MDF

EMPOWERING PEOPLE,
CREATING IMPACT

Demonstration Project Endline Assessment for MENTARI

(Menuju Transisi Energi Rendah Karbon)

Evaluation Report

Bali, August 2025

MDF

EMPOWERING PEOPLE,
CREATING IMPACT

MDF Indonesia Office
Jalan Bypass Ngurah Rai 379
Sanur, Bali
Indonesia
+62 (0)361 287 020
mdfpi@mdf.nl
www.mdf.nl

Table of Contents

List of Acronyms

AD/ART	Anggaran Dasar / Anggaran Rumah Tangga (Articles of Association / Bylaws)
APBN	Anggaran Pendapatan dan Belanja Negara (State Budget)
APKMK	Access, Participation, Control, Benefits, and Wellbeing framework
BLK	Balai Latihan Kerja (Vocational Training Center)
BPD	Badan Permusyawaratan Desa (Village Consultative Body)
BUMDes	Badan Usaha Milik Desa (Village-Owned Enterprise)
CCBN	Collaboration and Capacity Building Network
CSO	Civil Society Organization
DAK	Dana Alokasi Khusus (Special Allocation Fund)
DEN	Dewan Energi Nasional (National Energy Council)
EBTKE	Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi (Directorate General of New, Renewable Energy and Energy Conservation)
ECA	Economic Consulting Associates
ESDM	Kementerian Energi dan Sumber Daya Mineral (Ministry of Energy and Mineral Resources)
FGD	Focus Group Discussion
GALS	Gender Action Learning System
GEDSI	Gender Equality, Disability, and Social Inclusion
HHS	Household Survey
IDR	Indonesian Rupiah
JETP	Just Energy Transition Partnership
KAK	Kerangka Acuan Kerja (Terms of Reference)
KEN	Kebijakan Energi Nasional (National Energy Policy)
KPPPA	Kementerian Pemberdayaan Perempuan dan Perlindungan Anak (Ministry of Women's Empowerment and Child Protection)
KSO	Kerja Sama Operasi (Joint Operation)
LEAP	Long-range Energy Alternatives Planning system
LPDP	Lembaga Pengelola Dana Pendidikan (Indonesia Endowment Fund for Education)
LPJ	Laporan Pertanggungjawaban (Accountability Report)
MEMR	Ministry of Energy and Mineral Resources
MENTARI	Menuju Transisi Energi Rendah Karbon Indonesia
MSME	Micro, Small, and Medium Enterprise
NTT	Nusa Tenggara Timur (East Nusa Tenggara)
OSS	Online Single Submission
PAD	Pendapatan Asli Desa (Village-Generated Income)
PAUD	Pendidikan Anak Usia Dini (Early Childhood Education Centre)
PEIDT	Directorate General of Economic Development and Investment in Disadvantaged Regions
PLN	Perusahaan Listrik Negara (State Electricity Company)
PLTS	Pembangkit Listrik Tenaga Surya (Solar Power Plant)
PPDT	Direktorat Jenderal Pembangunan Daerah Tertinggal (Directorate General of Development of Disadvantaged Regions)

PT	Perseroan Terbatas (Limited Liability Company)
PV	Photovoltaic
PUE	Productive Use of Energy
RENSTRA	Rencana Strategis (Strategic Plan)
RPJMD	Rencana Pembangunan Jangka Menengah Daerah (Regional Medium-Term Development Plan)
RUED	Rencana Umum Energi Daerah (Regional Energy Plan)
RUEN	Rencana Umum Energi Nasional (National Energy Plan)
RUPTL	Rencana Usaha Penyediaan Tenaga Listrik (Electricity Supply Business Plan)
SD	Sekolah Dasar (Elementary School)
SKKNI	Standar Kompetensi Kerja Nasional Indonesia (Indonesian National Work Competency Standard)
SMK	Sekolah Menengah Kejuruan (Vocational High School)
TWG	Technical Working Group
UIW	Unit Induk Wilayah (Regional Main Unit of PLN)
UK	United Kingdom
UKM	Usaha Kecil dan Menengah (Small and Medium Enterprises)
VA	Volt-Ampere

Executive Summary

The MENTARI Demonstration Project (the Project) is one of four strands of the five-year MENTARI (*Menuju Transisi Energi Rendah Karbon Indonesia*) Programme. MENTARI is a UK–Indonesia partnership funded by the UK Government and implemented by PT Palladium International Indonesia, in a consortium with Castlerock Consulting, Economic Consulting Associates (ECA), and Hivos. The Project offers a practical model to deliver decentralised renewable energy solutions to off-grid communities with the aim of expanding energy access, improving livelihoods, and enabling productive use of energy (PUE). From 2020 to 2025, the Project team implemented the Project in two villages in Central Sumba, East Nusa Tenggara (Nusa Tenggara Timur/NTT). This endline evaluation focuses on Mata Redi village in Central Sumba, where the mini-grid system provides wider coverage reaching across five dusun and all households and has been operating reliably for more than four years under established local management.

The endline evaluation assessed the Project's long-term results and viability to generate evidence for learning, accountability, replication, and future planning. In line with the Terms of Reference (ToR), the evaluation focused on two OECD-DAC criteria, impact and sustainability, and addressed nine evaluation questions agreed with the Project team. The evaluation applied a mixed-method approach that included household surveys, focus group discussions (FGDs), key informant interviews, document review, and participatory workshops. Data collection took place between May and July 2025, with fieldwork limited to Mata Redi due to scope refinements. The analysis triangulated quantitative and qualitative evidence to provide a balanced assessment of achievements, challenges, and lessons, with particular attention to Gender Equality, Disability, and Social Inclusion (GEDSI).

Key findings and conclusions

The Project has delivered substantial and multi-dimensional results, with measurable progress across all six Intermediate Outcomes (IOs) of the Theory of Change (ToC). These improvements are visible at household, community, and institutional levels, supported by reliable solar-powered electricity, strengthened governance, and targeted GEDSI measures. The changes extend beyond technical outputs to social and economic transformation, showing that a community-based, GEDSI-responsive mini-grid model can catalyse improvements in quality of life, governance, and early economic development when embedded within local institutions.

At household and community level (IO3), electricity access in Mata Redi is now universal, with every all household connected to the PLTS mini-grid. The majority (79% of surveyed households, the survey covered 50% of all households in Mata Redi) report relying fully on PLTS as their main source of lighting. This transition away from kerosene has improved safety, reduced indoor air pollution, and extended productive and leisure hours into the evening. Families report spending more time together, supporting children's evening study, and moving around the village with greater confidence at night. Public services have also improved, with village offices now able to carry out administrative tasks locally, schools use lighting and basic digital tools to enhance teaching methods, and community facilities such as churches and village halls hosting evening activities. These changes have enriched quality of life and strengthened community interaction. These results confirmed that the Project has achieved IO3 by linking clean energy access to tangible social benefits.

In terms of productive use and efficient energy utilisation (IO2), the proportion of households using electricity to generate income has increased from 4% at baseline (around 5 households from the survey sample) to 18% at endline (21 households out of the 120 surveyed, representing half of all households in Mata Redi). Electricity is now being used for weaving, food processing, candlenut shelling, and selling refrigerated beverages. The adoption of modern appliances has also increased, leading to greater convenience and efficiency. However, the use of high-wattage appliances remains limited due to affordability constraints, daily quota restrictions, and concerns about system overload. This means that benefits are concentrated among households with

higher-capacity connections and greater financial capital. While this demonstrates the capacity of the PLTS to stimulate economic activity, it also highlights that without targeted support such as microfinance for appliances, and business development assistance, economic participation will remain uneven. The PLTS system itself is flexible, with smart meters enabling households to go beyond their basic daily quota by purchasing additional electricity as needed. Households with limited financial means may be unable to take advantage of this flexibility, leaving the potential of IO2 for achieving widespread income gains unrealised fully.

Strengthening institutional capacity has been one of the Project's most notable achievements (IO1 and IO4). Village-owned enterprise (BUMDes) Hali Dewa now operates under a formal governance structure, with Standard Operating Procedures (SOP) for technical operations and payment collection and has taken on daily responsibility for system operations. Eleven local youth including three hired operators have obtained nationally recognised SKKNI certification on O&M and K3, allowing them to carry out preventive maintenance and diagnosing technical issues independently while third party O&M company assisting them for three years duration. Local government oversight has also increased, with the PLTS now integrated into village planning and budgeting documents (RPJMDes and APBDes). These developments demonstrate significant progress towards building local ownership and operational competence. However, periodic disagreement between BUMDes and village government (Pemerintah Desa/Pemdes) regarding roles and financial management have disrupted coordination. This suggests that the long-term success of IO4's will depend on clear role definitions and established mechanisms for institutional mediation.

The Project has contributed to more inclusive energy governance and policy engagement (IO5 and IO6). At the village level, inclusive decision-making improved through community consultations and the integration of energy priorities into development plans. At district and provincial levels, engagement through the Working Group (Pokja) informed policy coordination and contributed to the revision of the Regional Energy Plan (Rencana Umum Energi Daerah/RUED) in NTT, the first provincial energy plan in Indonesia to integrate GEDSI considerations. At the national level, the Project's lessons influenced the design of Special Allocation Fund on energy (DAK Energi) and generated interest from the Ministry of Villages (Kemendesa) in adapting the model for wider replication. These linkages between grassroots practice and policy-level change confirm that the Project has strengthened institutional pathways for scaling up and embedding community-based renewable energy models into government frameworks.

GEDSI principles are integral to these achievements. Electricity access combined with the Gender Action Learning System (GALS) enabled women to expand their role in the local economy, take leadership positions in BUMDes, and actively contribute to village planning processes, which signals a gradual change in social norms and household decision-making patterns. Women champion networks also advocated for priorities such as girls' education and fair employment. While this confirms that the Project has made meaningful progress on GEDSI, cultural expectations and structural barriers still to limit the participation of some women, youth, and vulnerable groups. This shows that IOs linked to GEDSI will require continued engagement beyond the Project's lifetime.

Despite the Project's successes, risks and challenges remain that could undermine lasting impact. Unresolved governance tensions between the BUMDES and the village government over roles and financial management have at times disrupted coordination. Limited market access, lack of affordable credit or micro finance for appliances, and inadequate post-training support also hamper productive use and reduce its potential to strengthen household income. Sustaining these results requires coordinated action at multiple levels: (a) BUMDes must ensure transparent, inclusive service delivery and reinvest revenues in maintenance and quality; (b) Village governments should guarantee equitable access and support for productive use of energy; (c) district and provincial governments need to provide technical backstopping and mediation; and (d) national ministries must integrated the Project's model into policy and financing frameworks.

Sustainability

The Project has established a robust technical, financial, and institutional foundation for the long-term operation of the Mata Redi PLTS system. These sustainability gains have been achieved through targeted capacity building for operators and BUMDes, the adoption of transparent operational procedures, and the integration of energy access into village-level planning. The results demonstrate that community-managed mini-grids can be technically reliable, financially viable, and institutionally anchored when supported by multi-level governance. However, the sustainability of these outcomes depends on stable revenues, effective governance, and external support for major maintenance and system upgrades. These are all factors that remain at risk without formalised support mechanisms.

From a technical standpoint, the PLTS system has achieved high reliability, with monitoring data indicating downtime well below PLN's service standard. Local capacity has also been strengthened, with certified operators now handling maintenance and coordinating with external technicians when required. This has reduced reliance on outside service providers, shortened response times for minor disruptions, and built community confidence in the system's resilience. SOPs for technical operations, meter installation, and payment collection have been adopted by BUMDes, further institutionalising consistent service delivery. These achievements confirm that the Project has achieved IO1 and IO4 by localising technical skills and governance routines. Ongoing refresher training from the contracted O&M company, which will provide technical support for a three-year period, will be necessary to maintain these results.

The system operates on a tiered tariff model, which covers routine costs and generates a modest surplus. This surplus has enabled BUMDes Hali Dewa to reinvest in community activities and support small-scale productive use initiatives, such as the candlenut shelling enterprise. While this demonstrates the potential for a self-financing service model, household affordability, especially for lower-tier users, remains a limiting factor. The fact that higher-tier households are the main users of these services restricts opportunities for revenue growth from broader economic activity, leaving the system reliant on a narrow base of higher-paying customers. In order to ensure that IO2 and IO3 to fully translate into sustained revenue streams, targeted interventions will be required. These interventions should focus on diversifying household energy use and expanding income-generating activities. This should include providing affordable access to modern appliances and supporting small businesses.

The transfer of PLTS assets to village government, with operational authority delegated to BUMDes, has established a locally managed model in accordance with Indonesia's village governance framework. BUMDes now functions as both a service provider and a local economic actor, while the village government fulfils a supervisory role. This arrangement strengthens local ownership, but periodic disputes over revenue allocation and financial reporting have delayed village fund disbursements and disrupted planning cycles. Unless these governance tensions are resolved through structured mediation and clearer role definitions, there is a risk of eroding service continuity and community trust, both of which are key elements for sustaining IO4 and IO5.

Beyond the village, sustainability is reinforced through district, provincial, and national-level engagement. At district level, Pokja MENTARI and the Dinas Pemberdayaan Masyarakat dan Desa (DPMD) can facilitate dispute resolution, connect BUMDes to markets and finance, and align energy priorities with district planning. At the provincial level, the Department of Energy and Mineral Resources (ESDM) is responsible for providing technical training, coordinating operator capacity development, and mobilising resources for major component replacements. At national level, ministries such as ESDM, Kemendesa, and National Development Planning (Bappenas) can institutionalise community-based mini-grid models through policy frameworks, dedicated financing mechanisms for battery and inverter replacement, and targeted support to expand productive use. This aligns with IO6 by anchoring the Project's approach within national electrification strategies.

In order to maintain sustainability gains, it is essential that BUMDes exercise transparent financial management, adhere to established SOPs, and allocate funds to a reserve for major maintenance. Village governments should provide active oversight, guarantee equitable access, and promote local economic initiatives linked to the PLTS. District authorities must establish systems of technical and governance support, while provincial and national agencies must integrate community-managed mini-grids into rural electrification policy and financing schemes. In conclusion, while the Project has created a robust platform for sustainable energy service delivery in Mata Redi, its long-term viability will depend on coordinated, multi-level action to strengthen governance, expand productive use, and secure financing for future system upgrades.

Key Recommendations

The evaluation identifies a set of strategic, stakeholder-specific recommendations to consolidate the Project's achievements, address identified challenges, and enable broader replication of inclusive, community-managed renewable energy models. These recommendations align closely a with the ToC pathways, energy access, institutional capacity, productive use, and policy engagement, and reflect the OECD-DAC criteria of impact and sustainability.

For Government and Policymakers, the priority is to embed the Project model into Indonesia's rural electrification framework. This will require strengthening the institutional relationships between BUMDes and village governments through clear roles, shared planning, and structured dispute resolution. At the national level, the Ministry of ESDM should lead on policy integration, while the Ministry of Kemendesa is expected to embed rural electrification within village development and ensuring fiscal capacity for O&M. The MoF and Bappenas play a critical role in designing and financing subsidies for meter installation and a minimum level of household electricity consumption. National and subnational energy planning instruments (RUEN, RUED, DAK Energi) should explicitly recognise and resource community-based, off-grid PLTS models, supported by village regulations and budget allocations.

For Civil Society, Universities, and Training Institutions, the Project's lessons on decentralised energy governance and GEDSI integration should be institutionalised through university curricula, vocational training, and field-based learning in sites like Mata Redi. Partnerships with local enterprises, women's groups, and youth entrepreneurs can be harnessed to expand productive use of electricity by connecting communities to markets, financing, and technical support. Such interventions would stimulate demand and allow households to upgrade their capacity and strengthen the financial viability of the system.

For International Development Partners, the priority is to amplify impact by promoting GEDSI-responsive planning tools, such as GALS, across the energy sector, and supporting structured policy dialogue platforms that connect village-level experience with national policy reform. Catalytic financing for PLTS-compatible appliances, particularly for women-led enterprises, has the potential to stimulate demand, diversify household energy use, and create inclusive economic opportunities that can strengthen impact and sustainability.

For the Private Sector and Renewable Energy Developers, the findings indicate potential opportunities to develop hybrid business models that combine village-level management with performance-based service contracts, long-term technical support, and scalable financing mechanisms such as lease-to-own or power-as-a-service. Partnerships with BUMDes and rural enterprises should aim to bundle energy-efficient appliances with market access, after-sales service, and tailored financing, thereby increasing electricity demand, supporting capacity upgrades, and improving household incomes.

It is clear that coordinated, multi-level action is required across all stakeholder groups to maintain the Project's achievements and enable replication of the Project's approach as part of Indonesia's just and inclusive energy transition. These actions should embed inclusive, community-based mini-grid models into policy frameworks, strengthen institutional capacity, ensure equitable access, and expand productive use.

1. Background and Context

The MENTARI Programme is a five-year partnership between the UK and Indonesia, launched in January 2020 and led by the British Embassy in Jakarta. PT Palladium International Indonesia is implementing the Programme in a consortium with Castlerock Consulting, Economic Consulting Associates (ECA), and Hivos. The Programme aims to promote inclusive economic growth and poverty reduction by accelerating the adoption of low-carbon energy solutions, especially in underserved and remote areas. MENTARI operates through four interrelated strands: Policy, Brokerage, Demonstration Projects, and Collaboration/Capacity Building (CCBN), with GEDSI mainstreamed throughout.

The Demonstration Project (The Project) supports Indonesia's just and inclusive energy transition. It aligns with Indonesia's national rural electrification and clean energy goals by expanding energy access through decentralised renewable solutions and contributes to the Electricity Supply Business Plan (RUPTL), the Just Energy Transition Partnership (JETP), and Indonesia's Net Zero 2060 roadmap. The Project offers a practical model to deliver decentralised renewable energy solutions to off-grid communities. It tests scalable approaches to increase energy access, improve livelihoods, and enable productive use of energy, particularly in underserved rural areas.

The Project operates in Central Sumba, NTT, a region with low electrification rates, limited infrastructure, and high poverty levels. Its core intervention involves designing, installing, and operating solar PV mini-grid systems in two villages: Mata Redi and Mata Woga. These community-based systems and managed in partnership with Village-Owned Enterprises (BUMDes), to strengthen local ownership, ensure service sustainability, and improve socio-economic outcomes.

2. Evaluation Objectives and Scope

2.1 Evaluation Objectives

The endline evaluation was commissioned to assess the performance, outcomes, and sustainability of the Project and to generate evidence for learning, accountability, replication, and future planning.

In line with the Terms of Reference (ToR), the specific objectives are to:

- Assess progress toward the objectives outlined in the Theory of Change (ToC) and logical framework;
- Compare selected baseline and endline indicators to measure changes in energy access, livelihoods, productivity, and inclusion;
- Assess the extent to which the project achieved its stated objectives, including both intended and unintended results;
- Analyse how strategy coherence, GEDSI mainstreaming, stakeholder partnerships, and policy alignment contributed to outcomes;
- Assess the sustainability of key interventions, particularly the operational and financial viability of the mini-grid and productive use activities;
- Identify institutional, technical, financial, and community-level factors influencing long-term outcomes and scalability;
- Capture stories of change from community members and stakeholders, especially women, youth, and marginalised groups;
- Draw lessons learned and identify good practices for future rural electrification efforts;
- Provide actionable recommendations for government, donors, private sector, civil society, and other stakeholders;

- Evaluate the replicability and scalability of the DP model for similar rural and off-grid contexts.

