infrastructure in the long term?

Endline Case Study Protocols – Cooperative KII Guide

A version of this KII was issued to the Head of the IIEE co-operative, the Treasurer, and the operators of the MHP Plant and processing or pumping facilities. Some questions applied to all four KIIs, while others applied to one or two, as indicated in the “KII” column.

Questions	KII
1. What do you understand the co-operative‘s responsibilities to be as a whole with respect to the MHP mini-grid and [CoK/Coffee Processing] facility in your area? Does your co-operative apply to all the villages served by the facilities, or just yours? What are the specific responsibilities of your role on the co-operative?	All
2. How would you describe your existing relationship with IIEE to this point? Are they still engaged with the co-operative following the grant? What is their role?	Head
3. How are routine and preventative O&M tasks handled for the MHP mini-grid and coffee machinery? What about complex O&M tasks or repairs? Are these handled by you, through a contract with an O&M provider, or both? Is IIEE your main external O&M provider, or are there others that you trust?	Operators
4. Please describe how the management units responded to any significant O&M challenges to the facilities in the past two years, and how often these challenges occur. Did they occur while IIEE’s guarantee was still active or after it expired? Are you confident the management units will be able to respond to significant O&M challenges in the future?	Head/ Operators
5. How easy and affordable is it to find replacement parts when they are needed? How long has it taken for replacement parts to arrive? If you use external technicians for repairs or maintenance, how long does it typically take from when you request service for service to be completed?	Operators
6. Do you feel adequately trained to handle your responsibilities in O&M? Has there been any need to pursue additional training to the training provided by the grant? Are the people who received training from the grant the same ones currently responsible for O&M, or has there been turnover?	Operators
7. How were responsibilities in day-to-day operation and maintenance handed over to you? Was this process reasonable?	Operators
8. Have there been significant challenges for the co-operative aside from O&M challenges, like political, social, or financial challenges? Does the community seem to be comfortable with the way that the village fund is used to support the facilities rather than other alternatives?	All
9. Are all households in this village members of the co-operative? If not, is there ever any conflict between households who are members and households who are not? How are these conflicts resolved?	Head
10. How would you compare the performance of the MHP mini-grid and CoK/Coffee Processing facility relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future? Have you been satisfied with the quality and reliability of the electricity supply?	All
11. In your experience, how do the households and public facilities connected to the mini-grid use the electricity? Do they ever use it for things that used to require fossil fuels? Have the uses of mini-grid electricity changed at all over time? Do you think it will change in the future?	All

Questions	KII
12. Has your training prepared you for your role in the co-operative? What part or parts of your training have seemed the most useful? Are there any situations you have encountered for which you felt you were not adequately prepared? Did you receive your training from the grant or from another source?	Head /Treasurer
13. Please walk me through the revenue and expenditures of the MHP mini-grid, CoK and coffee processing facility. Do households pay for consumption or for a flat monthly fee? Are there sources of revenue outside of tariffs, like revenue-sharing from users of the CoK or coffee processing facility? How much does revenue amount to per month in total? What is the cost of operating MHP mini-grid and [pumping/processing] facility per month? Is revenue enough to cover all expenses, or is supplementary funding required from the village fund?	Head /Treasurer
14. Do you think community members have internalized the message that electricity must be paid for? Do you anticipate they will be willing and able to pay more for electricity over time? How might this affect the sustainability of the assets?	Head /Treasurer
15. How do you decide who gets to use the processing facility and at what time? Is there ever conflict for use of the facilities?	Head
16. How has your co-operative chosen to use surplus electricity or revenue, if a surplus exists?	Head /Treasurer
17. What actions has the co-operative taken to ensure gender equality and social inclusion in benefits from the new RE systems? Were these actions successful? Why or why not?	Head
18. How are responsibilities within the co-operative distributed between females and males?	Head
19. How confident are you that the co-operative is prepared, in terms of capacity, equipment, and legal status, to operate the infrastructure in the long term?	Head

