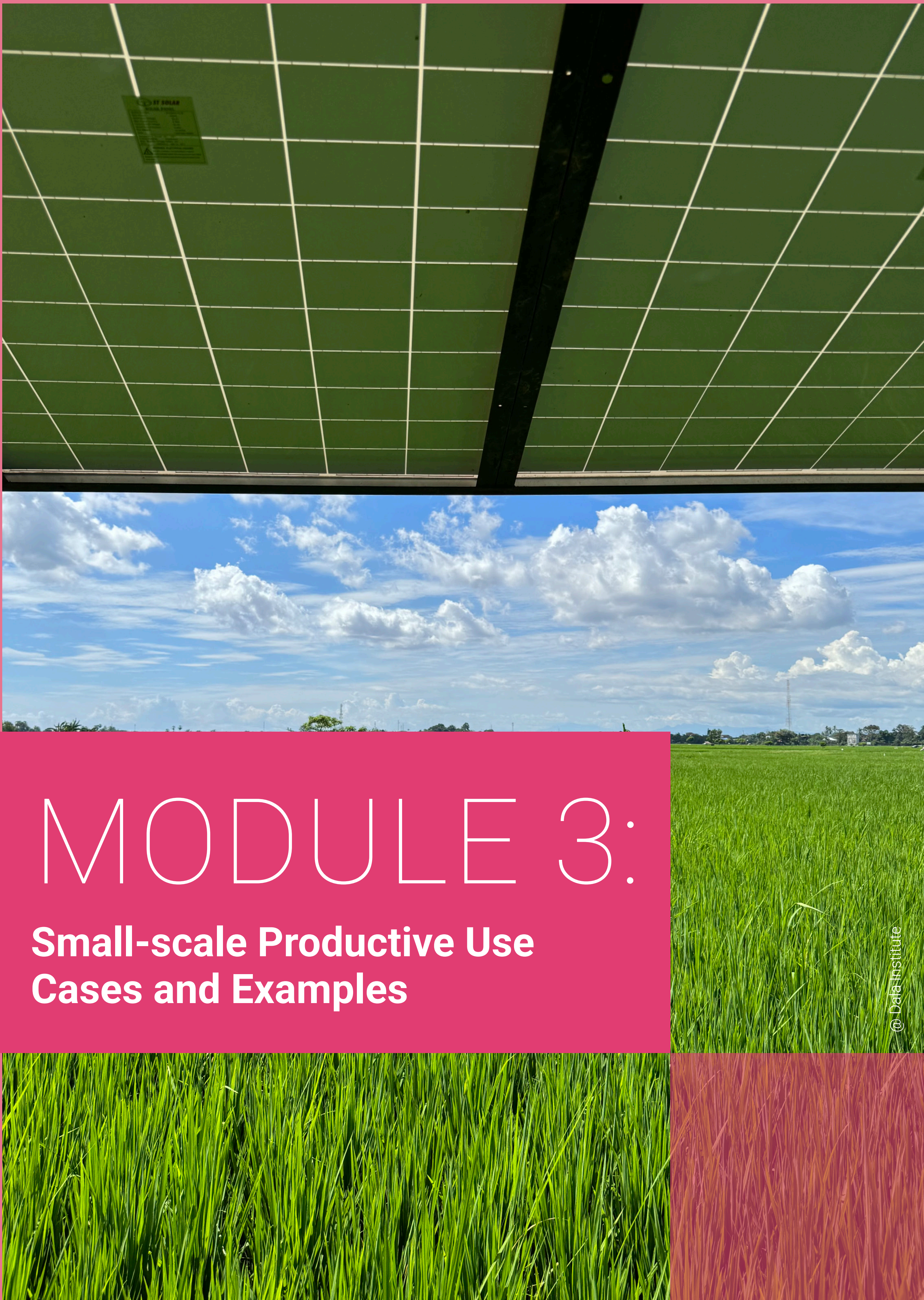

MODULE 3:

Small-scale Productive Use Cases and Examples

3.1 What is small-scale renewable energy?

Small-scale renewable energy refers to low- to medium-capacity electricity generation systems that rely on locally available renewable resources and operate in a decentralised manner. These systems typically serve villages, communities, productive sectors, or isolated grids and may operate off-grid, within mini-grids, or connected to the PLN network through dedicated power purchase arrangements. In practice, small-scale systems are generally below utility-scale and are often developed to support local energy access, productive uses, and regional development objectives.

Under Presidential Regulation (Perpres) No. 112/2022 on the Acceleration of Renewable Energy Development for Electricity Supply, renewable energy is defined broadly to include geothermal, wind, bioenergy, solar, hydropower, ocean energy, and other sustainable sources. The regulation also provides the framework for PLN to procure electricity from renewable energy–based generators, with tariffs jointly determined by the Ministry of Energy and Mineral Resources (MEMR) and PLN and formalised through Power Purchase Agreements (PPAs).

It is important to note that PLN power purchases under the Perpres 112/2022 apply primarily to non-rooftop, grid-connected renewable energy projects, including small hydropower, bioenergy/biomass, biogas, and other distributed generation facilities that feed electricity into the grid under contractual arrangements. This framework does not constitute net metering for rooftop solar PV, which is currently not in place in Indonesia. Rooftop PV systems are therefore treated differently and are generally limited to behind-the-meter consumption, subject to capacity quotas and technical approval by PLN.

Small-scale renewable energy systems that operate off-grid—such as village-scale solar PV, solar irrigation, cold storage, micro-hydro, community biogas digesters, and hybrid mini-grids, are typically governed through sectoral programmes, village development mechanisms, and local ownership models rather than electricity market transactions. These systems play a critical role in expanding access to energy, reducing diesel dependence, and supporting productive activities in rural and remote areas.