2.2 Evaluation Scope

During the inception phase, the scope of the evaluation was refined at the kick-off meeting held on 13 May 2025 with the Project team and representatives of the British Embassy. This refinement prioritised learning and relevance while remaining consistent with the original ToR. The following refinements were implemented:

- The assessment focused exclusively on two OECD-DAC criteria, impact and sustainability, to capture the long-term results and viability of the Project model.
- Although the Project operates in both Mata Redi and Mata Woga, the evaluation focused primarily on Mata Redi due to its wider mini-grid coverage across five hamlets (*dusun)*, and longer and more established operational track record, which provided richer implementation learning. The evaluation also included the dusun in Mata Woga where the Project intervened, with household sampling and FGD participants from this area as well.
- The evaluation used a targeted comparison based on priority indicators jointly selected with the Project team, instead of revisiting the full baseline set. These indicators covered household quality of life related to electricity access, continued reliance on traditional cooking fuel, and increase in household income –which was not measured in the baseline but included as a key outcome in the endline survey.
- Instead of a full cost-benefit analysis, the evaluation assessed financial sustainability from the perspectives of users and the community. This included willingness to pay, revenue collection, perceptions of the equal watt allocation tariff model, and its implications for long-term service viability.
- A single validation workshop was held with the the Project and the Project team to review and discuss the preliminary findings.

3. Demonstration Project Intervention: Theory of Change

The Project piloted a decentralised, off-grid solar photovoltaic (PV) mini-grid model in Mata Redi Village, NTT. It aimed to deliver reliable and inclusive electricity access, encourage the productive use of energy, empower local institutions, and generate replicable lessons for rural electrification in Indonesia. To guide the Project's design, implementation, and evaluation, a ToC was developed, and revised three times, most recently in 2024 to reflect lessons from implementation, baseline results, and evolving contextual conditions.

Theory of Change

The 2024 version of the ToC outlines a results chain that connects community-based energy interventions to broader systems-level impacts through learning, institutional strengthening, and policy engagement. The Project operated across three interrelated levels:

- Community level: ensuring household electrification, stimulating productive use of energy at the household level and through anchor loads (e.g., BUMDes enterprises), and strengthening local capacity and ownership through training for BUMDes and operators.
- District and provincial levels: engaging local governments in planning, safeguarding, and governance processes to create an enabling environment.
- National level: generating knowledge and informing rural electrification strategies, including through Special Allocation Funds (DAK), development budgets, or policies to sustain decentralised systems. Examples include working with PLN to provide through Operations & Maintenance (O&M) support financial subsidies, or Joint Operation (KSO) arrangements.

The project's design and implementation were structured around three core pathways that connect these levels and translate inputs into results:

1. Energy Access and Infrastructure Development: deployment of off-grid solar PV mini-grids in underserved communities.
2. Capacity Building and Local Ownership: supporting community institutions (e.g., BUMDes and operators) to manage systems and promote PUE.
3. Policy and Stakeholder Engagement: collaborating with the government, PLN, and other stakeholders to promote investment, governance, and replication.

The ToC identifies four levels of change:

1. **Activities and Outputs**: feasibility studies, technical assistance, implementation of off-grid systems, training, and dissemination of knowledge products.
2. **Intermediate Outcomes**: behavioural and institutional changes achieved at the community and subnational levels.
3. **Outcomes**: an enabling environment and socio-economic improvements.
4. **Impacts:** long-term inclusive and low-carbon energy transformation.

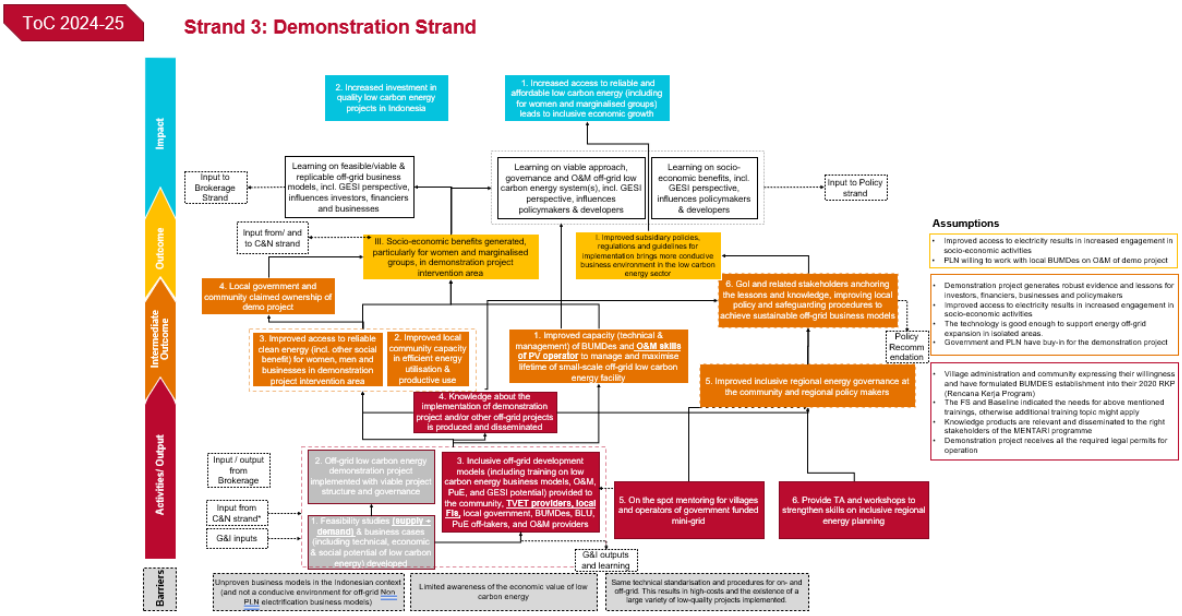

Figure 1. Theory of Change – MENTARI Demonstration Project Strand (2024 version)

At the **Intermediate Outcomes,** the Project aimed to achieve six interrelated results:

1. Improved technical and management capacity of BUMDes and enhanced O&M skills of PV operators to manage and maximise the lifetime of small-scale off-grid low-carbon energy facilities.
2. Improved capacity of local communities in efficient and productive use of energy.
3. Improved access to reliable, clean energy (including other social benefits) for women, men, and businesses in the Project area.
4. Local government and community ownership of the Project.
5. Improved inclusive regional energy governance at the community and subnational policy levels.
6. Government of Indonesia and related stakeholders incorporating lessons learned into stronger policy and safeguarding procedures to support sustainable off-grid business models.

These six intermediate outcomes collectively contribute to two Outcome-level changes, which in turn support the Project's long-term impact goals below. Progress on several intermediate outcomes was measured through indicators such as the percentage increase in BUMDes revenue (IO1), the percentage of households accessing productive uses of energy (IO2), and the percentage of households with improved access to renewable energy (IO3).

Outcomes

1. Improved subsidiary policies, regulations, and guidelines that support implementation, thus creating a more conducive business environment for low-carbon energy.
2. Socio-economic benefits generated, particularly for women and marginalised groups, in the Project intervention area.

In turn, these two Outcomes are expected to support the Project's intended **long-term Impact Areas:**

Impact Areas

1. Increased access to reliable and affordable low-carbon energy, including for women and marginalised groups, contributing to inclusive economic growth.
2. Increased investment in high-quality low-carbon energy projects in Indonesia.

4. Evaluation Approach and Methodology

4.1 Overall Evaluation Approach

This endline evaluation is guided by two OECD-DAC criteria: impact and sustainability. Impact refers to improvements in livelihoods, PUE, and social inclusion resulting from access to electricity, such as increased household income, business development, improved access to services, and greater participation of women and marginalised groups in local economic and decision-making processes. The sustainability criteria cover the ability of communities and local institutions to maintain reliable electricity services over time, their technical and institutional capacities to operate and maintain the system, the potential for service continuity, and the presence of supportive policies and governance mechanisms that enable long-term sustainability and replication.

To assess the Project's contribution to sustainable and inclusive energy outcomes, the evaluation uses a theory-based approach, based on the Project's ToC. As outlined in Section 3, the Project pursued change through three interrelated pathways: energy access and infrastructure development, capacity building and local ownership, and policy and stakeholder engagement. These pathways are used as a frame to analyse the causal links between Project interventions and the results observed at the community, district/provincial, and national levels.

The evaluation also employs a participatory approach, using stakeholder sense-making to validate and refine findings. This approach ensures that the analysis is grounded in local perspectives and leads to actionable, stakeholder-informed recommendations for future programming and policy replication.

The original evaluation questions, developed during the inception phase, were refined prior to data collection. This refinement was based on a review of project documents and several rounds of discussions with the Project team to improve clarity, reduce overlap, and better align the questions with the realities of Project implementation. For example, the original questions on household economic activity (1) and PUE (2) were closely related and partially overlapping. In the revised version, Question 1 focused on non-economic household and community-level benefits, such as comfort, family interaction, and neighbourhood safety. Meanwhile, Question 2 concentrated on PUE, such as income generation and improved business efficiency. These refinements ensured a clearer thematic structure and allowed the evaluation to better capture the range of outcomes observed in the field.

4.2 Mainstreaming GEDSI

GEDSI considerations were integrated into both the impact and sustainability criteria, as reflected in the evaluation matrix. The evaluation examined the influence of improved energy access on access to skills, services, and economic opportunities; participation in energy governance and decision-making; control over energy use, financial resources, and productive investments; and benefits such as time savings, reduced workload, enhanced safety, income gains, and leadership opportunities. The APKMK framework (Access, Participation, Control, Benefits, and Wellbeing) guided the formulation of GEDSI-related outcomes and shaped data collection and analysis.

These considerations also informed respondent selection, which was intentionally inclusive. The evaluation team collaborated with the Project to ensure diverse representation across gender, age, socio-economic status, and, where relevant, disability. Particular attention was given to engaging women entrepreneurs, local champions, GALS participants, and youth through focused FGDs. Inclusive and accessible methods were used in the field, including separate FGDs for different user subgroups to encourage comfort and openness, and tools adapted to meet varying literacy levels. Disaggregated data were collected wherever possible to enable nuanced analysis of gender and social inclusion outcomes.

Key stakeholders involved in inclusive and gender-responsive energy planning at the provincial level, were also consulted to ensure that policy perspectives on GEDSI were captured alongside community experiences. GEDSI-sensitive analysis and reporting were carried out to identify the intended and unintended effects on gender roles, access, and inclusion.

4.3 Participatory Approach and Sense-Making

The evaluation applied a participatory approach to capture the experiences and perspectives of diverse stakeholders, from end users to national policymakers. Involving those directly affected by the Project in dialogue, collaboration, and validation of the results, led to inclusive and credible assessment.

Participatory methods were integrated throughout the evaluation process. In the inception phase, the evaluation team consulted with the Project team and the British Embassy to present and confirm the evaluation scope, approach, and data collection plan. Follow-up discussions clarified the Project's operational realities and key elements, such as institutional arrangements, GEDSI mainstreaming, and sustainability strategies. Together with the Project team, the evaluators co-developed data collection tools to ensure contextual relevance, technical accuracy, and sensitivity to local dynamics.

These tools were then used in participatory data collection activities. For instance, FGDs and interviews engaged a wide range of stakeholders, including community members, BUMDes leaders, women champions, youth, operators, local government officials, and provincial and national stakeholders. These engagements created safe, inclusive spaces by ensuring that participants of all gender and roles had the opportunity to contribute.

The process concluded with a validation workshop involving the Project team and the British Embassy. This session provided an opportunity to validate preliminary findings and contextualise emerging insights on impact, sustainability, GEDSI outcomes, and policy implications. Workshop feedback underlined the need to strengthen the analysis of ministry-level findings and to formulate clearer, stakeholder-specific recommendations.

4.4 Evaluation Methodology and Sampling

This endline evaluation used a mixed-methods, complexity-aware approach to capture the Project's diverse outcomes. The methodology combined theory-based evaluation principles with participatory methods to assess the contribution of decentralised solar energy interventions to inclusive and sustainable impacts at household, community, and policy levels.

Although contribution analysis was not applied formally, the evaluation considered the influence of external and enabling factors on the observed changes. For instance, while the creation of BUMDes in pilot villages was initiated by the Project, it was enabled by existing national-level regulations such as the Village Law (Law No. 6/2014) and related policies supporting village-owned enterprises. In this context, the Project played a catalytic role by facilitating the establishment of inclusive and gender-responsive BUMDes structures, where none had previously existed. Similarly, the absence of prior electricity access in two villages made the Project's contributions more visible and attributable. However, the evaluation acknowledged contextual enablers and constraints.

Data collection combined quantitative and qualitative methods. A household survey was conducted in two pilot villages (Mata Redi and Mata Woga), covering 50 per cent of all households to provide a representative sample. Qualitative data collection took place between June and July 2025 and included a series of FGDs and key informant interviews (KIIs).

FGDs were held with diverse stakeholder groups, including:

- Provincial and District Pokja MENTARI
- Community members and youth
- Village government *(Pemerintah Desa)*
- BUMDes leaders, PLTS operators, women champions, and GALS participants

KIIs were conducted with:

- Village Secretary (*Sekretaris Desa*)
- Directorate General of Development of Disadvantaged Regions (PPDT), Ministry of Villages (*Kemendesa*)
- Directorate General of Electricity (Gatrik), Ministry of Energy and Mineral Resources (ESDM)
- Secretariat of the Directorate General of New Renewable Energy and Energy Conservation (EBTKE), ESDM
- National Energy Council (DEN)
- Ministry of Women Empowerment and Child Protection (KPPPA)
- Directorate General of Economic Development and Investment in Disadvantaged Regions (PEIDT)
- PLN NTT, Planning Division

The evaluation matrix -developed during the inception phase- guided the overall design and ensured alignment between evaluation questions, data sources, and stakeholder groups. While the overarching focus remained on impact and sustainability, tailored question guides were prepared for each stakeholder group according to their respective roles in project implementation, policy support, or energy system management.

Ethical considerations were integrated throughout the evaluation. Informed consent was obtained from all participants, and confidentiality and safety were guaranteed during interviews and FGDs. Most sessions were recorded with permission to maintain accuracy and support reliable analysis.

4.5 Evaluation Process

The endline evaluation of the Project took place between May and July 2025. The process began with preparatory meetings between the evaluation team, the Project team, and the British Embassy to revisit the evaluation scope, approach, and timeline. From mid-May, the Project team delivered a series of presentations and technical discussions, both during the inception phase and in the weeks before fieldwork. These sessions provided operational insights that refined the evaluation focus and ensured contextual relevance.

Fieldwork –initially scheduled for the second and third weeks of June- was rescheduled to 18-30 June to accommodate the availability of key informants and the Project team. Activities included a review of project documents, eight FGDs, and eight KIIs with representatives from national, provincial, district, and village levels. The FGDs engaged 49 participants, while the household survey covered 120 respondents, bringing the total number of participants in FGDs and the household survey to 169 individuals.

The evaluation team convened a validation workshop on 14 July 2025, one week later than planned. The session brought together the Project team, the British Embassy, and other key stakeholders to review and validate preliminary findings, identify strategic insights, and co-develop recommendations for replication and policy engagement. Feedback from the session, particularly on strengthening the analysis of national-level contributions and refining stakeholder-specific recommendations, has been incorporated into the conclusions and recommendations of this report.

Despite minor delays, the evaluation remained on track. The evaluation team worked closely with the Project team and remain flexible to address stakeholder needs, while ensuring the quality and usefulness of the assessment.

4.6 Limitations

While the evaluation provides strong evidence of outcomes, there are several limitations that should be acknowledged. *First,* comparison between baseline and endline findings was constrained by the scope of available data. For example, household income could not be directly compared because no baseline data was collected. Instead, proxy indicators such as modern appliance ownership, productive activities, and perception of income chance were used. These proxies provide useful insights, but they cannot fully substitute for income figures.

Second, several findings, particularly those related to economic change, rely on self-reported information. These responses may be influenced by social sensitivities or reluctance to disclose actual earnings, which can affect the precision of data.

Third, the evaluation did not include a technical assessment of the PLTS infrastructure itself. While the evaluation considered user experiences and institutional arrangements, it did not review the physical system's condition or lifetime performance, which ar also central to long-term sustainability.

Finally, the evaluation did not capture the perspectives of some external actors such as companies that had trained communities in product cultivation (e.g. sereh). Communities reported that they discontinued the activities because there were no buyers willing to purchase their products. The absence of company perspectives limits the analysis of why market linkages did not materialize and what conditions might enable sustained demand.

5. Findings

5.1 Impact

1. What significant changes have occurred in household and community life after gaining access to electricity, including in economic, social, and empowerment aspects?

This question explores the broad, non-income-related changes in households and communities after gaining access to electricity through the PLTS system. It focuses on improvements in daily life, such as lighting, safety, communication, education, and social interaction, and how these have increased comfort, convenience, and household well-being. These findings relate to Intermediate Outcome 3 of the Project's ToC: improved access to reliable, clean energy and associated social benefits for women, men, and businesses in the intervention areas. Although the question includes the term "economic," this refers to household-level efficiencies such as

reduced kerosene use or lower mobile phone charging costs. It does not cover income-generating activities or PUE, which are addressed under Evaluation Question 2.

Summary

Access to PLTS electricity in Mata Redi and Mata Woga has significantly improved household well-being, daily routines, and the delivery of public services. Most households have switched from kerosene to solar lighting, which has increased comfort, safety, and family interaction in the evenings. Children can now study at night, parents feel safer moving around after dark, and mobile phone charging is more convenient, allowing stronger communication with family members outside the village.

Community services have also improved. Village officials now process administrative documents locally, and schools benefit from better lighting and the use of basic digital tools such as computers and speakers, which support both teaching and student engagement. Public facilities, including churches and village halls, now have lighting at night, which allows evening gatherings and create a greater sense of safety and inclusion.

Context

The significant changes observed in household and community life in the two villages cannot be attributed to the electricity infrastructure alone. Rather, they were shaped by the Project's community-based implementation approach, which prioritised inclusion, local ownership, and institutional strengthening. As part of its mandate, the Project supported the design of the PLTS system based on technical and socio-economic feasibility studies, co-developed tariff structures, and led a participatory process to set household quotas, payment schemes, and service rules. The Project also established governance mechanisms involving BUMDes, Pokja Desa, and the village government, and provided training and mentoring to enable them to manage the system.

This Project created the foundation for local actors to assume long-term responsibility. The BUMDes took over daily operations, meter installation, and fee collection, while the village government assumed oversight of equitable service delivery and responses to emerging social needs.

The observed improvements in household well-being, evening routines, access to information, communication, education, and sense of safety resulted from both reliable electricity access and how communities and institutions adapted to and managed the new system. The extent and inclusiveness of these changes, and their long-term viability, depend on how effectively local actors uphold the governance and service delivery arrangements initiated with the Project's support.

Improved quality of life and household well-being

The introduction of the PLTS system led to significant and multi-dimensional improvements in quality of life for the majority of households in the two target villages. Community members reported a stronger sense of well-being and greater convenience in their daily lives. Electricity access allowed families to take part in more evening activities, improved household safety and comfort, strengthened communication, and reduced dependency on polluting energy sources.

These general perceptions are supported by the endline household survey, which found that 79.1% of households now rely on PLTS as their primary lighting source. This has replaced the use of kerosene lamps, which produced smoke and strong odours and posed fire hazards. A further 15% continue to use a combination of PLTS and kerosene, while 5.9% still rely entirely on kerosene, due to habit, lower perceived costs or limited access to suitable appliances or adequate wattage.

Figure 2 illustrates the average scores for ten quality-of-life indicators before and after PLTS installation. The most substantial improvements occurred in the ability to study and work at night, access to information and entertainment, reduced exposure to smoke and pollution, and an increased sense of safety. The average score for "general quality of life" also increased significantly from baseline to endline, which reinforces the qualitative findings from FGDs and previous reports.