Endline Case Study Protocols – Village Official KII Guide

	Questions
1.	Please describe how the village government supported the RE activities during project implementation? How about since the project ended?
2.	Has the village government changed since the project ended? What effect do you think this has had on the government's involvement in the RE technology?
3.	To the best of your knowledge, how was the regional government involved with supporting the RE technology during implementation? How about since the project ended?
4.	Are there any sources of regional or village funding that are still used to support the *[RE Technology]*?
5.	If applicable, do you think community members are supportive of the village fund being used in to support these facilities? Are there any ways you think the community would prefer for these funds to be used? In an ideal world, how do you think the village fund should be used?
6.	What are the main benefits that the *[RE Technology]* have brought this village? Are there major drawbacks or disadvantages to these assets? Do any of these apply more to men or women, specifically?
7.	The grant aimed, at least in part, to improve economic outcomes in this community. In your perspective, have economic opportunities improved as a result of *[RE Technology]*?
8.	[May not be relevant for SWP]: To what extent do you think that small businesses in your village are using less fossil fuels (diesel, gasoline, kerosene, etc.) now that the *[RE Technology]* are available?
9.	Do you think community members who received training from *[grantee]* are more skilled as a result of the training? What have they become more skilled in? Do you think they will achieve higher wages as a result of these skills?
10.	Do you think that the *[Farmer's group/SPV/Co-op/Village Government]* has proven capable of managing the *[RE Technology]*? How confident are you that this technology will continue to work in the long run?
11.	Do you feel the community was adequately engaged in designing the grant and constructing the facilities? Are there any ways engagement could have been improved?

Endline Case Study Protocols – Small Business/Farmers Group KII Guide

For each grant, six to eight KIIs will be conducted with individuals engaged in small business or use of RE technology for farming or other economic purposes (ensuring balance between the number of male and female respondents). Small businesses here may include individual household income-generating activities.

	Questions
1.	Could you please all introduce yourself, share the product that you produce, and describe how long you have been in this business?
2.	***[Farmer, women or business group only – leaders]*** Please describe your roles and responsibilities in the leadership of your small business/farmers group.
3.	For those of you whose business is new/new to produce for sale (with the past 2 years), what did you do for a living before? Were you producing another product or involved in some other trade or domestic activities?
4.	How does your business/farm use the *[RE Technology]* in this village? Have you been satisfied with the service? Is it available and functioning well all the time that you need it?
5.	***[May not be applicable for SWP]*** Compared to the time before the RE technology was built, would you say the amount of fossil fuel you use for producing your good (or for your previous trade) has changed, or is it about the same? What about the amount of time you spend producing your good, or the number of goods you are able to produce?
6.	*If applicable, p*lease describe what you learned from any trainings provided by the grant. How do you use these lessons in your work? Do you feel members of your profession are able to earn more because of the lessons you have learned?
7.	How would you describe the relationship between the various small business owners/farmers in this village? Is there ever conflict between the owners surrounding use of the *[RE Technology]* or other issues?
8.	*If applicable, c*an your small business/farm reasonably afford the share of cost of using the *[RE Technology]*? *If applicable,* do you feel that the level of assistance from the village fund and the regional government is fair and adequate?
9.	*If applicable,* describe your understanding of the way that the village fund is used to support the technology? Are you supportive of the village fund being used in this way? In an ideal world, how do you think the village fund should be used?
10.	To whom is your small business product/produce generally sold? Do you think demand for your product/produce has increased over time, decreased, or stayed about the same? Are you able to sell outside your village/community?
11.	*If applicable,* if PLN power was available in your village, would you still use the *[RE Technology]* to produce your products? Why/why not?
12.	What are the main benefits that the *[RE Technology]* have brought this village? Are there major drawbacks or disadvantages to these assets? Do any of these apply more to men or women, specifically?
13.	Do you think economic opportunities for women have changed in this community since before the grant? If so, how?

14.	Do you think that the [*SPV/Co-op/Village Government/your group]* has proven capable of managing the *[RE Technology]*? How confident are you that these facilities will continue to work in the long run?
15.	Do you feel the community was adequately engaged in designing the grant and constructing the facilities? Are there any ways engagement could have been improved?

Endline Case Study Protocols – Household KII Guide

For each grant, six to eight KIIs were conducted with household members for IIEE, Sky Energy and LAKPESDAM – PBNU (ensuring balance between the number of male and female respondents).