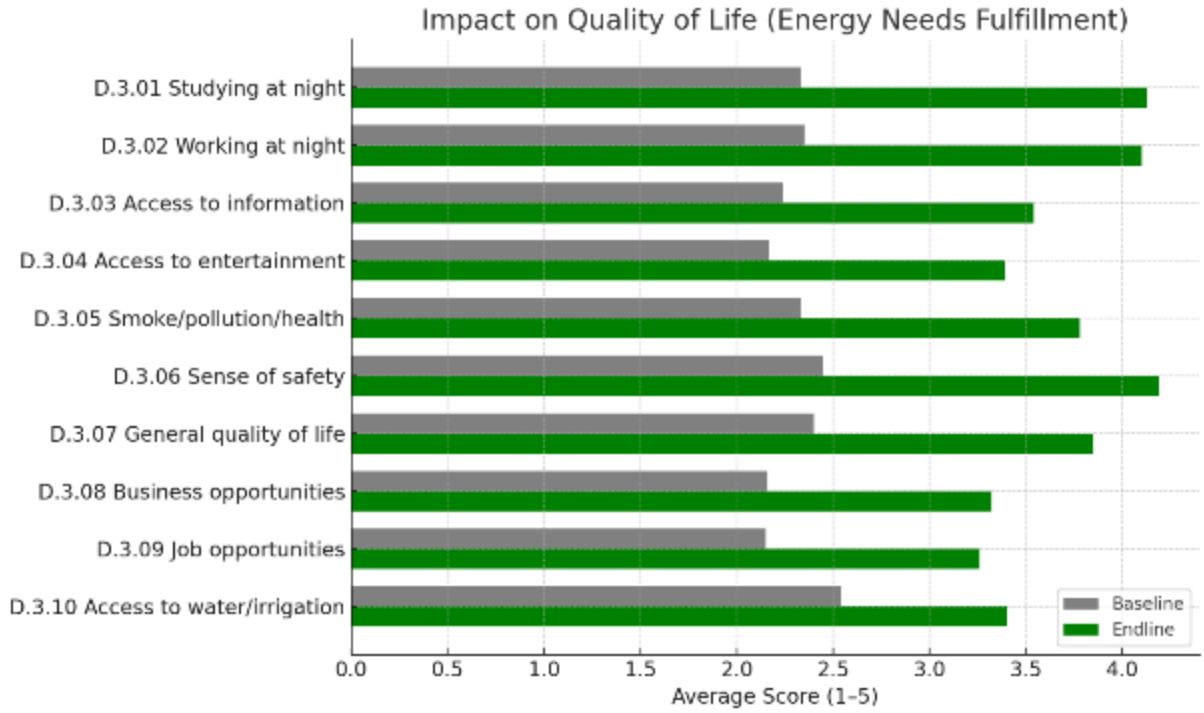

Figure 2-Average scores of quality-of-life indicators before and after PLTS installation (on a scale of 1–5)

Before electricity, evenings in the village were typically quiet and short. After returning from the fields, most families would have dinner and then go to bed early, as there was not much else, they could do in the dark. Now, with lights in their homes, families spend more time together in the evening. They talk, share meals, and parents help their children with their homework. Around 55% of survey respondents said that their children can now study at night, which was not possible before. Parents also reported feeling safer and more at ease moving around the house and the village after dark. In FGDs with community members and youth, many described how electricity had changed the atmosphere at night, transforming it from a quiet, inactive time into an opportunity for connection. As one person put it, *"Before electricity, we used to go to bed early. But now, we can sit and talk before going to sleep"*.

Before the installation of PLTS, many community members, particularly women, said that they felt unsafe walking at night due to the lack of lighting. With the introduction of household and street lighting, most people now feel significantly more secure. The District Pokja also noted that theft and petty crime were more common in the past when the village had no electricity and job opportunities were limited. Since the arrival of the PLTS and an increase in economic activity, such incidents have reportedly decreased, that creates a broader sense of safety.

During FGDs, several participants said that they no longer hesitate to go outside in the evenings, whether to visit neighbours or check on livestock. However, one participant from the village government noted that a few streetlights that had previously been working have stopped functioning in recent months. The cause is unknown, but the issue has been reported to both the BUMDes and the operator, and the community hopes for a quick resolution. This problem appears to be localised and has not significantly affected the broader perception of improved

safety. Household survey data supports this, showing that the average rating for sense of safety at night increased from 2.45 at baseline to 4.19 out of 5 at the end of the study.

Access to electricity allows households to charge mobile phones at home. Currently, 78% of respondents do so, compared to before when they had to travel to neighbouring villages with access to PLN's grid electricity. Both endline survey data and FGD responses highlight this increased convenience since the PLTS installation, although there is no direct evidence that mobile phone ownership itself has increased because of the intervention. Previously, some people had to take a motorbike taxi (*ojek*) to reach a phone charging service and then return later to collect their fully charged devices. This process was both time-consuming and costly. Electricity has removed this burden and has made communication easier and more frequent. In total, 65% of households reported improved communication with family members through phone calls, messaging, and video calls. Some respondents also reported that they now use YouTube for entertainment and informal learning, such as tutorials on cake-making. In one FGD, participants shared that electricity enables parents to video call their children who work outside the village, something they could not easily do before.

Although some respondents acknowledged that the monthly PLTS subscription fee was slightly higher than their previous kerosene expenses, 82% of the endline survey respondents agreed that the benefits far outweighed the costs. They no longer need to buy fuel, batteries, nor pay transport fees just to charge devices. Overall, households emphasized that the transition to PLTS has improved both convenience and quality of life, even if affordability remains a concern for some low-income families. Affordability remains an important consideration for some households, highlighting the for mechanisms such as subsidies of flexible payment schemes to ensure equitable access to electricity over the long term.

Improved public services, education, and community life

Electricity access from the PLTS system has made public service delivery in the village more efficient. Before the installation, village officials had to travel to neighbouring areas with PLN electricity to type and print official documents, which often delayed administrative processes by several days. As was noted during the FGD with the village government, tasks such as civil registration that previously took two to three days can now be completed in about one hour. Being able to perform these tasks locally has significantly improved efficiency and reduced the burden on officials and the community. Nonetheless, some administrative tasks are not fully handled at the village office. The village secretary often works from his house, which is only equipped with a Tier 1 meter (5.65 kWh/day). He reported experiencing power interruptions when using a laptop to print and processes documents. These interruptions were likely due to load surges when the laptop was operated alongside other high-wattage appliances. Such problems could have been avoided if he worked in the village office, which is equipped with a higher-capacity Tier 3 meter (2,200W or 25.55 kWh/day) that was specifically designed to support administrative functions.

In the education sector, PLTS has improved service quality, with the early childhood education centre (PAUD) now equipped with lighting and speakers, and the primary school with lighting, computers, and Wi-Fi. These developments were shared during the FGD with village officials. The Education Office also noted a significant improvement in students' report card scores in Mata Redi since the introduction of electricity. This qualitative observation is supported by household survey data, which revealed a significant improvement in children's ability to study at night, with scores rising from an average score of 2.33 to 4.13 on a 5-point scale. Respondents also strongly agreed that PLTS supports children's evening learning (mean score 4.22). Enhanced learning environments at home may have contributed to this improved academic performance.

Other public facilities, such as churches and the village hall, are now well-lit and host social and religious activities in the evening. These changes reflect broader community-level gains in access, inclusion, and quality of life.

2. To what extent has electricity supported productive activities and the adoption of modern appliances? What are the enabling and limiting factors?

This question explores the extent to which access to electricity through the PLTS system has enabled households, businesses, and community members to adopt modern appliances or engage in productive activities that support livelihoods, income generation, or improved efficiency. the focus is on the economic use of electricity, such as for refrigeration, food processing, sewing machines, or digital tools, and their impact on time savings, increased productivity, and expanded economic opportunities. These findings contribute to Intermediate Outcome 2 of the Project ToC: improved local community capacity in efficient energy utilisation and productive use. The analysis also considers aspects related to Intermediate Outcome 1, where technical capacity and system reliability influence the access to and use of energy for productive purposes. The enabling and limiting factors include affordability, wattage capacity, appliance availability, technical skills, entrepreneurial motivation, and market or institutional support.

Summary

Access to PLTS electricity has enabled productive use and modern appliance adoption, though uptake remains modest. By the end of the project, 18% of surveyed households reported using electricity for income-generating activities, up from just 4% at baseline. These activities included weaving, selling food and beverage, processing cassava, repairing tyres, and charging mobile phone. Productive use was most prevalent among households with higher daily electricity quotas, highlighting the importance of sufficient and reliable energy access for supporting livelihoods. Notable examples include BUMDes-led candlenut shelling and a village-run food dryer, which enhanced local value chains and created community-level benefits.

At the household level, the use of modern appliances such as TVs, fans, and rice cookers has gradually increased, adding convenience and comfort. However, adoption of higher-wattage appliances remains limited due to concerns over the affordability of monthly fees and the nability to subscribe to higher daily energy quotas. While some women and youth have used access to PLTS s to start or expand small businesses, many still face barriers such as lack of capital, limited market access, or insufficient post-training support. In order to improve productive use and ensure more inclusive benefits, local institutions, including BUMDes, village governments, and district agencies, will need to expand access to enabling resources and strengthen follow-up mechanisms that link energy access with livelihoods and economic resilience.

Context

The Project aimed to provide communities with electricity and ensure they could use it in meaningful ways, particularly for economic development. To achieve this, the Project adopted an inclusive, community-based implementation approach that combined access to electricity with measures to improve skills, strengthen governance, and develop small businesses. This holistic approach was a key strength, with stakeholders such as Kemendesa and district officials commending the Project for its productive focus.

In line with this goal, Project facilitated GALS-based livelihood training, introduced technical skills development (e.g., carpentry and food processing), and helped BUMDes align their business strategies with opportunities created by PLTS electricity. The Project also collaborated with local partners to explore productive applications in farming, post-harvest processing, and small-scale retail. Community members made use of these opportunities in different ways and to varying

degrees, depending on factors such as household energy capacity, appliance affordability, skills, and market access.

In response to these diverse needs and capacities, the PLTS system was designed with a smart metering arrangement and tiered power and daily load energy limit. BUMDes operates three energy tiers, with power limit of 450W, 900W, and 2200W. The load was allocated up to 100% limit of each tier between 8am-17pm and then dropped between 24-27% between 7-9 pm before being further reduced to 15% between 9pm-6am. These scheduled limits are designed to manage energy consumption efficiently, especially during times when solar generation is low or battery storage is limited.

Tier 3 (2,200 W) provides 25.55 kWh/day for Rp210,000/month (approximately Rp274/kWh); Tier 2 (900 W) provides 10.98 kWh/day for Rp110,000/month (approximately Rp334/kWh); and Tier 1 (450 W) provides 5.65 kWh/day for Rp50,000/month (approximately Rp295/kWh). Households could choose the package that best suits their electricity needs and ability to pay.

All PLTS fees are significantly lower than PLN's non-subsidised rate (Rp1,444/kWh) and even lower than the subsidised range (Rp415–605/kWh). However, many Tier 1 and Tier 2 households still struggle to make monthly payments, reflecting weak purchasing power despite the relative cost advantage. The tiered structure has important implications for the productive and efficient use of energy. While the tiered structure provides flexibility for load management and affordability, the main challenge for lower-tier households is limited understanding and habits around how to optimise electricity use. This reflects the need for continued socialization and user education to encourage more confident and efficient use of the available energy.

Emerging use of electricity for productive purposes

Across the intervention areas, there is growing evidence that electricity access through the PLTS system has begun to unlock new opportunities for economic activities at household and community-levels. While the scale of productive use remains modest, qualitative feedback from community members, youth, and local officials, together with system monitoring and implementation reports, points to early and encouraging signs of economic diversification, greater efficiency in existing businesses (particularly in processing), improved time efficiency, and increased use of energy for livelihood purposes. This emerging trend is consistent with the Project's ToC, which suggests that, in addition to improved lighting, access to reliable electricity enables households and small enterprises to adopt modern appliances and tools that enhance productivity, generate income, and support local value chains.

These qualitative insights are supported by endline household survey data showing that, by the end of the Project, 21 out of 120 households surveyed (18%) reported using PLTS electricity for income-generating activities, up from just 4% at baseline. Reported uses included weaving at night, running small kiosks, selling cold beverages using refrigerators, processing food, providing tire repair services, and charging mobile phones

Productive users were present in all energy usage groups, but uptake was significantly higher among households with larger daily electricity allocations. Only 14% of Tier 1 households (450 W, 5.65 kWh/day) reported using electricity for income generation, compared to 55% of those with higher-tier allocations. While this reflects the enabling role of increased daily energy access, it also highlights affordability as a key constraint. Many households remain in Tier 1 because they cannot afford to upgrade or are concerned about higher monthly payments. As a result, they cannot operate the appliances required for productive use, which prevents them from obtaining the full benefits of the PLTS system.

Findings from FGDs with community members and youth reinforced these trends. For example, two participants who had completed a furniture-making training were interested in starting businesses but were unable to do so as their household load capacity could not support the required tools for the desired use of duration, and they could not afford to upgrade to a higher

tier. Although they knew that the BUMDes owned electric carpentry tools available for rent, they chose not to use them. The specific reasons were not stated, but this may have been due to other barriers such as the cost of raw materials (e.g., purchasing wood) or limited working capital to start production.

These examples show that while the training can build skills and motivation, the absence of enabling support, such as access to affordable materials, working capital, or targeted financial assistance, can prevent individuals from utilising their training to generate income. The challenge lies not in the training itself, but in the broader economic and systemic constraints that limit its application after training has finished.

To address these challenges, the village government, BUMDes, and relevant district agencies such as the Office of Cooperatives, Small and Medium Enterprises (Dinas Koperasi dan UKM) could offer options such as soft loans, subsidies for raw materials and production tools, or links to revolving funds. Incorporating post-training support into the training package would help ensure that energy access and skills development lead to tangible improvements in livelihoods.

The village government also emphasised that electricity access had resulted in higher incomes and stronger entrepreneurship. In FGDs, officials noted that with active support from the BUMDes, community-based economic activities had grown in line with local potential, such as poultry, rice, corn, ginger, lemongrass, and vegetable farming. Stronger livelihoods have made it easier for communities to afford monthly electricity payments. At the time of the evaluation, the village authorities reported that at least ten new or expanded horticultural and agricultural businesses had emerged, particularly in the areas of planting (e.g. lemongrass, ginger, root vegetables) and processing (e.g. candlenut, *porang*).

A notable example of productive use, made possible through direct local government support, is the operation of an electric spinet dryer in Mata Redi Village. The facility, powered by electricity, is as a central processing hub for banana and cassava chips, sourcing raw materials from three surrounding villages. The finished products are sold in markets as far as West and East Sumba. This demonstrates how local government investment in post-harvest technology, combined with access to reliable electricity, can strengthen rural value chains and generate economic benefits that extend beyond a single village.

Importantly, the Kemendesa recognised the integration of economic activities within the PLTS model as one of Project's key strengths. Kemendesa emphasised that the Project went beyond merely installing infrastructure by offering sustained, field-based accompaniment that helped connect energy access with livelihood development. This holistic support was seen as critical in strengthening village self-reliance and income diversification.

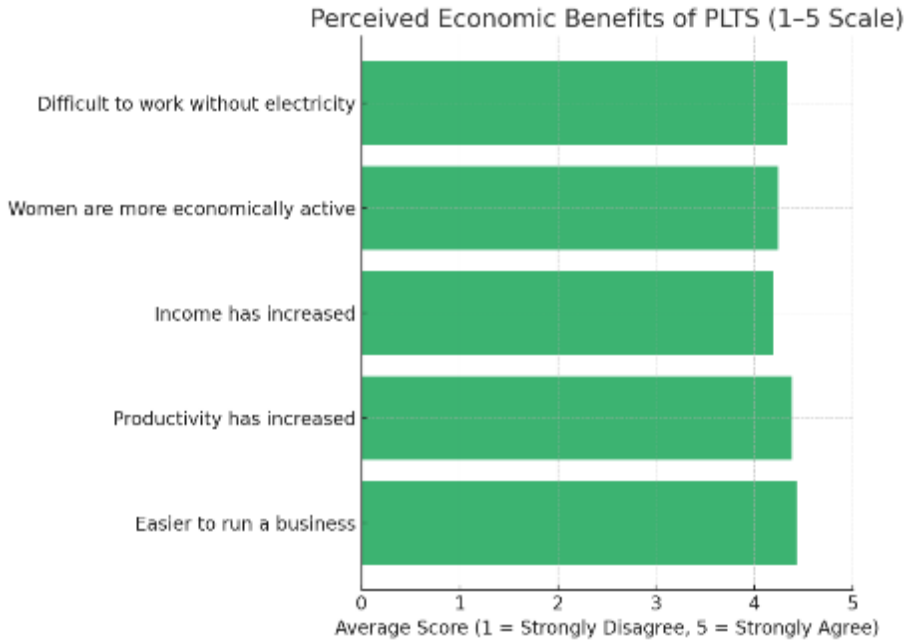

Figure 3. Perceived economic benefits of PLTS among productive users

As shown in the above figure, respondents who used electricity for productive purposes rated several benefits highly. These included greater ease in running a business, improved productivity and income, and increased economic activity among women in the household. These high average scores suggest that, even though productive use is limited in scale, households recognise that PLTS electricity is a valuable enabler of livelihood development.

Perceptions of income change among productive users further reinforce these initial economic gains. As shown in the figure below, 33% of productive users reported a significant increase in income since connecting to PLTS, while another 38% experienced a slight increase. In contrast, only 26% of non-productive users reported even a slight increase, with most indicating no change. These findings suggest that households using PLTS electricity for productive purposes were more likely to experience tangible improvements in their financial well-being.

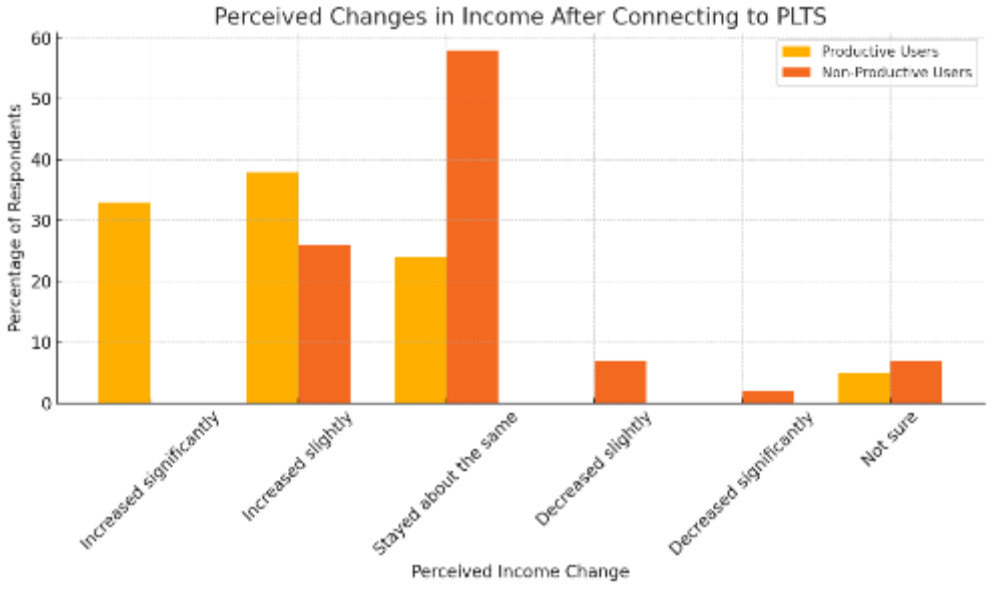

Figure 4. Perceived changes in household income after connecting to PLTS, comparing productive and non-productive users

Daily energy or load quota was not the only factor influencing whether households used electricity for economic activities. In FGDs, some participants explained that they could not afford to upgrade their energy tier service due to combined cost of the initial fee to increase capacity and the higher monthly payments. Others lacked the capital required to purchase the necessary tools and raw materials, and they were further discouraged by limited market access, low or unstable selling prices, and lack of post-training support from local institutions such as BUMDes and the Dinas UMKM. In some cases, such as with citronella or ginger farming promoted by the Project, activities stalled because there was no reliable market or the BUMDes buyback price was too low to sustain production.