	Questions
1.	What is your HH's main use for electricity (appliances, lighting, productive uses)? Has this changed since you were connected to the mini-grid/receive SHS?
2.	Please describe a typical day or week in terms of your energy usage. Which energy sources do you use most often, or prefer to use? Are there certain times of day, or certain times of the year, when you use some energy sources more than others?
3.	How much do you pay per month for electricity? Is this a flat rate, or based on consumption? Are you satisfied with the price? What are the main reasons for your satisfaction/dissatisfaction? Please discuss.
4.	Are you satisfied with the quality of electricity your family currently receives? What are the main reasons for your satisfaction/dissatisfaction? Please discuss.
5.	Are you satisfied with the hours per day of electricity your family currently receives? What are the main reasons for your satisfaction/dissatisfaction? Please discuss.
6.	Are you satisfied with the operator model (SPV, co-operative, home ownership) of the electricity your family uses currently? What are the main reasons for your satisfaction/dissatisfaction?
7.	How would you compare the performance of the mini-grid/SHS relative to your expectations? Do you feel it will sustainably provide electricity that meets your communities needs for the foreseeable future?
8.	Has access to the mini-grid/SHSs in this village brought growth in economic activities? How? What else is needed in your community to raise economic wellbeing?
9.	Who has benefitted most from energy access in your community? Is there anyone who has not benefited from access to the mini-grid/SHSs?
10.	What are the main benefits that the MHP mini-grid/SHSs have brought this village? Are there major drawbacks or disadvantages to these assets? Do any of these apply more to men or women, specifically?
11.	How has electricity access changed the life of women, and their rights and roles within the community?
12.	Are there activities for which you used to use kerosene, diesel, or gasoline that you can now do using electricity from the mini-grid/SHS instead? Do you think less of these fuels is used in your community now than before the mini-grid was commissioned? If so, how has this change affected your finances, health, or the local environment?
13.	Has the introduction of the co-operative or processing facilities in your community affected interpersonal or social community dynamics in any significant way? How so?
14.	If PLN were to extend the grid into your village, would you prefer to consume electricity from PLN or the mini-grid/SHS? Why?
15.	*LAKPESDAM – PBNU Only* - How are routine and preventative O&M tasks handled for the *[RE technology]*? What about complex O&M tasks or repairs? Are these handled by you, through a contract with an O&M provider, by someone else in the village or a combination? Please describe how those in your community responded to any significant O&M challenges to SHSs in the past two years, and how often these challenges occur. Are you confident households will be able to respond to significant O&M challenges in the future?

16.	Describe your understanding of the way that the village fund is used to support the mini-grid/SHS. Are you supportive of the village fund being used in this way? In an ideal world, how do you think the village fund should be used?
17.	Do you feel the community was adequately engaged in designing the grant and constructing the facilities? Are there any ways engagement could have been improved?

Endline Case Study Protocols – Processing/Pumping Facility User KII Guide

For each grant, six to eight KIIs were conducted with users of the agricultural processing, water purification or irrigation pumping facility for LAKPESDAM – PBNU, IIEE, and Burung grants (ensuring balance between the number of male and female respondents). Some of these questions applied to users of all of these facilities, while others only applied to one type of facility or the other.

Questions	FGD
1. Could you please all introduce yourself and share your occupation (the main thing you do to earn income?) How do you use the [facility]?	All
2. Have you always produced this good, or are you producing it for the first time now that the processing facility is available? Compared to the time before the processing facility was built, would you say the amount of fossil fuel you use for producing your good (or for your previous trade) has changed, or is it about the same? What about the amount of time you spend producing your good, or the number of goods you are able to produce?	Processing
3. How do you decide who gets to use the processing facility and at what time? Is there ever conflict for use of the facility?	Processing
4. Compared to the time before the pumping facility was built, how have your farming activities changed? Are you able to harvest more crops, or grow different crops? Have you saved time relative to previous arrangements for irrigation?	Pumping
5. [For Burung only]: How did the community decide what area would be served by the irrigation pumping facility? Does the area served cover the whole village, or are there parts that are left out? Has anyone moved into the area to be able to benefit from the facility?	Pumping
6. Please describe what you learned from any trainings provided by the grant. How do you use these lessons in your day-to-day life?	All
7. How would you describe the relationship between the various individuals and groups who use the [facility]? Is there ever conflict between the groups surrounding use of the facilities or other issues?	All
8. What, if anything, do users of the [facility] contribute in exchange for the use of the [facility]? Do you feel this contribution is fair for what the [facility] provides? If the managing co-operative informed you that you would need to pay more to continue using the facility, could you afford it? Would you be willing to do so?	All
9. Describe your understanding of the way that the village fund is used to support the [facility]. Are you supportive of the village fund being used in this way? In an ideal world, how do you think the village fund should be used?	All
10. To whom do you generally sell your product after you have made it at the processing facility? Do you think demand for your product has increased over time, decreased, or stayed about the same?	Processing
11. If PLN power was available in your village, would you still use the processing facility to produce your products? Why/why not?	Processing
12. Do you think the provision of water purification facilities has benefited the community? How? Before the [facility] was built and purification assets were provided, where did your customers source their water from? Do you have information on the quality and cost of water from these sources?	Purification

Questions	FGD
13. What are the main benefits that the [facility] has brought this village? Are there major drawbacks or disadvantages to these assets? Do any of these apply more to men or women, specifically?	All
14. Do you think economic opportunities for women have changed in this community since before the [grant name] grant? If so, how?	All
15. Do you think that the co-operative has proven capable of managing the MHP plant and [facility]? How confident are you that these facilities will continue to work in the long run?	All
16. Do you feel the community was adequately engaged in designing the [grant name] grant and constructing the facilities? Are there any ways engagement could have been improved?	All

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