Despite these constraints, a few initiatives showed strong livelihood potential. For example, the BUMDes Hali Dewa began operating an electric candlenut shelling machine, which reduced production time from one month to just one day. This was possible because the BUMDES workshop is equipped with a three-phase meter that can absorb excess power without load limitations. Other new ventures also emerged from GALS training alumni, such as the production of candlenut oil and herbal snacks and tyre repair businesses using compressors.

Early signs of modern appliance adoption

In addition to income generation, access to PLTS has enabled the gradual adoption of modern household appliances. While almost all survey respondents reported using electricity for lighting and charging mobile phones, many have started using low-wattage appliances such as speakers, televisions, and fans. Some households now own refrigerators and rice cookers, signalling an expansion of electricity use within the home. Some FGD participants noted that rice cookers allow them to prepare food more quickly and easily, while others shared that they often store perishable items, such as meat, at neighbours' homes with refrigerators. These practices reduce daily burdens and improve convenience, particularly for food preparation and storage, and they contribute to a greater sense of comfort in everyday household routines.

As shown in the figure below, lighting and charging remain the most common uses, with the adoption of modern appliances beginning to diversify. However, the uptake of more energy-intensive appliances, such as sewing machines or ovens, remains limited. According to the household survey, 96.7% of households still rely on firewood for cooking. Respondents attributed this to a combination of affordability barriers (e.g., inability to purchase electric cooking devices) and constraints related to their daily energy quota, which may be insufficient to power high-wattage appliances.

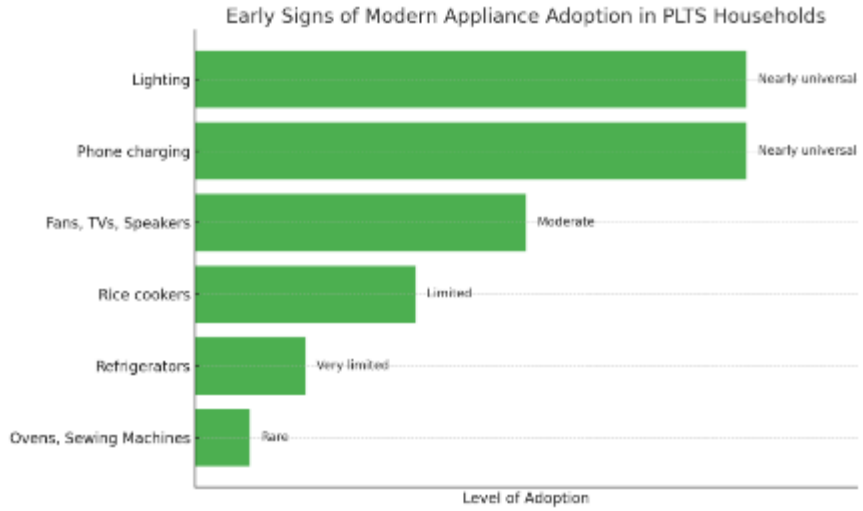

Figure 5. Early signs of modern appliance adoption in PLTS households

In the FGDs with the community, several participants shared mixed experiences when using rice cookers during the day, when the PLTS system operates at its highest generation-capacity. One participant reported no issues when using a 2-litre rice cooker, others said that their rice cookers did not function properly. However, it was unclear whether these appliances had the same wattage. Some participants were reluctant to use higher-wattage devices in case they damaged either the PLTS system or the appliances themselves. In several cases, the problem stemmed from using multiple devices simultaneously, which triggered power surges that quickly exceeded the household's power limit and caused the meter to trip. These experiences underscore the need to improve understanding of dynamic load limits and strengthen household-level power management.

These findings demonstrate progress towards Intermediate Outcome 2 and Intermediate Outcome 3. The growing use of electricity for productive activities indicates that certain community members are developing the ability to utilise energy efficiently for livelihood purposes. However, this progress is currently limited to users with higher-capacity connections and sufficient financial means. Meanwhile, although still limited, the adoption of modern appliances, reflects early improvements in comfort, convenience, and household well-being. Overall, the PLTS system has contributed to more reliable energy access and delivered a mix of social and economic benefits for women, men, and local enterprises.

3. How have the roles and participation of women and vulnerable groups changed since the introduction of electricity?

This question examines the impact of access to electricity through the PLTS on gender roles, access, participation, and empowerment among women and other vulnerable groups. It explores whether access to electricity has created new opportunities or contributed to behavioural changes, such as increased time for productive or educational activities, greater involvement in community affairs, or changes in household dynamics. The analysis focuses on fulfilling practical gender needs, how women, men and marginalised groups use their time, access services or resources, and engage in social or economic life, rather than assessing formal gender indicators or outcomes. It also considers community perceptions of the inclusion, visibility, and leadership of these groups in the context of energy access and local development.

Summary

Access to electricity through the PLTS system, combined with the Project's empowerment initiatives, particularly GALS, has expanded women's participation in the village economy. The proportion of women-led or jointly managed businesses has increased, supported by electricity-powered appliances that extend productive hours, reduce domestic workloads, and enable new income-generating activities such as cooking, selling herbal products, and operating kiosks. Women reported greater autonomy in managing their time and contributing to household income. Survey data confirmed these trends, with most respondents agreeing that women had gained greater opportunities for economic participation gained greater opportunities for economic participation. These changes reflect a broader move towards shared responsibilities and economic inclusion. However, some participants noted that increased productivity could exacerbate women's existing burdens in the absence of support for redistributing domestic roles.

Women also reported stronger decision-making roles within the household and greater visibility in public forums. Their representation in BUMDes leadership has expanded significantly and village meetings and planning processes now see broader participation, with more women actively contributing. Household survey results indicate that most women now make joint decisions with their spouses on electricity use, reflecting more equitable household dynamics. However, persistent social norms, especially in Mata Redi, continue to restrict the participation of women, youth, and other vulnerable groups. Many women and girls still feel unqualified or are expected to remain in the background, and young women in particular face pressure to stay within the household. While progress is evident, deeper changes in social expectations are necessary to ensure that the benefits of energy access and empowerment reach all groups equally.

Context

Before the Project began, women and other vulnerable groups in Mata Redi and Mata Woga had limited influence in both household and community decision-making. Social norms largely confined women to domestic responsibilities, with little opportunity to contribute to economic activities, participate in the village meetings, or influence development planning. Public forums, such as *musrenbang* (village development planning), were dominated by male leaders. If women were present at all, their involvement was usually limited to support tasks such as cooking.

The Project intentionally integrated GEDSI into its community-based implementation model by providing electricity access through the PLTS system and combining it with targeted empowerment activities such as GALS training. These interventions aimed to transform unequal household power dynamics, strengthen individual agency, and build the leadership and decision-making capacity of women and youth in economic and social spaces. Local ownership mechanisms, such as active engagement of women in BUMDes management and facilitation of mixed-gender focus groups, helped challenge entrenched gender norms and increase recognition of women's leadership and public roles. Although structural barriers remain, particularly those linked to long-standing social and gender norms, the intersection of energy access and social empowerment is widely acknowledged as a potential catalyst for women's agency and promoted more equitable participation and role-sharing among women, youth, and, and other marginalised groups.

Increased participation of women as drivers of the village economy

Access to electricity through the PLTS system in Mata Redi has broadened community participation in the local economy. Both men and women can now pursue new or expanded livelihood activities. Women in particular have become active contributors through home-based food production, such as selling ice, which did not exist before, and kiosks operations, which existed previously but have since expanded significantly with access to electricity. Energy access

has also allowed women to organise their working hours more flexibly, use appliances, and explore new types of business. These opportunities have led many women to take on leadership roles or co-manage income-generating activities within their households. The household survey, covering 50% of households affirm these improvements, with women now managing 48% of businesses and jointly managing a further 38%, compared to much lower proportions at baseline. a significant increase in the proportion of women-led businesses compared with baseline figures. Taken together, these changes indicate gradual progress towards more inclusive economic participation, with electricity acting as a lever for equal access to economic opportunities and more balanced household decision-making.

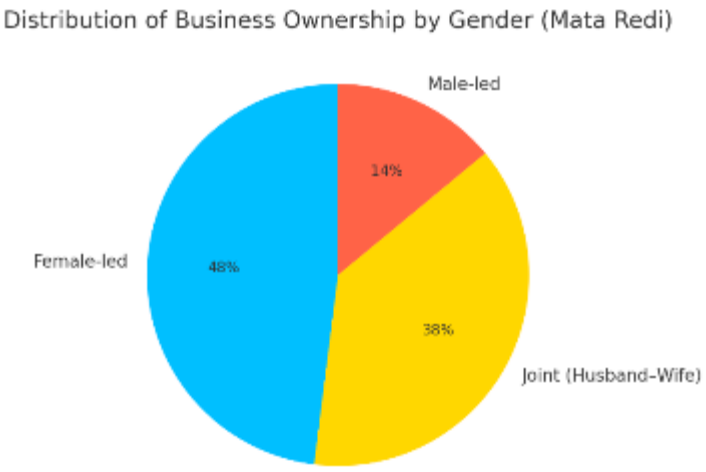

Figure 6 – Distribution of Business Ownership by Gender

These trends reflect a broader move towards shared responsibilities and inclusive economic participation. Survey respondents rated the statement "*Women in the household are more economically active*" at 4.24 out of 5, which shows a strong perception that PLTS access has strengthened women's role in the economy. FGDs with women GALS participants confirmed this view, with many stating that access to electricity gave them the means to start ventures such as selling ice, cakes, or herbal products. One participant said, *"Before, I closed my shop at 5 or 6 PM. Now with PLTS, I can stay open longer. I earn more and have time to prepare goods for the next day."* While these changes demonstrate greater economic agency, they also call for caution as increased productivity does not necessarily lead to a reduced workload for women.

Women's increasing voice in household and public decision-making

Access to electricity through the community-based PLTS system, combined with the Project's empowerment approach, particularly GALS training has brought significant changes in gender roles and participation in both household and public decision-making. Women reported having greater influence over household decisions and being more involved in village-level forums and institutions, thanks to increased self-confidence and shifting perceptions of their roles.

Qualitative findings from FGDs suggest that tools such as GALS have encouraged more balanced household roles and introduced dialogue on shared responsibilities. Some women described how their involvement in the Project activities supported them to participate more actively in household decision-making and to advocate for their daughters' education. In one FGD, a participant reflected: *"Before MENTARI* (the Project)*, my main role as a woman was to stay home and care for the children. I was rarely involved in any household decisions. Even in community gatherings, women were expected to cook and take care of the kids."* Meanwhile, some men in another FGD expressed appreciation for more collaborative relationships, in which responsibilities and planning were shared with their spouses.

These accounts point to evolving household dynamics, with signs of growing partnership in decision-making. According to the Household Survey, 70–80% of female respondents reported making electricity-related decisions jointly with their spouse, such as purchasing appliance or prioritising household energy use, while 16–20% made such decisions independently. These changes represent a gradual move towards more equitable family roles, influenced in part by improved access to electricity and accompanying empowerment activities.

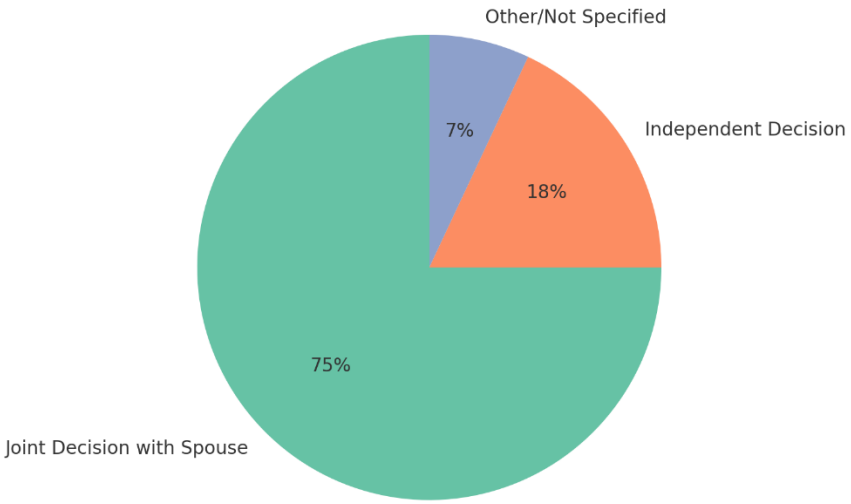

Figure 7 – Women's Role in Household Electricity-Related Decisions

Incremental changes are also evident in public spaces, where women increasingly take on leadership roles and speak up in village forums. In Mata Redi Village, five of the nine BUMDes committee members are now women. As one GALS participant shared, *"Before, women weren't involved in any forums, not even village meetings. They only invited certain people. But thanks to MENTARI's facilitation, and because the village government often joined the training, they started to realise that women had to be involved, both culturally and administratively. Now, even at Musrenbang, although only 20% of attendees are women, at least we're there."*

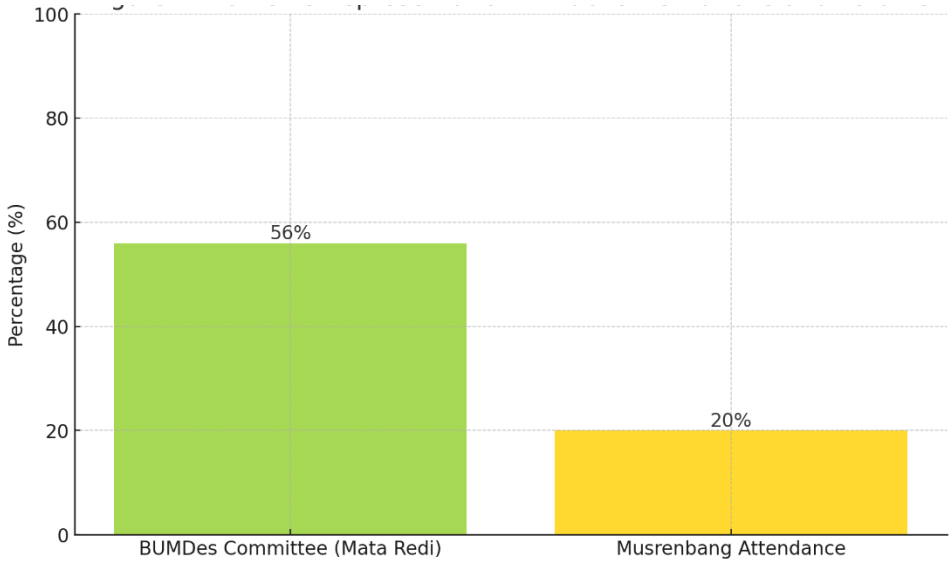

Figure 8. Women's Representation in Public Institutions and Forums

Sustaining women's leadership through champion networks

Building on the individual and household-level changes described earlier, the Project also worked to embed women's leadership within community structures by supporting gender champion networks and advocacy platforms in Mata Redi and Mata Woga. This was part of the Project's broader commitment to inclusive, community-led development.

Through GALS approach and regular facilitation, the Project created spaces for training, peer learning, and collaborative action planning. In June 2024, 26 gender champions joined a participatory monitoring session to review progress on their earlier advocacy plans and co-develop new strategies tailored to the needs of their hamlets. They prioritised issues such as preventing gender-based violence, improving girls' access to education, and creating fair employment opportunities. Several of these priorities were already incorporated into the 2024–2025 Village Development Plan (RKPDes).

Women champions also gained visibility in public forums. At the CSO Dissemination Event in March 2025, several of them presented the progress of BUMDes Hali Dewa and shared their experiences of leading community engagement efforts.

Despite the positive impact of the women champions, challenges remain. The annual report and GALS FGD show that some champions became less active due to household responsibilities and a lack of structured follow-up. GALS, as participants shared, helped women gain confidence and speak in public forums for the first time. To ensure continued participation, women need encouragement and peer support. While the evaluation highlighted the absence of structured follow-up as a challenge, the Project strategy intentionally emphasized informal mechanisms, such as arisan, to build solidarity and sustain motivation.

Youth Empowerment through energy access and skills training

The Project intentionally placed gender inclusion at the centre of its community-based energy model. Women were engaged as leaders, learners, and agents of change, rather than beneficiaries, through targeted activities, such as GALS, technical training, and inclusive governance mechanisms, the Project helped women, particularly young women, redefine how they saw themselves and their roles in the communities.

With the Project-facilitated training and leadership opportunities, young women emerged as entrepreneurs, facilitators, and decision-makers. Their participation in village meetings, BUMDes structures, and technical roles challenged long-standing norms that had confined them to domestic spaces. This change was neither easy nor immediate. Women faced resistance, renegotiated household roles, and learned to assert themselves in, rooted longstanding traditions and customary practices, male-dominated spaces. Yet their growing visibility and leadership, reinforced peer learning, coaching, and the solidarity of women's groups, signalled a broader cultural change. The Project's approach showed that when women take part in energy management, not only as users, they help reshape the village's entire social system.

Mama Yanti Sada Mura
Director of BUMDes Hali Dewa

Before the Project, I never imagined that I would become the Director of BUMDes Hali Dewa. Like most women in Mata Redi, I was simply a housewife. I once ran for Village Head in 2017 and later for a legislative seat in 2019, but I still believed my main duty was to care for my family and raise my children. In village meetings, even when women were present, we were only responsible for cooking and serving food, never for giving opinions or leading. It was the same at home, where I rarely took part in decision-making. My husband, despite having no formal education, was the final decision maker.

My participation in MENTARI (the Project) activities brought changes I had never imagined. At the GALS training, we learned about gender roles, business planning, and visualising our dreams. I drew a tree of dreams in which I pictured my children succeeding at school, and I quietly wished that one day I would lead. That training opened my eyes and led to many opportunities. I joined more training courses, travelled to Bandung for an internet course for communities, then to Kupang and Jakarta for workshops. With each step, my confidence grew.

What I learned changed my relationships. At home, I started sharing responsibilities with my husband. He was reluctant at first and dismissed the idea. He would say things like, "*Oh, you think you know everything.*" But I didn't give up. I gave him time, communicated patiently, and slowly he began to listen. We started sharing household tasks, and gradually, he began to value my opinions more.

As my confidence grew, the people in the village began to see me differently. I was chosen to lead the women farmers' group, and then something happened that I had never dreamed of. I was elected Director of BUMDes Hali Dewa. This showed me that people believed in my capabilities, and that my voice mattered at home and in the community.

Being a leader is not easy. I sometimes doubt whether I can do it. However, I told myself that as long as I lead with honesty, communicate well, and uphold transparency and accountability, I can succeed. Today, I manage a BUMDes that runs a solar energy system, supports new business ventures, and serves the broader community. I feel proud -not just for myself, but also because of what this role represents for other women. We now know that our place is not limited to the kitchen or the well. We can lead; we can decide for ourselves and shape the future of our village. Our voices matter in every space we enter.

I see a bright future ahead. I want to expand the businesses that currently produce lemongrass oil, candlenut oil, and herbal teas, and generate real income for Mata Redi by using electricity from our PLTS system. I also want to keep learning and help other women find the confidence to step forward. MENTARI has changed my life and the lives of other women, and in turn, the life of the village.

Challenges in participation for women and vulnerable groups

Before the Project, women's participation in household and community decision-making in Mata Redi and Mata Woga was limited. FGD participants shared that although women sometimes attended public events, their roles were limited to supporting roles such as food preparation, with no opportunity to influence planning or decision-making. Other vulnerable groups, including the elderly and a female-headed household, also faced barriers, as limited mobility often prevented the elderly from attending village meetings and having their voices heard.

The energy access and associated empowerment initiatives have begun to change these social dynamics. However, FGDs show that deeply rooted social and cultural norms still restrict women's participation in village forums and decision-making spaces. Men continue to dominate customary local leadership and public service roles, making it difficult for women to voice their opinions or influence decisions, even on issues that affect them directly. Many women said they lacked confidence or felt uncomfortable speaking in public meetings, often deferring to male relatives or remaining silent. In Mata Redi, it is still common for women to be expected to stay behind during community discussions. A GALS participant reflected that women were rarely invited to community discussions and were usually tasked with cooking during gatherings.

Similar patterns were observed among youth. Many young women in the FGD said that they had never joined village activities, instead spending most of their time at home helping their parents with household chores. Although the PLTS system has created more opportunities in the village, several young women said they were unsure about their future and did not know how to take advantage of electricity access. They cited social expectations that discouraged them from spending time outside the household or engaging in public life. One participant said that in her community, women were still expected to stay quiet and not get involved in decision-making, either at home or in village meetings. She noted that although many young people seek work or education outside the village, social expectations often pressure young women to stay at home, help with household chores, and avoid spending time outside the home.

4. To what extent has the Project influenced policy, planning, or institutional practices related to renewable energy at the village, district, and national levels?

This question explores the extent to which the Project has strengthened renewable energy governance at various levels of policymaking. It examines the impact of the Project's integrated approach, which combines infrastructure support, capacity-building, technical assistance, and GEDSI, on policy development, planning processes, and institutional practices. The impact evaluated includes the integration of PLTS systems into local and regional planning instruments, adoption of the Project-produced guidelines and training curricula, and institutional commitments to sustaining off-grid energy models. The findings relate directly to Intermediate Outcome 5 of the Project's ToC: improved inclusive regional energy governance at community and policymaking levels. They also link to Intermediate Outcome 6, where national institutions begin to adopt lessons learned from the Project to improve frameworks that support the long-term sustainability of renewable energy systems.

Summary

The Project has significantly influenced renewable energy governance at village, district, provincial, and national levels by piloting inclusive planning models and strengthening institutional coordination. At the village level, the project formalised BUMDes-led PLTS governance, integrated energy access into RPJMDes and APBDes, and positioned Mata Redi as a provincial vocational training hub through a partnership with Don Bosco BLK.

At the district level, Pokja in Central Sumba improved coordination among relevant district offices, and helped mediate institutional tensions between BUMDes and village governments. At the provincial level, The Project contributed to the revision of the NTT RUED using participatory and GEDSI-responsive approaches. As a result, NTT is the first province in Indonesia explicitly integrating GEDSI into its energy plan. At the national level, ministries such as EBTKE and Bappenas have used the Project's lessons to inform DAK Energi schemes, while Kemendesa has shown interest in adapting the Project's approaches for village-level training.

Sustaining and expanding these innovations will require stronger coordination across government levels, clearer mandates for local institutions, and targeted national support to embed inclusive energy planning in policy, planning, and funding systems. National and provincial governments must institutionalise these approaches, while district actors and village institutions continue to lead implementation and maintain community engagement.

Context

Renewable energy governance in Indonesia, particularly in remote areas like Sumba, was relatively weak before the Project, marked by fragmented planning, limited institutional coordination, and poor integration of GEDSI principles. The National Energy Policy (KEN) and National Energy Plan (RUEN) already provide a governance framework for renewable energy. However, the mechanisms to operationalise this framework into inclusive, grounded, and sustainable off-grid energy models are underdeveloped. At the provincial level, most Regional Energy Plans (RUED) lacked operational detail, and GEDSI considerations were rarely incorporated into energy planning or policy. The situation was worsened by the limited role of district stakeholders. While formal authority for renewable energy oversight rests with the provincial government, this mandate was not effectively extended to district or village levels. Consequently, energy access and needs were absent from local development plans (RPJMD) and budgetary at the village level, energy governance was rarely discussed in Musrenbang (village development planning) discussions, and BUMDes had little or no experience in managing energy infrastructure or planning for its sustainability.

The Project addressed these institutional gaps through a multi-tiered approach that combined technical assistance, participatory planning, and capacity building. At the national level, the Project supported the Directorate of New and Renewable Energy (EBTKE) in adopting technical documents, including implementation guidelines, instructions, and TORs, as formal references for APBN-funded energy programmes. The Project also advised the Ministry of National Development Planning (Bappenas) on designing the DAK Energi scheme by integrating community mentoring and infrastructure rollout. At the provincial level, the Project supported the NTT Provincial Government to revise its RUED and embed a participatory, gender-responsive approach in the plan. At the district level, the Project activated inter-agency Working Groups (Kelompok Kerja/Pokja) to support the integration of energy into planning processes, facilitate stakeholder engagement, and coordinate village-level implementation support. At the village level, the project piloted a community-based energy governance model managed by BUMDes, developed SOPs for PLTS operation and maintenance, trained local operators, and facilitated the integration of energy access into RPJMDes and APBDes. This institutional layering across governance levels has gradually improved renewable energy planning, management, delivery, and monitoring to meet broader development and social inclusion goals.

Influence on policy and planning at national and provincial levels

The Project influenced renewable energy policy and planning through a multi-tiered strategy combining technical standardisation, GEDSI integration, and institutional collaboration.

At the national level, the Directorate of New and Renewable Energy (EBTKE) within the Ministry of Energy and Mineral Resources (ESDM), adopted key Project-produced documents, Implementation Guidelines (Juklak), Technical Instructions (Juknis), and ToR, as official references for APBN-funded programmes. These documents inform technical training, institutional mentoring, and infrastructure deployment. EBTKE also acknowledged the Project's role in selecting durable technologies suited to rural conditions and in demonstrating the potential of energy access to drive local economic empowerment.

Bappenas confirmed the Project's critical role in linking technical assistance with infrastructure rollout, particularly in 3T (Tertinggal, Terdepan, dan Terluar) regions where PLN grid expansion is not viable. These lessons informed the design of DAK Energi schemes in 2023–2024, which combine renewable energy investments with institutional capacity building and community mentoring. Bappenas and EBTKE also noted that the Project's integrated model of linking technical design, institutional governance, and community participation- is already informing the implementation of DAK Energi programmes.

At the provincial level, the Project guided the revision of East Nusa Tenggara's RUED through a participatory, gender-responsive approach. The draft RUED 2025–2034 is the first in Indonesia to systematically integrate GEDSI principles, a milestone recognised by the National Energy Council (DEN). This was achieved through targeted training, energy modelling, facilitating ToC workshops, toolkit and developing GEDSI-responsive indicators.

In Sumba, interventions combine solar PV infrastructure with local training and organisational development. A mini-grid management module for government personnel, based on the Project's experience, is being developed to support application in underserved areas. Kemendesa is committed to embedding the Project's practices into national training modules for village officials and is digitising these materials for use on its online learning platforms and its Training Centres (BLK). The Project's documentation and field-based mentoring approach are considered essential for replication. Meanwhile, EBTKE is working with the Directorate of Vocational Education to integrate the Project's lessons into SMK curricula. This initiative aims to position vocational schools as laboratories where students can apply energy transition concepts and develop skills for green jobs.

In NTT, RUED is already guiding provincial energy planning, even though it has not yet been formalised through a regional regulation. The delay in enactment is due to the absence of national RUEN, which is a prerequisite for legal adoption. In addition to national policy alignment challenge, there are still persistent systemic gaps, such as incomplete energy data, limited modelling capacity, and institutionalisation of GEDSI that depends on individual champions rather than embedded systems. To address these issues, DEN is calling for stronger intergovernmental coordination and proposing incentives, such as the Anugerah DEN award, to promote and reward inclusive energy planning at the provincial level.

Strengthening institutional support at the district level

District governments play a critical role in sustaining decentralised renewable energy system, even though formal authority for energy planning and budgeting lies with the provincial and national levels. Their responsibilities include integrating energy access into local development plans (RPJMD and Renstra), facilitating coordination among village actors and service providers, and strengthening local institutions such as BUMDes. While they may lack direct budget lines for energy infrastructure, they contribute through planning, advocacy, and institutional oversight. By doing so, they help connect village-level initiatives to higher-level policy and funding opportunities. For example, Pokja Energi facilitated discussions between the village government,

BUMDes, and national programmess such as DAK Energi, in order to identify eligible villages and advocate for funding support.

In Central Sumba, the Project worked closely with district-level Pokja, a multi-stakeholder working group comprising district level sectoral offices led by Bappeda, to sustain the Project's impact beyond its completion. Without a formal energy budget, Pokja focused on coordination by facilitating the official handover of PLTS assets to the village government, mediating tensions between BUMDes and village government, maintaining dialogue with stakeholders, and advocating village funds for PLTS operations and maintenance.

During the FGD, Pokja members acknowledged budget constraints, yet emphasised their ability to contribute through coordination and facilitation. Kemendesa also recognised the strategic role of district stakeholders, stating that *"The Project lessons are beginning to gain attention and will be discussed in upcoming workshops with district line agencies."*

The Ministry also committed to inviting the Project to a national-level dialogue prior to the project handover to explore concrete solutions for sustainability, including tariff setting, village fund utilisation, and long-term O&M schemes. A senior Kemendesa official remarked, *"Cross-agency training and documentation of good practices must be enhanced. Projects like MENTARI should not be viewed as isolated local solutions but as structured national references that can guide other districts and villages."*

Influence on policy and planning at village level

At the village level, the Project piloted a community-based energy management model anchored in BUMDes. The model has significantly influenced institutional practices in renewable energy governance.

In Mata Redi, this model formalised local ownership and accountability for PLTS through Standard Operating Procedures (SOPs) that set out technical operations, tariff collection, and maintenance, diagnosis and troubleshooting protocols. It also introduced Occupational Health and Safety (K2/K3) training and provided structured mentoring for local operators. These measures strengthened operational reliability and increased community trust.

Beyond operational governance, the Project facilitated participatory village planning processes, including Musdes (village deliberation meetings), to integrate PLTS management and productive-use initiatives into RPJMDes and APBDes. These processes helped establish formal links between energy services and local development priorities and created a foundation for gender-responsive budgeting and inclusive planning. Village officials reported that the model has influenced the allocation of development resources, including support for women's economic activities and training for young operators.

This approach led to the designation of Mata Redi's PLTS as a Centre of Excellence for renewable energy vocational training. This status was formalised through a Memorandum of Understanding (Mou) between BUMDes Hali Dewa and the Don Bosco Vocational Training Centre (BLK). The MoU allows Mata Redi to function as a practical training hub for students and instructors from across the province, connecting grassroots innovations with provincial capacity-building systems. This recognition establishes the village as a site for institutional learning for local actors, provincial training institutions and national ministries.

5.2 Sustainability

5. To what extent are the PLTS (solar PV) systems being operated reliably and safely? What technical and operational challenges have emerged?

This question explores the extent to which the Project has strengthened renewable energy governance at different levels of policymaking. It examines the influence of the Project's integrated approach, which combines infrastructure support, capacity building, technical assistance, and GEDSI principles on policy development, planning processes, and institutional practices. The evaluation focuses on the integration of PLTS systems into local and regional planning instruments, the adoption of the Project-produced guidelines and training curricula, and institutional commitments to sustain off-grid energy models.

The findings relate directly to Intermediate Outcome 5 of the Project's ToC: improved inclusive regional energy governance at community and policymaking levels. They also contribute to Intermediate Outcome 6, in which national institutions embed lessons from the Project and improve frameworks to support the long-term sustainability of renewable energy systems.

The analysis also considers the reliability and sustainability of the PLTS systems implemented under the Project, with a focus on non-technical aspects of operations and maintenance. It examines whether local actors, such as BUMDes and trained operators, manage the systems effectively using established procedures, safety protocols, and routine oversight. These findings reflect progress toward Intermediate Outcome 1 of the Project's ToC: improved technical and management capacity of BUMDes and PV operators to operate and extend the lifespan of small-scale off-grid energy systems. The assessment further explores emerging technical and operational challenges, such as equipment failures, staffing gaps, documentation issues, and whether local institutions have the mechanisms and motivation to address these without external support.

Summary

Community members, particularly youth, demonstrated strong ownership of the PLTS system, a result of targeted training and engagement supported by the Project. They actively reported issues and discouraged electricity misuse, which contributed to a culture of shared responsibility. Local operators gained a high level of trust, with household survey respondents rating service quality at an average of 3.7 out of 5. Operators followed SOPs for routine operations and were typically the first point of contact during disruptions.

The data from the monitoring system shows downtimes remained well below the national utility average, although some challenges persist. Residents cited occasional outages caused by incidents such as fallen tree branches and delays in response times. There was also confusion about operator responsibilities, particularly in relation to payment collection, which affected perceptions of transparency. To enhance long-term sustainability, stakeholders need to establish clearer communication, define roles, and ensure more responsive troubleshooting mechanisms.

Community commitment to system reliability

FGD findings revealed a strong sense of community ownership and vigilance in maintaining the PLTS system, particularly among youth. Participants consistently stated their readiness to report operational issues, such as fallen trees, illegal connections, or damaged cables, directly to local operators. Although not all residents had the tools (e.g., saws) or skills to resolve these issues themselves, many took personal responsibility for protecting and preserving the system's functionality through vegetation control.

Youth participants emphasised that electricity theft and unauthorised connections harmed the entire community and violated principles of fairness and shared responsibility. In some cases, they confronted those responsible for such actions and underscored the gravity of the issue.

Role and performance of local operators

Local PLTS operators play a crucial role in ensuring system reliability and addressing daily technical issues. They have received standardized SKKNI O&M Level 3 and work under established SOPs for system operation, maintenance and troubleshooting. Community members stated that they rely on operators for technical support and trust them as the primary point of contact when problems occur. This trust reflects both the operators' accessibility and the confidence residents place in their competence and commitment.

According to the Household Survey, overall trust and satisfaction in the operators ranged from moderate to high. Respondents rated the operators' technical capabilities relatively well (average score 3.71/5), with most aspects of the service scoring in the "medium" range (3.46–3.66). These include understanding residents' needs, communicating service hours clearly, and responding to complaints.

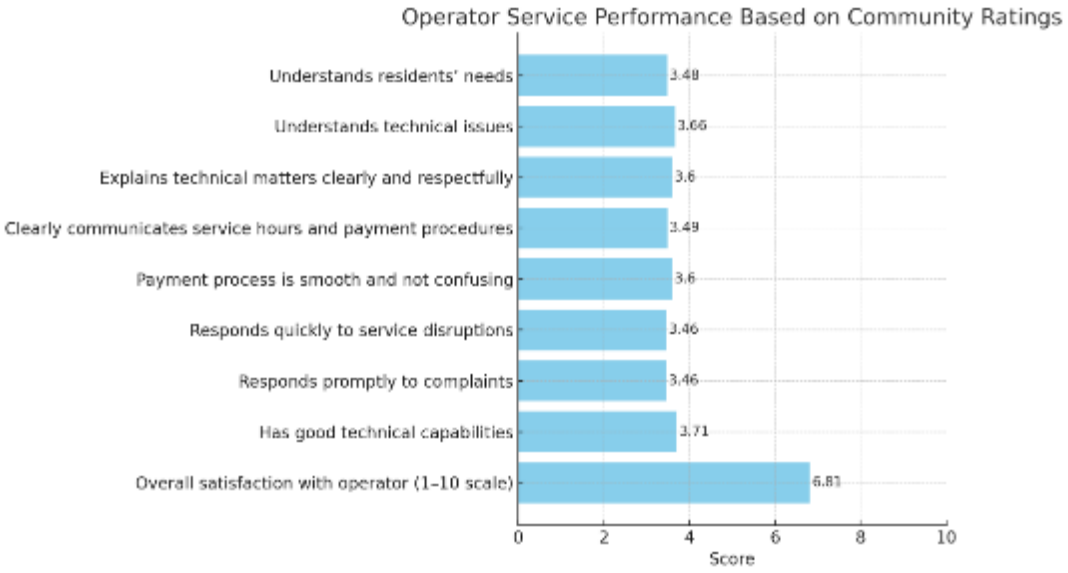

Figure 9. Operator Service Performance Based on Community Ratings

Most users described the electricity supply as generally reliable. However, some participants in FGDs raised concerns about occasional service disruptions, such as unannounced blackouts, and disconnections before the end of the monthly payment period. They also complained of delays power restoration despite timely payments. Community members also expressed confusion about the causes of outages, and inconsistent communication deepened their uncertainty about electricity management.

The Project's 2024–2025 Annual Report reinforced these concerns. The Report documented low bill payment rates (only 52 per cent of villagers paid regularly), unethical practices by local leaders, and collusion between former operators and village elites to improperly upgrade meter capacity. Community FGDs did not always openly discuss these issues, which contributed to growing mistrust in the management of PLTS services. To achieve fair and sustainable service delivery, all stakeholders must strengthen transparency, enforce payment compliance equitably, and close governance gaps.

Participants in several FGDs, including those with village officials, also raised concerns about the responsiveness of local operators during outages. They noted that operators sometimes responded slowly or failed to provide timely explanations during technical disruptions. There was also confusion about the scope of the operators' responsibilities. Some residents and officials believed operators were responsible for collecting electricity payments, which raised concerns about the transparency and accountability of fee management.

The Project's annual reports corroborated these concerns and identified systemic governance issues. These included the selective enforcement of payment obligations, the manipulation of meter allocations, and the unpaid use of electricity by influential individuals, such as village officials or their relatives. The FY2024–2025 annual report revealed that only 52 per cent of villagers consistently paid their bills, while some individuals continued to receive electricity without paying because of their social status or connections to former operators. Such practices not only undermine accountability and fuel distrust in the service provider but also reflect deeper village power hierarchies and elite capture of the electricity system, highlighting the need for clear rules, stronger enforcement, and transparent communication within the community.

6. Is the community payment and financing model sufficient to ensure the operational sustainability of the PLTS system?

This question assesses the financial sustainability of the community-based PLTS model piloted under the Project. The model combines household electricity payments (based on energy quotas), village funds, and BUMDes-managed revenues to fund system operation, maintenance, and long-term replacement needs. The Project provided the initial capital investment, developed SOPs, delivered operator and BUMDes training, facilitated the handover process, and embedded a mentor to support financial and operational governance. The village government was expected to oversee and support implementation, while BUMDes was responsible for managing infrastructure, payment collection, enforcing rules, tracking expenditures, and ensuring transparency.

The analysis examines whether the current financing structure matches actual costs, including operator stipends, minor repairs, and investments for long-term sustainability. It also considers whether willingness to pay is reinforced by effective enforcement and sound financial planning. These findings contribute to Intermediate Outcome 1 of the Project's ToC: improved technical and management capacity of BUMDes and PV operators to manage and maximise the lifespan of off-grid low-carbon energy systems.

Summary

Community members show a strong willingness to pay for PLTS services, yet actual payment compliance remains inconsistent because of unclear procedures, weak enforcement, and the absence of digital payment options in Mata Redi. Over time, BUMDes tested and adapted multiple payment models, including direct payments at the BUMDes office, agent-based collection, and more recently, commodity-based contributions, to find an approach that fits local capacities and preferences.

This process reflects a strong internal culture of learning and responsiveness within BUMDes. Commodity-based payments can offer a locally relevant and potentially inclusive solution, but they also carry risks if not supported by clear valuation methods, proper documentation, and secure storage systems. These safeguards are essential to ensure financial transparency and long-term sustainability.

Willingness to pay

Community members expressed a strong willingness to pay for PLTS services, yet actual payment behaviour remained inconsistent and raised concerns about the financial sustainability of the system operation. Household survey results recorded high attitudinal scores across all willingness-to-pay dimensions. The average score for intention to continue using PLTS as the primary electricity source reached 4.15, while willingness to pay if service quality is maintained scored 4.10. Agreement that everyone must pay on time for the collective benefit received a score of 4.04 and understanding that payments are necessary to keep the electricity on scored 4.06. These results indicate a strong underlying commitment to the PLTS model, provided that service remains fair, reliable, and of high quality.

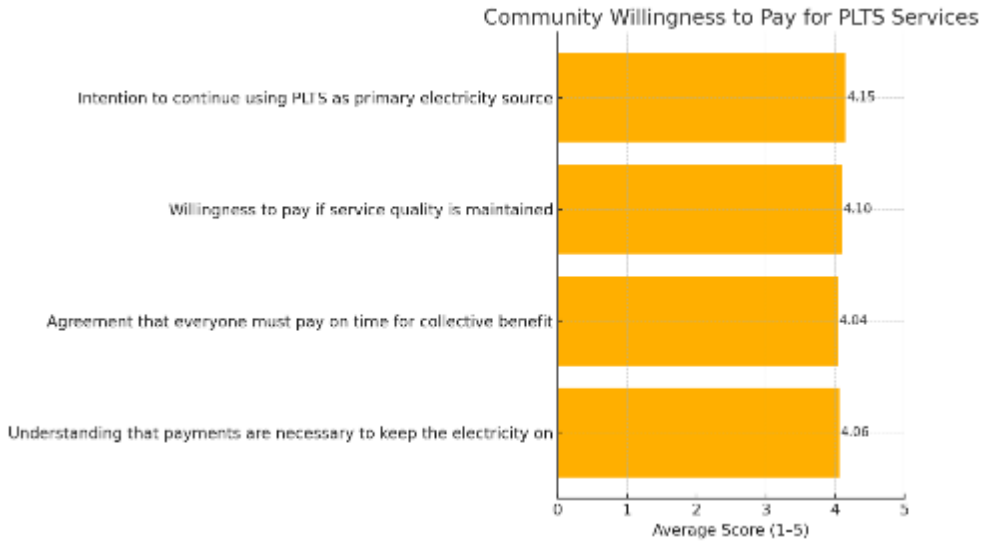

Figure 10. Community Willingness to Pay for PLTS Services

Despite this positive attitude, only 52 per cent of respondents in the endline household survey reported paying their electricity subscription fee regularly, while 33 per cent paid irregularly, and 15 per cent never paid. MDF did not have access to financial records, but these survey results matched findings from community FGDs. FGDs and interviews with village officials identified several factors behind this gap between intention and actual behaviour.

Residents frequently cited confusion about payment deadlines. Many did not know the required payment window (typically the 1st to the 15th of each month), because operators or BUMDes did not communicate clearly. Some users also reported disconnection despite timely payments, which created frustration and mistrust. Although meter trips caused by unmanaged load explained many of these disconnections, users viewed them as unfair, especially when operators failed to explain the technical issues.

Governance and administrative weaknesses deepened these problems. Standard Operating Procedures required payments to be made at the BUMDes office, yet reinforcement was inconsistent. Some residents paid operators directly, which created opportunities for misuse. FGDs revealed that former operators and, in some cases, previous BUMDes management, allegedly collected subscription fee without proper documentation and, in some cases, kept the funds. These practices undermined accountability and eroded trust in the payment system. A *buku pelanggan* (customer logbook) system was introduced to improve transparency, but project monitoring found that the previous BUMDes leadership stopped using it midway through implementation without explanation. Removing this system increased the risk of misreporting, miscommunication, and conflict over payment status.

BUMDes responded to these issues by introducing an agent model for payment collection after uncovering the irregularities. This approach centralised payment communication and reduced the possibility of informal or undocumented collection by individual operators. BUMDes also introduced locally relevant and flexible payment options, such as in-kind contributions (for example, woven textiles or machetes) and extended payment windows to accommodate irregular income patterns. Youth and community groups called for continued outreach and education, as many residents, especially elders, still did not understand payment rules, deadlines, and the reasons for tariff changes.

Commodity-based payment

Commodity-based payment was also available as a payment option to accommodate local needs. FGDs with community members showed strong support for this option because many households often lacked cash at the time of payment but usually had goods available. They hoped that these contributions would be fairly valued at local market prices. Community members and hamlet endorsed this idea and proposed allowing electricity payments through in-kind contributions of local commodities such as woven textiles, crops, or machetes. The Project and BUMDes then informally introduced this hybrid payment model in parts of the intervention area to accommodate households with limited cash flow.

This approach has the potential to expand financial inclusion and sustain community-based access to renewable energy, particularly in remote areas and in communities where capital often takes the form of agricultural assets rather than cash. In-kind contributions also align with existing community modalities and exchange systems. Rather than imposing external systems, stakeholders should ensure clear socialisation, consistent communication, and mutual agreement on valuation and procedures. While the practice is widely accepted, FGDs revealed that some goods might be undervalued or accepted inconsistently, which could lead to mistrust or social tension.

FGDs confirmed that reluctance to pay did not stem from unwillingness. Rather, it arose from a gap between community expectations and the clarity, consistency, and fairness of payment management systems. The Project supported BUMDes by developing SOPs and tools to guide transparent and accountable payment management. However, inconsistent implementation risks creating confusion and eroding trust. These risks could undermine the financial viability of the PLTS system, even in a community that supports it. Closing this gap, will require stronger institutional commitment and follow-through from BUMDes.

Institutional financing and long-term sustainability

The evaluation found that the Project effectively established the core institutional arrangements required to operate and maintain the PLTS system. This included training local operators, developing SOPs, and handing over PLTS assets to the village government. These steps have enabled the PLTS system to operate effectively, supply electricity, and build community trust in local service delivery. While the Project has provided essential capacity building and governance frameworks, its long-term sustainability now depends on local institutions, such as BUMDes, the village government, and PLTS operators. These stakeholders are responsible in maintaining financial discipline (i.e., collecting and managing funds transparently), enforcing agreed standard procedures, and allocating resources for ongoing operations and maintenance.

Trust and reliability in local operators are high among communities. FGDs and the household survey confirmed this, with an average score of 3.7 out of 5 for service quality. The role also provides a valuable new source of income. Operator stipends account for around 50% of the PLTS monthly revenue, placing their earnings above the average income level in the area. Therefore, consistent fee collection is essential to sustain operator salaries, maintain the PLTS system, support administration, and deliver reliable service to the community.

BUMDes reported savings of approximately IDR80 million, from village equity contributions (*penyertaan modal*), which were specifically allocated for routine operations and maintenance.

The allocation reflects intent to sustain the system throughout its expected manufacture's lifetime. The cost of replacing major components exceeds what BUMDes and the community-based financing model can afford. In order to ensure the long-term sustainability of the PLTS system, the government will need to coordinate efforts to integrate these costs into public energy and infrastructure funding budgets.

The allocation of village funds to support the PLTS operations covers salaries, minor repairs, and the purchase of tools and equipment for productive energy-related activities. Some of these expenditures are still being clarified, but the use of village funds shows promise in integrating energy sustainability into formal village development planning. In discussions, Pokja and village authorities raised concerns about the long-term availability of village funds for PLTS operations, given competing village priorities and budget limitations. There is an awareness that village funds can only serve as a supplementary funding source. Long-term sustainability will require stronger financial planning, coordination with other funding streams, and support from higher levels of government.

Currently, no subsidy mechanism exists to support PLTS operations. Pokja members warned that relying on household fees alone could lead to payment fatigue. Kemendesa emphasised the need to identify and access national or regional funding schemes to support O&M, especially for vulnerable households, to maintain affordability and service continuity.

In line with this, a private sector company has been contracted to provide backup technical support for the next several years. This arrangement secures short-term reliability while stakeholders develop options for long-term continuity. Over the past few years, the Project and BUMDes have collaborated with Don Bosco to deepen their relationships and prepare for a future, scaled-down contract focused solely on essential technical aspects. BUMDes has also recognised that it could allocate some of its reserved funds to sustain this technical support. This demonstrates a growing readiness at a local level and highlights the need for BUMDes to extend the current O&M contract to ensure technical support continues beyond the external provider's term.

7. How capable and motivated are local institutions such as BUMDes in managing and sustaining PLTS operations?

This question assesses the institutional capacity and motivation of local actors, particularly BUMDes Hali Dewa, in managing and sustaining the PLTS system in the demonstration villages. Under the Project's community-based model, BUMDes is responsible for the daily operations of the PLTS, including user registration, tariff collection, coordination with operators, financial oversight, and long-term planning for maintenance and potential system upgrades. Village governments are expected to support these efforts through policy endorsement, resource mobilisation (e.g., village funds allocations), and alignment with broader village development goals.

To support this transition, the Project provided a comprehensive package of technical assistance, which includes co-developing Standard Operating Procedures (SOPs) with BUMDes and BLK Don Bosco, facilitating mentoring on business processes and leadership, and embedding two local mentors to guide implementation. The Project also delivered technical training and certification based on the national competency standards (SKKNI).

The evaluation examines the extent to which these institutional arrangements have been implemented and internalised, how local leadership and community trust have evolved, and whether BUMDes and other actors are equipped to address the operational, financial, and governance challenges of managing off-grid energy infrastructure. These findings contribute to Intermediate Outcome 1 of the Project's ToC: improved technical and management capacity of BUMDes and PV operators to manage and maximise the lifetime of off-grid low-carbon energy systems.

.

Summary

The Project supported the establishment of BUMDes Hali Dewa as the lead institution for managing the PLTS system under a community-based governance model. This support included co-developing SOPs, certifying operators, embedding local mentors, and formally transferring operational responsibility to BUMDes 1.5 years before the Project's conclusion. These efforts established the basis for locally owned energy service delivery, and helped introduce new accountability standards, such as structured tariffs, reporting tools, and the integration of energy into village development planning. The current BUMDes leadership has shown openness to capacity building, and operators are generally trusted and responsive to technical issues.

However, BUMDes' institutional capacity remains fragile, particularly in financial governance and coordination with village government (Pemdes). Financial reporting is inconsistent, accountability gaps remain unresolved, including unreported village capital contributions, and community trust in BUMDes' financial transparency is low. Tensions between BUMDes and village government undermine oversight and delay budget allocations. These challenges persist due to a combination of structural-political and capacity related factors. Rules are applied unevenly, as local power dynamics allow influential actors to bend procedures to their advantage. This reflects a broader transition from governance shaped by personal influence and informal arrangements to one based on transparent rules and accountability. While some tensions are expected during this adjustment period, Pokja, Pemdes, and district authorities must provide sustained support through oversight, mentoring, and inter-agency coordination to institutionalise good practices and ensure long-term sustainability. Without clearer roles, stronger accountability mechanisms, and improved coordination, BUMDes may struggle to sustain PLTS services beyond the life of the Project.

The strategic role of BUMDES in managing village-level infrastructure

BUMDes, as mandated by Law No. 6/2014 on Villages, can drive local economic development and improve basic service delivery. In the context of rural electrification, BUMDes plays a pivotal governance and operational function by linking infrastructure, finance, and community engagement.

Interviews with Kemendesa revealed that stronger BUMDes is key to achieving village self-reliance and reducing rural poverty. Kemendesa confirmed that the Project's strategy of placing PLTS management under BUMDes authority aligns with national priorities and offers a promising model for scaling up sustainable energy services in rural areas.

The effectiveness of this model depends on the internal capacity, accountability, and coordination mechanisms of BUMDes. In this role, BUMDes is expected not only to operate the system, but also to serve as an institutional platform that builds local ownership, ensures financial sustainability, and integrates renewable energy into broader village development planning.

Critical role but constrained performance

BUMDes Hali Dewa plays a central role in the day-to-day management of the community-based PLTS system. Its responsibilities include collecting electricity fees, recruiting and supervising local operators, and managing productive-use enterprises such as candlenut oil and cassava chips. With support from the Project, BUMDes has strengthened its institutional capacity by developing an organisational structure, adopting clear SOPs for technical operations, and introduced a digital accounting system. These tools, co-designed with BUMDes and piloted over the past several years, have built community ownership and social capital, both essential for long-term sustainability.

Concerns about BUMDes' governance emerged in the FGDs, ones that may harm equitable amd transparent service delivery. Participants reported strong perceptions of favouritism and accused BUMDes of prioritising electricity access for relatives or individuals with close ties to the management team, allegedly including the village head. Furthermore, unclear payment periods and abrupt disconnections fuelled distrust. On the contrary, local operators received more positive descriptions as responsive and reliable. This contrasting view shows that community trust is stronger in individual operators than in BUMDes as an institution.

After the handover of PLTS assets to the village government, BUMDes now has operational authority, while the village government assumes a supervisory role. This transition required both parties to adjust their roles and relationships. Although formal structures now exist, Pokja and FGD participants noted that BUMDes still faces constraints, particularly in financial governance, recordkeeping, and coordination with village government.

These institutional limitations occur within an ongoing adaptation. The transition to a community-managed energy system is intricate and involves new tools, roles, and accountability expectations. Changes supported by the Project have introduced new norms that require time to take root. Some emerging tensions, such as overlapping responsibilities, unclear lines of accountability, and transparency concerns, reflect a transitional phase rather than a failure of institutional intent. To safeguard sustainability, BUMDes and village authorities must align around shared goals, strengthen oversight and internal capacity, and sustain the institutional momentum built during the Project. Community involvement can also help close communication gaps and hold institutions accountable.

At the same time, institutional and technical capacity remain in development. Challenges in financial reporting and longer-term planning persist despite BUMDes' important steps to operationalise PLTS management. The current financial reporting system lacks consistency, and accountability reports (LPJ) are not submitted routinely. In FGDs, Pokja members raised concerns over approximately IDR150 million in village capital allocations that remain unreported, which reflects ongoing gaps in financial transparency. This also highlights a learning curve, particularly among Pokja members, in distinguishing between capital expenditures (capex), such as battery or inverter replacement, and operational expenditures (opex), such as routine system maintenance or operator salaries. While no formal plans exist yet for long-term system maintenance or component replacement, discussions with BUMDes show growing awareness of these future needs.

Internal governance processes within BUMDes have faced notable challenges but also show signs of institutional learning and adaptation. The handover between the former and current management teams was poorly documented because the previous head of BUMDES refused to participate in the transition process and ignored repeated invitations from the new team. Several new members admitted during the FGD that they had not yet fully aligned with the organisation's core governance documents (AD/ART), but expressed willingness to improve coordination with village government. Relations between BUMDes and the village government remain strained due to the unresolved LPJ of the previous board, which includes questions surrounding the use of IDR70 million in village capital contribution.

Collaboration between BUMDes and the village government remains limited. The village head has not demonstrated a clear willingness to engage constructively, which hinders efforts to resolve accountability issues and strengthen coordination. In this context, external facilitation from actors such as the Village Consultative Body (BPD), DPMD (District Office for Community and Village Empowerment), or even enforcement bodies like Satpol PP may be necessary to mediate institutional tensions and ensure effective local governance.

While these issues reflect broader institutional and political dynamics, they also show the need for continued support to strengthen governance and the importance of respecting local decision-making processes. Encouragingly, the current BUMDes leadership has shown openness to

capacity building, and the experience of navigating these challenges provides an opportunity for institutional learning and greater resilience.

Community trust in BUMDes governance is moderate. Household survey results show medium satisfaction scores across six dimensions of BUMDes performance, including perceived responsibility for PLTS sustainability (3.60), responsiveness to electricity problems (3.37), and clarity of rules and tariffs (3.38). However, the lowest rating (2.97) was recorded for financial transparency, confirming widespread concerns about unclear use of funds and the lack of accountability reports. These results, shown in the graph below, indicate that while the community recognises BUMDes' essential role, they remain cautious about its governance performance, particularly with regard to financial matters and fairness.

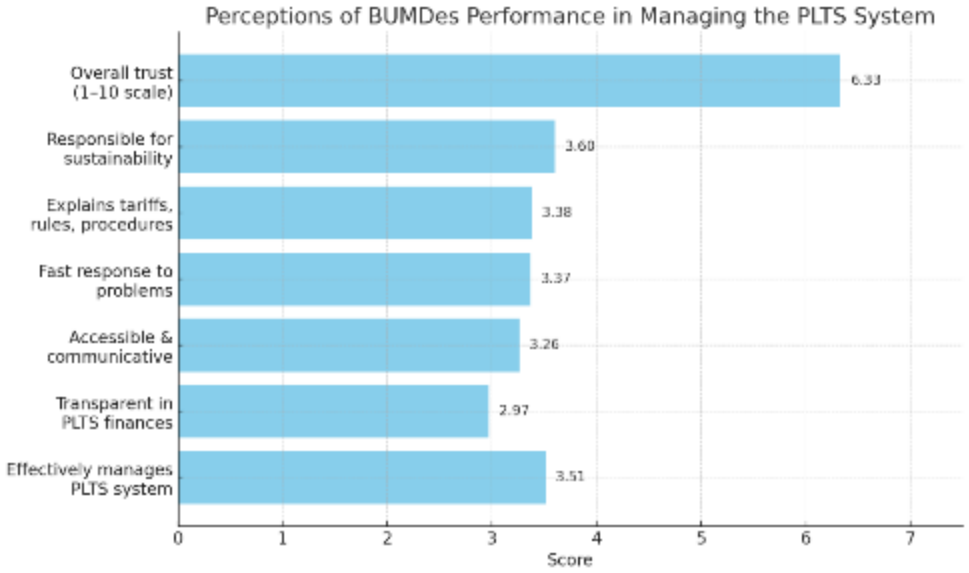

Figure 11. Community Perceptions of BUMDes Governance in Managing PLTS Services

Despite these challenges, Pokja proposed a formal handover of tasks from the Project to the local government to clarify roles and ensure continued oversight. Given the current performance of BUMDes, Pokja emphasised that they would need to become more actively involved once the project ends. They also recommended holding quarterly coordination meetings between district-level agencies, the village government, and BUMDes to sustain accountability and technical support. Without strengthened internal governance and a structured transition mechanism, however, BUMDes may struggle to sustain PLTS services beyond the life of the project.

Navigating power dynamics and institutional adjustment in PLTS governance

The PLTS system operates under a community-based model, with BUMDes Hali Dewa managing daily operations. Under the mandate of UU Desa (Village Law), the village government is responsible for supervising BUMDes and allocating village funds in line with energy planning. While consistent with national regulations, this governance arrangement still requires substantial adjustment from local actors, including BUMDes Hali Dewa, the village government, and community members in general. The official handover of PLTS assets to the village government, with BUMDes as operator, created a new distribution of roles. FGDs revealed tensions between BUMDes and village government during the transition, particularly regarding oversight, coordination, and accountability. Pokja and village government representatives noted that village authorities were often not fully engaged in system monitoring. They also pointed out that unresolved issues from the previous BUMDes leadership, including the allocation of IDR70 million, contributed to mistrust.

Community members expressed frustration over perceived unfairness in service provision. FGDs repeatedly alleged favouritism, whereby households with personal ties to the BUMDes or village leadership reportedly received preferential treatment in terms of fee enforcement or connection status. While residents generally trusted operators and considered them responsive, they viewed BUMDes as lacking credibility.

These dynamics reflect institutional challenges and power asymmetries within the village governance structure. The Project's intervention introduced a rules-based model emphasising SOPs, digital reporting, and formal accountability mechanisms. New BUMDes leaders acknowledged gaps in following AD/ART and financial procedures but expressed interest in improving coordination with village government and learning from past missteps.

The community modality, the way roles, responsibilities, and norms are structured and practiced at the village level, is transitioning towards more formal systems of accountability and service delivery. This incremental adaptation represents a system that is adjusting rather than failing. Institutional sustainability will depend on how effectively local actors manage tensions, rebuild trust through transparent financial governance, and ensure that the village government embrace their supervisory mandate. Power dynamics and contestation are not signs of failure, but indicators of the deep institutional transformation the model seeks to achieve.

8. What are the challenges and opportunities for establishing long-term partnerships with PLN or other institutions?

This question explores the challenges and opportunities in building long-term partnerships between villages, BUMDes, and external institutions such as PLN, local governments, and relevant ministries. The evaluation examines the extent to which the community-based PLTS management model can be integrated into broader energy policy frameworks, including its potential adoption, replication, and support through national and subnational programmes. It also assesses the readiness of local institutions to establish sustainable cross-sector partnerships, covering technical capabilities, governance structures, and funding mechanisms. These findings contribute to Intermediate Outcome 3 in the Project's ToC: strengthened policy frameworks and institutional collaboration to support inclusive renewable energy expansion.

Summary

The Project built a strong foundation for partnerships by aligning PLTS systems with PLN standards and facilitating national and local dialogues. The pursuit of formal collaboration with PLN is not yet possible. A key challenge is the absence of a registration pathway for BUMDes within the OSS (Online Single Submission) system. Additionally, according to PLN's regional office in Sumba (UIW), barriers to engagement include the low commercial viability of rural systems and the weak payment culture in rural communities. ESDM further noted that PLN, as a state-owned enterprise, is mandated to generate profit, making engagement with PLTS difficult unless returns are assured. While PLN values the skills of the Project - trained operators, but long-term engagement would require legal reforms and subsidy mechanisms. This cautious stance at the regional level contrasts with earlier signs of interest at the national level, where authority for strategic direction rests, and therefore the Project focused its advocacy nationally. while keeping regional offices informed.

Other pathways for institutional sustainability are emerging. Kemendesa and EBTKE have proposed scaling up through multi-actor models involving village governments, vocational institutions (e.g., SMKs, BLKs), and financing tools such as village funds or DAK Energi. These efforts are progressing, but challenges persist, including weak financial governance in BUMDes, unclear regulations for off-grid energy, and the absence of formal local energy policies. Continued coordination, technical mentoring, and institutional strengthening remain vital to building lasting partnerships.

Partnership prospects with PLN

The Project's design envisioned long-term sustainability, with the potential integration of community-based solar energy systems into broader public service frameworks. The PLTS systems were developed to comply with PLN's technical standards, including requirements for power quality, system safety, O&M support and designed-ready interconnection. From 2022, the Project facilitated a series of multi-level engagement platforms, including a national workshop with PLN and ESDM, a feasibility study on operational partnerships (KSO), and regional forums with PLN, BUMD, and NTT provincial stakeholders. These initiatives aimed to assess the feasibility of long-term collaboration. The idea of partnering with PLN received conceptual support from both technical ministries and local governments.

However, several structural obstacles hinder the formation of such partnerships. While legally PLN could enter into formal agreements with BUMDes, one of the biggest challenges is the OSS (Online Single Submission) system does not yet provide a registration pathway for BUMDes, creating practical barriers to formalising operational or asset management roles. PLN' s regional office in Sumba (UIW) also emphasised that it has no operational or financial obligation to manage or maintain these systems that are not part of its asset base and were constructed outside its official network. In the event of system failure, PLN would prefer to expand its own network infrastructure rather than invest in repairing third-party systems it does not own. With Perpres No. 112/2022, PLN is mandated as the sole off-taker of electricity from renewable energy systems. This opens regulatory space for potential integration of decentralized systems, particularly in unserved or remote areas. BUMDes faces challenges in meeting procurement terms and securing the necessary licensing status, which constrain its ability to engage in formal collaboration with PLN.

Interviews with PLN at the regional level (PLN UIW NTT) revealed a cautious approach to taking responsibility for the community-based PLTS systems in Mata Redi and Mata Woga. PLN UIW noted that the commercial viability of taking over such systems remains low, citing the limited purchasing power of rural households and inconsistent payment behaviour. PLN further argued

that in areas such as Sumba, electricity fees are often deprioritised in favour of social or ceremonial expenses, and many residents do not yet view them as regular, mandatory costs. According to PLN, these factors lead to low electricity consumption and weak payment compliance, making operational takeovers financially unattractive to PLN without subsidies or incentives. Reflecting PLN's focus on financial efficiency, PLN UIW is unlikely to take on unprofitable systems in areas lacking a stable energy payment culture.

Technical capacity is another critical factor in sustaining off-grid energy systems. Both PLN and the Directorate General of Electricity (Gatrik) observed that, across Indonesia, trained operators often leave villages after project completion, and that few systems have mechanisms in place for ongoing capacity development. To address this challenge, the Project designed a localised training strategy focused on long-term talent development. In collaboration with BLK Don Bosco, the Project trained and certified 11 local operators in Mata Redi and Mata Woga. The training covered O&M procedures, K2/K3 occupational safety standards, and troubleshooting protocols. This initiative expanded the local talent pool and reduced post-project dependency.

As a result, the Project's operator training has been recognised as a best practice. Operators in Mata Redi and Mata Woga have obtained SKKNI certifications confirming that they meet national competency standards in PLTS operation and maintenance. This represents a significant step towards achieving technical capacities comparable to those of PLN field staff. Gatrik expressed interest in continuing technical cooperation through refresher training, mentoring, or troubleshooting support, provided local governments and relevant ESDM directorates, particularly Aneka EBTKE, align on priorities. Gatrik also recommended integrating village PLTS operations with local vocational training institutions such as SMKs and BLKs, in order to embed operator capacity within local systems and reduce dependency after project completion.

From energy access to productive energy access through a multi-stakeholder approach

Institutional sustainability of the PLTS model requires stronger district-level engagement. During the FGD with Pokja, stakeholders noted that BUMDes performance and transparency remain fragile, particularly due to unresolved reporting on village capital allocations. Pokja members stated that they would likely need to intervene more actively once the project ends. They stressed the need for a formal handover from the Project to the district government to clarify responsibilities and prevent oversight gaps. Pokja also proposed regular coordination meetings between BUMDes, the village government, and district agencies to maintain monitoring, address problems, and strengthen institutional learning.

Kemendesa shared these concerns and noted the challenges involved in scaling up this BUMDes-managed energy service model. These include limited technical understanding at the village level, ongoing dependence on PLN or government budgets, and a lack of institutional innovation in many BUMDes. To address these issues, Kemendesa proposed expanding access to soft financing, such as unsecured loans of up to IDR100 million for community energy services, including battery replacement, productive-use equipment, and digital metering. They also encouraged BUMDes to obtain the necessary business permits the OSS (Online Single Submission) platform, to enable partnerships with third parties such energy cooperatives, private companies, and vocational institutions.

Beyond PLN, both Kemendesa and EBTKE identified the potential to develop broader multi-actor models to support community energy systems. This could involve bundling electricity services with agro-processing or other village enterprises and accessing government financing instruments such as village funds or DAK Energi. EBTKE emphasised that the Project model has generated institutional and human resource development outcomes that align well with the government's broader energy transition strategy. They recognised the potential for PLTS community systems to serve as learning platforms that contribute to rural electrification and the national discourse on inclusive, locally anchored energy governance.

Despite these opportunities, several cross-cutting constraints remain. For example, regulatory frameworks for off-grid village energy are unclear in most districts and provinces. Financial management in many BUMDes is weak, particularly in areas with limited oversight or reporting systems. Cross-sector coordination between technical, administrative, and financial actors is inconsistent, partly because few local governments have issued formal policies (such as SK Bupati or local energy regulations) that provide a legal basis for ongoing energy governance.

9. What is the readiness for scaling or replicating the model in other communities?

This question explores the extent to which the Project's model -community-based PLTS systems managed by BUMDes- can be replicated or scaled to other rural or underserved areas. It examines the enabling conditions and barriers to replication, including institutional capacity, financing mechanisms, and community readiness. The analysis draws on stakeholder views at local and national levels, including district governments, PLN, and relevant ministries, to assess the roles they can play in supporting replication, through policy integration, budget allocation, technical assistance, and cross-village learning. These findings contribute to Intermediate Outcome 5 of the Project's ToC: strengthened institutional frameworks and multi-level collaboration to advance inclusive and sustainable energy access.

Summary

Stakeholders recognise the Project model as a promising solution for rural electrification, and it aligns with national priorities to promote village self-reliance, poverty reduction, and energy access. Ministries such as Kemendesa, EBTKE, and KPPPA show strong interest in expanding the model due to its potential for community ownership, GEDSI integration, and productive use. Initiatives to support replication are already in progress, including development of guidelines, cross-sector dialogues, and the deployment of village facilitators.

Successful scale-up will require stronger institutional frameworks, clear documentation of lessons, and improved post-project capacity at district and provincial levels. Financing remains a challenge, though opportunities exist through village funds and national. Multi-ministerial collaboration and policy advocacy are key to building the systemic support needed for replication.

Government readiness and institutional support

The community-based PLTS model developed under the Project in Mata Redi and Mata Woga is regarded by stakeholders as an innovative and contextually appropriate approach for remote rural areas. Successful replication will depend on institutional strengthening, systematic documentation of lessons learned, and supportive national and local policies that prioritise community ownership.

Kemendesa stated that the model aligns closely with its agenda to promote village self-reliance and reduce poverty through strengthened BUMDes and increased village-generated income (PAD). As an initial step, Kemendesa has committed to deploying 30 LPDP alumni as village facilitators across the Sumba region and plans to co-develop a practical replication guideline in collaboration with the Ministry of Energy and Mineral Resources (ESDM).

Gatrik has played an active role throughout the Project, by participating in the National Technical Working Group (TWG) and strategic coordination meetings. Gatrik expressed support for the nomination of Mata Red Village as an official PLN-assisted community. They emphasised the importance of continued technical training for local operators, the promotion of energy entrepreneurship, and tariff harmonisation to ensure that community-managed PLTS systems remain competitive with grid-based electricity. Gatrik also noted that technical incentives could

be made available, subject to internal coordination within ESDM, particularly with the Directorate of New and Renewable Energy (Aneka EBTKE).

Cross-ministerial coordination and GEDSI integration

Bappenas underlined the importance of a compelling narrative for successful replication. To achieve this, they recommended the systematic documentation of evaluation findings and success stories from the Project, which should be presented at cross-sector dialogues to increase the likelihood of national adoption.

The Ministry of Women's Empowerment and Child Protection (KPPPA) also identified strong potential for the Project model, particularly in promoting empowerment for women and marginalised groups. KPPPA is facilitating the establishment of a National Secretariat for the Gender and Climate Change Action Plan (RAN-GPI), a cross-ministerial coordination platform to integrate GEDSI principles into energy policy, including potential scale-up programmes such as Project Phase 2.

The Project has demonstrated that multi-stakeholder collaboration across ministries, local governments, and non-governmental actors can strengthen legitimacy and readiness for replication. Partnerships with the Ministry of Finance and the private sector, alongside coordination through local energy working groups (Pokja Energi), have positioned the Project model as a strong example of community-based renewable energy in line with broader rural development and community empowerment goals.

Financing and policy advocacy pathways

In terms of financing, Kemendesa and EBTKE have explored cross-ministerial funding schemes, including integrating the PLTS systems into village funds and Indonesia's *Merah Putih* national programmes. These efforts signal growing institutional interest in mainstreaming decentralised renewable energy. However, long-term success will require systemic institutional support and greater operational capacity for district-level energy working groups, which remain limited in many regions.

Kemendesa also noted that the Project exemplifies the ability of electricity to drive economic activity, not just lighting. Consistent community facilitation was identified as a critical strength of the Project. Kemendesa emphasised that local experiences, including how the project navigated social conflict and community dynamics, should be documented in a "project logbook" to inform future initiatives. The Ministry is preparing to convene a high-level meeting with the Project team to address critical issues ahead of the Project's closeout, including village fund allocations, electricity fee collection, and long-term sustainability mechanisms.

6. Conclusions

6.1 Conclusions: Impact

The Project has delivered meaningful and multidimensional impacts on household and community life in Mata Redi and Mata Woga. Access to electricity through the PLTS system has driven notable improvements across social, economic, and empowerment domains, particularly for women and youth. These impacts mark substantial progress towards the Project's intended intermediate outcomes and demonstrate the value of integrated, community-based renewable energy models.

First, the PLTS system has improved household well-being by enhancing lighting, safety, communication, and evening routines (IO1). Families report spending more time together,

supporting children's education, and feeling safer moving around at night, while public services, including village administration and schools, also became more efficient (IO2).

Second, the tiered energy model has enabled households with higher capacity (Tier 2 and Tier 2) to adopt modern appliances and start productive activities such as food processing and value-added agriculture (IO2). Despite this, systemic barriers, such as affordability constraints, and limited capacity to produce goods in the required volume, consistency, and quality required by the market, continue to hinder widespread uptake.

Third, electricity access and the Project's empowerment strategies, particularly GALS training, have increased women's visibility in decision making, business, and leadership (IO3 and IO4). Young women are demonstrating increased confidence, leadership, and entrepreneurial initiative with men also becoming more supportive of joint decision making. Cultural and structural barriers remain, but the overall trend points towards greater inclusion and shared empowerment within the community.

Finally, the Project has improved energy governance practices at village and national levels by strengthening existing tools and frameworks (IO 5 and IO6). The Project refined the SOPs and Juklak for PLTS operation and maintenance, adding practical guidance and community feedback to improve usability and inclusiveness. At the provincial level, the RUED revision process integrated GEDSI principles, particularly around equitable energy access and community participation. This was achieved through a bottom-up consultation approach informed by the Project's experience in Sumba. At the local level, capacity building is sustained through the designation of Mata Redi as a vocational training hub and partnerships with SMKs to institutionalise knowledge.

6.2 Conclusions: Sustainability

The sustainability of the Project's PLTS model depends on six interrelated factors: social engagement, financial viability, institutional maturity, technical reliability, systemic policy support, and environmental alignment. Findings from EQ5 to EQ9 confirm that, although the model is widely supported and aligned with national priorities, its outcomes remain evolving and conditional. These challenges are not fixed constraints, but opportunities for adaptive reform, as long as stakeholders at all levels take ownership of their respective roles.

Social Sustainability

The Project has fostered a strong culture of shared responsibility for the PLTS system. Community members, particularly youth, demonstrated strong ownership by reporting disruptions and discouraging misuse, while local operators were generally trusted and responsive. However, some users reported confusion over operator roles (especially payment collection), service disruptions, and unclear communication during outages.

These issues do not indicate disengagement but rather reflect active expectations from users. BUMDes and the village government are best placed to improve outreach, clarify roles, and maintain consistent communication.

Financial Sustainability

Communities show strong willingness to pay, yet compliance remains inconsistent because of limited income, weak enforcement, and unclear procedures. In response to this problem, BUMDes piloted alternative payment models, including in-kind commodity payments. However, these require transparent valuation, better record-keeping, and clear communication. These challenges create an opportunity to co-design payment systems that balance local realities and basic accountability standards.

Institutional Sustainability

Transferring operational responsibility to BUMDes is a major step towards community ownership. SOPs were adopted, operators were certified, and internal tools such as digital accounting

systems were introduced. However, BUMDes governance systems remain underdeveloped. Financial reporting is irregular, capital fund accountability is unresolved, and coordination with village government is strained, leading to mistrust. These challenges reflect the ongoing shift from informal to more formalized governance arrangements, which requires clearer mandates and stronger alignment between institutions.

Policy and Systemic Sustainability

The Project's technical alignment with PLN and facilitation of national dialogues created strong foundations for long-term institutional partnerships. However, current regulatory and permitting barriers continue to prevent formal collaboration with PLN. While PLN can legally enter agreements with BUMDes, the OSS system does not yet provide a clear pathway for BUMDes registration. At the same time, PLN (UIW NTT) perceives limited commercial viability, unclear local regulations and weak inter-agency coordination hinder replication.

Nevertheless, Kemendesa, EBTKE, and KPPPA have expressed strong interest in scaling the model. The opportunity now lies in enabling multi-stakeholder frameworks involving SMKs, BLKs, and local governments. National ministries must lead legal reforms, define institutional roles, and fund replication. Local governments should issue enabling instruments (e.g., SK Bupati) and integrate energy into local development plans.

Technical Sustainability

Operator performance is strong, reflected in household satisfaction ratings and compliance with SOPs. However, issues persist, including occasional outages and lack of planning for major component replacement (e.g., batteries, inverters). These challenges highlight risks to sustaining the system over its intended lifetime, in line with the Project's outcome framework.

There is an opportunity to address this through preventive maintenance planning and build a local ecosystem of technical support. Current arrangements, which focus on routine O&M and limited fund allocations for minor repairs, do not yet provide for preventive maintenance and planning for component replacement over the system's lifetime.

7. Lessons

1. Electricity access catalyses social transformation when grounded in inclusive governance and community ownership

Electricity access through the PLTS system has transformed daily life. It has improved safety, , enabled night-time study, reduced energy costs, and strengthened community interaction. These improvements were not solely the result of infrastructure. The Project's participatory, community-based approach, anchored in BUMDes leadership, village deliberation, and transparent processes, built trust and ownership among users. Where ownership and roles were clearly defined, electricity use remained equitable and systems were well-maintained because of the tier system. In contrast, weak or contested relationships between local institutions led to management and sustainability challenges. The experience shows that energy systems in rural areas are more likely to succeed when designed and governed inclusively from the start, with shared accountability and community-driven decision-making.

2. Culturally grounded and flexible payment models enhance affordability and ownership

Flexible and locally adapted payment systems, such as in-kind contributions, were agreed upon through village consensus and proved effective in delivering affordable electricity to low-income households. These alternatives responded to community norms, reinforced collective responsibility, and encouraged willingness to pay. They have the potential to expand financial inclusion, provided that clear yet flexible accountability mechanisms are in place. Simple,

context-appropriate tools for recording contributions and assessing equivalent monetary value are essential to uphold transparency and ensure long-term financial sustainability.

3. Supporting ecosystems are essential to unlock productive use of energy

PLTS access enabled some households to start or expand income-generating activities, demonstrating the potential of electricity to support rural livelihoods. With the right support, many more households could follow this path. However, widespread uptake is constrained primarily by affordability, both in terms of appliances and working capital, as well as limited market access and minimal post-training support. When combined with improved market access, consistent supply, and alignment with local demand, skills gained through training can be translated into viable business opportunities.

Electricity becomes a true enabler of livelihoods only when embedded in a broader ecosystem that includes financial services (such as soft loans or revolving funds), business incubation, and targeted follow-up support. These elements, when strengthened together, will unlock the economic potential of rural electrification and ensure that energy access leads to tangible, inclusive development outcomes.

4. Women's empowerment accelerates when energy access is integrated with structured mechanisms that support women's leadership, skills development, and participation

The Project's approach demonstrated that combining electricity access with intentional empowerment strategies, such as GALS and women's leadership networks, empowered women to gain broader economic and leadership opportunities. They became entrepreneurs, co-managed household businesses, participated in village forums, and gained visibility in leadership structures such as BUMDes. This broader participation also opened space for more balanced household decision-making, ensuring that the benefits of empowerment were shared and sustained. Two lessons emerge: targeted initiatives are essential to build women's confidence and leadership, and household-level support reinforces and sustains gains achieved in the public sphere.

5. Technical performance and system sustainability depend on institutional capacity and social accountability

The Project's experience shows that even with high-performing infrastructure, long-term sustainability depends on the ability of local institutions, particularly BUMDes including their operators, to manage and troubleshoot the system, and to communicate with users. Where capacity and coordination were strong, communities used the system with confidence and uptake was higher. Reliable hardware alone is not insufficient. Sustained performance requires continuous investment in institutional capacity through refresher training, mentoring, and budget integration (e.g., APBDes allocations for operations and maintenance).

6. Strong governance and institutional trust are essential to village-level energy services sustainability

The Project found that sustained collaboration depends on clearly defined mandates, responsible institutional behaviour and accountability. For example, tensions between BUMDes and village government stemmed not only from role ambiguity but also from financial misconduct by both parties, failure to submit financial reports, and an unwillingness to engage in dialogue. These issues undermined trust and disrupted effective management of the PLTS. Decentralised energy systems require sound design, capacity building, and mechanisms to uphold integrity, transparency, and mutual accountability. A governance mechanism that promotes structured oversight, community monitoring, and district-level mediation can prevent individual misconduct from jeopardising system sustainability when disputes arise. Only then can energy governance effectively serve the public interest.

7. Local innovations, supported by clear pathways for scale-up, can influence national policy

The Project showed that local innovations, such as inclusive PLTS governance and GEDSI-responsive planning, can influence policy beyond the village level. Through systematic documentation, ongoing engagement with ministries, and participation in policy platforms, The Project contributed to national and provincial energy frameworks, including the DAK Energi scheme and the GEDSI-integrated NTT RUED. These outcomes were possible because learning and policy engagement were integral to the Project's component and cycle.

Pilot implementation can influence policy when lessons are deliberately captured, results are shared, and innovation are linked to institutional processes. In summary, learning, adaptation, and knowledge transfer are levers that enable local solutions to gain broader traction instead of remaining isolated examples.

8. GEDSI integration strengthens both energy access outcomes and governance

The Project did not treat inclusion as an add-on, but as a core principle integral to project design, facilitation methods, institutional partnerships, and policy engagement. As a result, women, youth, and marginalised groups experienced tangible benefits, from improved access to energy services and economic opportunities to greater participation in leadership and decision-making making processes. Inclusion also enhanced the credibility and accountability of local governance. Participatory processes became more representative, resource allocations more equitable, and community trust stronger. The Project's experience suggests that these outcomes endured where inclusive structures, GEDSI-aware capacity, and institutional follow-up existed and were operationalised.

8. Recommendations

This section presents a set of strategic recommendations based on the evaluation findings and insights from stakeholder sense-making discussions. The recommendations are organised by stakeholder group and aim to strengthen the sustainability, replication, and long-term relevance of the Project model, particularly in scaling decentralised renewable energy systems that are inclusive, community-owned, and institutionally embedded. Each recommendation responds to specific problems identified through the evaluation and/or capitalises on opportunities that are already emerging or anticipated. They are closely linked to the ToC pathways, relating to energy access, institutional capacity, productive use, and policy engagement, and aligned with the OECD-DAC evaluation criteria, particularly impact and sustainability. Collectively, the recommendations address gaps in policy, institutional capacity, financial viability, and community inclusion, while building on promising practices and stakeholder momentum to deepen impact and enable broader scale-up.

8.1 Recommendations for Civil Society Organisations (CSOs), Universities, and Media

1. Integrate the Project model into university curricula and vocational training programmes.

The evaluation found that while the Project has generated valuable experience in decentralised energy governance and GEDSI integration, this knowledge has not been fully embedded in academic and training institutions. There has been a missed opportunity to incorporate these insights into energy planning, rural development, and gender studies programmes at the university and vocational school level. On a positive note, Kemendesa has expressed interest in using learnings from the Project-assisted training of local government and village facilitators, particularly in Sumba, and incorporating them into the curricula of its Training Centres (BLKS). Similarly, EBTKE at the Ministry of Energy and Mineral Resources (ESDM) plans to work with the Directorate of Vocational High Schools (SMK) to integrate the Project model into technical and vocational education. Universities, SMKs, and vocational institutions are encouraged to partner with Kemendesa, ESDM, and development partners to develop learning modules, case-based

teaching tools, internships, and site-based training in places such as Mata Redi. This approach embeds learning from Project's lessons into institutional curricula and builds a pipeline and builds a pipeline of locally rooted energy practitioners with practical skills and an understanding of inclusive energy governance.

2. Partner with local enterprises to expand PUE.

The evaluation noted that although PUE pilot activities have been initiated, they remain small in scale, undercapitalised, and disconnected from broader value chains. This presents both a constraint and an opportunity. Local enterprises and MSMEs networks could play a pivotal role in scaling up the productive uses of electricity by providing access to markets, financing, technology, and business mentoring. Partnerships between BUMDes, women's groups, youth entrepreneurs, and private sector actors could be strengthened through incubation programmes, digital marketing platforms, and bundled services combining energy-efficient equipment with training and maintenance support. Such partnerships would stimulate greater demand for electricity and strengthen the business case for households to upgrade to higher load meter capacities, from 450 W to 900 W or 2200 W service. This would directly support the economic impact pathway in the ToC. However, these outcomes depend on adequate support for both capital upgrades and demand generation. Public or donor-supported capital subsidies or microcredit schemes may be required to enable households to invest in higher-capacity connections. Without such measures, demand may stagnate, and communities may be unable or unwilling to pay for higher service levels, which would undermine the financial sustainability of PLTS operations.

8.2 Recommendations for the Government of Indonesia and Policymakers

3. Strengthen the institutional relationship between BUMDes and village governments through clear roles, shared planning, and dispute resolution mechanisms.

The evaluation found that persistent tensions between BUMDes and village government -due to financial mismanagement- had delayed reporting. In addition, and lack of constructive engagement disrupted planning cycles and weakened coordination for PLTS operations. While these issues were observed in the Project sites, they represent a broader challenge in decentralised service delivery for rural electrification, where local institutions must work together to manage resources, maintain systems, and respond to community needs. Addressing this requires strengthening governance arrangements that can be applied across rural electrification initiatives.

At the district level, the Dinas Pemberdayaan Masyarakat dan Desa (DPMD), together with the District Inspectorate and Pokja Kabupaten, can act as neutral facilitators to resolve disputes, rebuild trust, and reinforce institutional accountability. National-level actors, such as Kemendagri and Kemendesa PDTT, should provide policy guidance, model SOPs, and capacity-building support for village-level service delivery. Formal agreements -through SOPs or MoUs- can define reporting lines, budgeting procedures, and joint decision-making processes, while regular coordination forums ensure alignment. Embedding these practices in the broader rural electrification framework will enable local institutions to manage funds transparently, sustain PLTS performance, and replicate effective governance models in other villages.

4. Resolve outstanding financial accountability issues from past BUMDes management to restore trust and unlock village-level investment.

A major challenge identified by the evaluation was the lack of financial accountability under previous BUMDes leadership, with unreported use of approximately IDR70–150 million from village capital allocations. While the evaluation team did not independently confirm the exact cause, stakeholders, including members of the Project team, acknowledged concerns that the

funds may have been diverted for non-BUMDes purposes. These unresolved issues eroded public trust and created hesitation among village governments to provide further funding, which threatened the continuity of PLTS operations. However, this challenge can serve as a catalyst for institutional reform and learning. The District Inspectorate, with oversight from DPMD and support from Pokja Kabupaten, should launch a transparent audit and reconciliation process. Public dissemination of audit findings, followed by appropriate administrative or legal action, will help restore credibility. In parallel, capacity-building programmes should strengthen financial literacy, internal controls, and accountability mechanisms for current BUMDes management teams. These measures will strengthen institutional sustainability and ensure that BUMDes can responsibly manage future funding and assets.

5. Mainstream decentralised, community-based renewable energy models into national and subnational energy planning.

The Project demonstrated that community-managed PLTS systems can deliver reliable, inclusive, and locally governed energy access. Despite these benefits, such models are not yet fully embedded in national and regional energy planning frameworks, such as the RUED or RUEN. This represents both a gap and an opportunity. Ministries such as MEMR (ESDM), Bappenas, and Kemendesa should collaborate to ensure that policy instruments, regulatory frameworks, and fiscal mechanisms explicitly support decentralised, community-based renewable energy. This includes integrating these models into the General Guidelines for Special Allocation Funds (DAK), updating technical standards, and enabling coordination between energy, rural development, and education agencies. At the subnational level, NTT Province has incorporated Project's learning into its RUED and planning processes. This experience should be documented and shared with other provinces facing similar challenges. Furthermore, policy and regulatory instruments such as village regulations (Perdes), SK Bupati, village funds, and DAK Energi should be recognised and enabled as mechanisms for financing long-term operations and inclusive energy service delivery. Institutionalising these models through planning and budgeting systems would reinforce their legitimacy and support the long-term embedding of inclusive, community-based energy systems within Indonesia's energy transition framework.

6. Establish a targeted subsidy mechanism for off-grid PLTS systems to ensure equitable access.

The evaluation found that several households struggle to pay the monthly fees consistently. This affordability gap risks excluding the most vulnerable from sustained access to electricity. During FGDs, village officials expressed strong support for a subsidy mechanism to ensure that no one is left behind.

To address this issue, the Government of Indonesia should develop a dedicated subsidy scheme for off-grid communities. The EBTKE (ESDM) should take the lead in designing the policy and build on its existing collaboration with Kemendesa to support rural electrification. The scheme could be co-financed through village funds and national poverty alleviation funds, with MoF coordinating fiscal support. Local governments and village councils should help identify eligible households and administer support transparently. A well-targeted subsidy for meter installation and basic electricity use would promote equity, strengthen community trust, and strengthen the long-term viability of the PLTS model.

7. Strengthen women's and youth participation in village energy governance

The evaluation found that entrenched gender and youth norms continue to limit participation in village-level decision making, with women often sill relegated to support roles and rarely engaged in public life. To address this, village governments and community leaders should adopt mechanisms, such as quotas for women's representation in forums, designated youth seats in BUMDes committees, and facilitation techniques learned from GALS to ensure inclusive

participation. Ministries such as Kemendesa can reinforce this by issuing guidance that promote women's and youth leadership in rural service delivery.

8.3 Recommendations for International Development Partners

1. Promote wider adoption of GEDSI-responsive tools in energy access programming

The evaluation confirmed that Project's use of participatory tools such as GALS and inclusive planning workshops had a significant positive impact on social inclusion and institutional responsiveness. These tools enabled women, youth, and marginalised groups to participate in PLTS planning, access training, and express their priorities. Despite this success, GEDSI integration remains uneven across the broader energy sector. International development partners could play a catalytic role by integrating GEDSI-responsive tools and indicators into the design, implementation, and evaluation of other rural energy and transition programmes. This could include supporting training for local facilitators, funding action research into the effectiveness of participatory methods, and promoting policy dialogue on GEDSI mainstreaming in decentralised infrastructure programmes. By championing inclusive planning models like GALS, development partners can help ensure that energy transitions do not reinforce existing inequalities, but instead serve as platforms for empowerment, behavioural change, and long-term transformation in terms of agency and confidence.

2. Support structured policy dialogue and cross-level learning platforms on decentralised energy

While the Project successfully facilitated multi-level engagement among village, district, and national stakeholders, the evaluation noted the absence of institutionalised platforms for sustained policy learning and coordination on decentralised energy. This gap limits the scale and policy uptake of innovative models as the one piloted in Mata Redi. Development partners are well-positioned to convene and support policy dialogue forums, communities of practice, and knowledge exchange platforms that bring together government agencies, practitioners, private developers, and local communities. These platforms could be embedded within existing national mechanisms, such as RUED coordination forums, or developed as new multi-stakeholder initiatives aligned with Indonesia's energy transition agenda. Showcasing demonstration sites like Mata Redi on these platforms would facilitate practical discussions on policy, financing, and implementation challenges, thereby helping to bridge the gap between top-down energy planning and community realities.

3. Provide catalytic financing for PLTS-compatible appliances and women-led PUE initiatives

While the Project demonstrated early adoption of productive use of electricity among some households, particularly those with 900 W connections, many women and vulnerable groups continue to face barriers in accessing capital and equipment to start or expand energy-based enterprises. Development partners should invest in financing mechanisms that target these barriers and stimulate local economic activity. Financing options can vary, such as zero-interest loans, revolving grant funds, or matching grants disbursed through BUMDes, cooperatives, or women's groups to finance the purchase of PLTS-compatible appliances. These schemes should be complemented by field-based mentoring, business coaching, and peer learning to build entrepreneurial capacity and ensure responsible use of funds. Targeted financial support will help activate latent demand for electricity, incentivise capacity upgrades, and unlock inclusive economic opportunities. This, in turn, contributes to impact and sustainability by enabling women to move from passive users to active agents in the rural energy economy.

8.4 Recommendations for the Private Sector and Renewable Energy Developers

1. Develop scalable, hybrid business models that include performance-based services and long-term technical support

The evaluation found that, although private sector actors -including renewable energy developers and social enterprises- show interest in rural energy solutions, they often hesitate to engage due to perceived financial risks, unclear roles for long-term operations, and a lack of viable service models. The Project demonstrated that community institutions such as BUMDes are strengthened and provided with operational SOPs and basic training, they can successfully manage decentralised PLTS systems. However, BUMDes still face technical and financial constraints, especially during system breakdowns or required upgrades. This presents an opportunity for the private sector to design hybrid business models that combine grant financing, village contributions, and private investment, and offering performance-based service contracts covering routine maintenance, repairs, and user support. While innovative financing models such as lease-to-own, power-as-a-service, and bundled service packages (PLTS, appliances, training) have been piloted in Indonesia, most have struggled to achieve long-term viability. Lessons from these experiences highlight that without subsidies, strong after sales service and local capacity, such models are unlikely to succeed. Future efforts should therefore prioritise strengthening enabling conditions.

2. Strengthen partnerships with rural enterprises and BUMDes to scale productive use of energy

The evaluation revealed that the uptake of the productive use of electricity in Mata Redi and Mata Woga has been limited. Existing activities are small-scale, fragmented, and disconnected from broader market systems. There is a clear opportunity for private sector actors, particularly those in agribusiness, equipment supply, fintech, and aggregation, to collaborate with rural enterprises and BUMDes to expand the reach and impact of PUE. These partnerships could involve co-developing inclusive business models, offering bundled energy-efficient appliances with after-sales services, providing market access, and offering tailored financing mechanisms (e.g., asset-based microloans or pay-as-you-go schemes). Scaling PUE would not only improve livelihoods and household income, but also increase electricity demand, encouraging households to upgrade to higher load meter capacities, from 450 W to 900 W or 2200 W. This upgrade is critical to ensure the financial viability of PLTS systems and to enable communities to pay for higher service tiers. These partnerships directly support the economic empowerment, energy access, and sustainability outcomes envisioned in the Project's ToC.

9. Appendices

9.1 List of FGD Participants

20 June 2025 / Pemprov (Provincial Gov.) NTT (Kupang)

No	Name	Name of Institution	Position	Gender
1	Adriani Laia	Dinas Perhubungan	Analis Kebijakan Jalan	Female
2	Herman	Biro Hukum	Pengawas Materi Hukum dan PUU	Male
3	Nelceszon Pua	Biro Hukum	Pengawas Materi Hukum & PUU	Male
4	Salman A. Hasbullah	Dishub NTT	Pranata Komputer	Male
5	Apriyani Gustiana	BPS Provinsi NTT	Statistisi Ahli Pertama	Female
6	Fransiska Dominica Ingi Kolin	BPS Provinsi NTT	Statistisi	Female
7	Elvia Evi Pada	Pokja PI	Anggota	Female
8	Rosmaida			Female
9	Adriani F. Malelak	DLHK NTT	Staf	Female
10	Jacinta F. D. S. Perera	DLHK NTT	Staf	Female
11	Gabriel Adu	Bappenda NTT	Perencana Muda	Male
12	Grasia D. Handayani	Bappeda NTT	Staf	Female

24 June 2025 / Session 1: Users / Villagers

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	Yosep K. Lelak	Mata Redi	User	Male
2	Amtiyas S. Setahal	Mata Redi	User	Male
3	Emilia R. Bera	Mata Redi	User	Female
4	Rosalia S. Peli	Mata Redi	User	Female
5	Desiana R. Taga Hana	Mata Redi	User	Female
6	Rosalia R. Meli	Mata Redi	User	Female
7	Mathilda Myeki	Mata Redi	User	Female
8	Adrianus K. I. Dappa	Mata Woga	User	Male
10	Agustinos S. Pekiam	Mata Woga	User	Male

24 June 2025 / Session 2: PemDes

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	Stevanus L. Bili	PemDes	LPM	Male
2	Lukas L. D. Pari	PemDes	Treasury	Male
3	Matius R. Magawi	PemDes	Village 4 head	Male
4	Karolus K. I. Lora	BPD	Head of BPD	Male
5	Jumat M. Wolang	PemDes	Village 2 head	Male

24 June 2025 / Session 3: BumDes

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	Kristina P. Boka	BumDes	Agt. Business Manager	Female
2	Yanti Sada Mna	BumDes	Director	Female
3	Agnes B. Tavu	BumDes	Operator	Female
4	Piras R. Wada	BumDes	Treasury	Female
5	Margaritha R. Wada	BumDes	Agent	Female
6	Rosalia R. K. Pah	BumDes	Treasury	Female
7	Petronela J. Kaniba	BumDes	Agt. Business Officer	Female
8	Jeni Rambu Leni Ngulu	BumDes	Agent	Female
9	Daniel Ledi	Mentari	Mentor Bumdes	Male
10	Andreas Pande Robo	Mentari	Mentor	Male

25 June 2025 / Session 1

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	David S. U. Duka	Koperindale	Section Head	Male
2	Umbu Ngariu	Dinsos - P3A	Section Secreraty	Male
3	Andreas D. Ledja	Kec KTN	Subdistrict head	Male
4	Martinus V. Daparawa	Bapelitbangda	Program officer	Male
5	Yulius Umbu Serii	Diskop	Staf	Male
6	Dominikus Sili Woco	Dinas Pendidikan	Secretary	Male

25 June 2025 / Session 2: GALS

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	Yuliana R. Bela	Mata Redi	Women Champion	Female
2	Rosalia R. K. Pah	Mata Redi	Women Champion	Female
3	Karolina K. Teda	Mata Redi	Women Champion	Female
4	Rosalia S. Peda	Mata Redi	Women Champion	Female
5	Margaritha D. Liu	Mata Redi	Women Champion	Female
6	Selviana B. Boki	Mata Redi	Women Champion	Female
7	Petronela J. Kantha	Mata Woga	Women Champion	Female
8	Yanti Sada Mura	Mata Redi	Women Champion	Female
9	Kristina P. Bota	Mata Redi	Women Champion	Female
10	Rosaria R. Wasa	Mata Redi	Women Champion	Female

25 June 2025 / Session 3: Youth

No	Nama	Nama Institusi	Posisi/Jabatan	Jenis Kelamin
1	Joclinda Lubu Lena	Mata Redi	Private sector employee	Female
2	Mory Roku Pati	Mata Redi	Farmer	Female
3	Selviana A. Tegu	Mata Redi	Farmer	Female
4	Piras R. Wada	Bumdes	Treasury	Female
5	Sipti Yanto K. I. Dapa	Mata Redi	Farmer	Male
6	Monika Aledia B. Kaya	Mata Redi	Farmer	Female

Europe

MDF Netherlands
Ede, Netherlands
mdf@mdf.nl

MDF Brussels
Brussels
info@mdfbrussels.be

Africa

MDF West Africa
Accra, Ghana
mdfwa@mdf.nl

MDF Eastern & Southern Africa
Nairobi, Kenya
mdfesa@mdf.nl

MDF Afrique Centrale
Goma, DRC
mdfac@mdf.nl

MDF Bénin
Cotonou, Benin
mdfbenin@mdf.nl

Asia

MDF Pacific Indonesia
Bali, Indonesia
mdfpi@mdf.nl

MDF Myanmar,
Yangon, Myanmar
mdfmmr@mdf.nl

MDF Bangladesh
Dhaka, Bangladesh
mdfbg@mdf.nl