Overall, small-scale renewable energy in Indonesia spans a range of technologies and governance models, from community-managed off-grid systems to grid-connected non-rooftop projects under PPAs with PLN. While provincial governments have limited authority over electricity procurement, they play an important enabling role by integrating energy planning (RUED) with sectoral development planning instruments, including the RPJMD and sectoral Renstra.

3.2 How small-scale renewable energy contributes to productive use?

Small-scale renewable systems play a critical role in expanding equitable and reliable energy access, particularly for Indonesia's many remote, rural, and island communities where extending PLN's grid is technically challenging or economically unfeasible. These systems help reduce dependence on diesel generators, lower household energy costs, and improve self-reliance and local resilience against fuel price shocks and logistical disruptions (see Box 3.1. for indicative cost calculation of small-scale renewable energy).

Box 3.1
Example of cost calculation for small-scale renewable energy

Case: solar-powered irrigation (PLTS for water pumping – smallholder agriculture)

Typical comparison: diesel pump vs solar pump

Component	Diesel pump	Solar pump (solar panel)
Initial investment	Low	Higher
Operating cost	High (fuel)	Very low
Maintenance	Moderate	Low
Fuel dependency	Yes	No

Simple cost illustration (indicative)

Diesel pump fuel cost:	Solar pump:
± IDR 30,000–50,000 per day	Initial cost: ± IDR 15–25 million
± IDR 900,000–1,500,000 per month	Monthly energy cost: ~0 (no fuel)

With diesel costs of about IDR 1,000,000 per month, the solar system can pay for itself in around 1.5–2 years, after which energy is essentially free.

Various studies show that solar-powered irrigation systems have lower operational costs and can recover investment within ~5–7 years, making them more cost-effective than diesel systems over time (Aini et al., 2021; Amir, 2021).

Beyond electrification, small-scale renewable energy directly supports local productivity and livelihoods. Stable and affordable electricity enables productive uses such as irrigation pumping, fish cold storage, agro-processing, small manufacturing, tourism services, and digital connectivity, which strengthen local economies and diversify income sources. This can lead to spillover benefits such as local skill development, new jobs, innovation capacities and entrepreneurship potential. When developed through community-based or mixed governance arrangements, small-scale EBT also enhances local ownership, institutional capacity, and long-term sustainability, ensuring that energy solutions are embedded in community priorities and social contexts.

3.3 Key Lessons Learned

This section summarises key lessons from the implementation of small-scale renewable energy projects in Indonesia, drawing on a range of case studies sourced from literature and development partners. It highlights the factors that enable inclusive and sustainable development.

The case studies reviewed include:

- MENTARI Programme. *Viability Gap Fund and demonstration projects* (Mata Redi and Mata Woga, East Nusa Tenggara).
- Hadji Kalla Foundation. *Kampung Hijau Energi (Green Energy Village) programme*, South Sulawesi.
- Climate Policy Initiative (CPI). Enhancing Decentralized Renewable Energy Investment to Achieve Indonesia's Nationally Determined Contribution (Case Studies: Community-based RE Projects in Eastern Indonesia).
- Universitas Negeri Makassar (UNM). *Solar-powered irrigation pump initiative* in Gowa, Takalar, and Jeneponto.
- United Nations Development Programme (UNDP). *Accelerating Clean Energy Access to Reduce Inequality (ACCESS) Project*.

Table 3.1 provides detailed information on lessons learned from the case studies above.

Table 3.1
Core Insights, Evidence, and Actionable Steps for Renewable Energy Integration from Case Studies

Core insights	Evidence	Actionable Steps
	Economic and Productive Linkages	
Productive energy use creates economic incentives that fund operations and maintenance, reducing external dependency and strengthening community ownership. Income from productive uses can cover O&M costs while improving livelihoods and local value chains.	› **Lenggora Pantai, Southeast Sulawesi:** The village enterprise (BUMDesa) operates two interconnected business units, electricity services and ice-making for fisheries. The ice-maker business generates IDR 4-5 million monthly (USD 230-330), eliminating fishermen's risky boat travel to neighboring villages for ice and enabling better fish preservation and market prices. Since inception, BUMDesa accumulated IDR 30.8 million (USD 2,000) in savings while the electricity unit saved IDR 97.8 million (USD 6,300). Solar power also enabled Ms. Tawaria, a 60-year-old widow, to scale her dried fish business, earning IDR 500,000 monthly (USD 33), income that didn't exist before. › **Kamanggih Village, East Sumba:** Community generated collective income by selling surplus power from their micro-hydro plant to PLN through a Power Purchase Agreement. › **Tepal Hamlet:** Electricity powered coffee processing, strengthening local value chains and improving livelihoods (Rospriandana et al., 2023). › **Mata Redi and Mata Woga, Central Sumba:** Solar PV access catalyzed 16 new small businesses, 15 of them women-led, processing agricultural commodities including candlenuts, citronella, ginger, and lemongrass. › **East Kalimantan:** RE integration enabled swallow's nest farming using sound systems and powered schools and health clinics (Solagratia et al., 2024).	› Identify where energy is critical to sectoral programs and activities › Map how RE can advance local economic indicators (income, productivity, employment) › Coordinate with energy offices (Dinas ESDM) to align sectoral and energy policies › Support integration of energy access with existing productive sector value chains

Table 3.1 Continuation ▶

Table 3.1 Continuation

Core insights	Evidence	Actionable Steps
	› **Green Energy Village, across South Sulawesi**: Biogas works because it ties directly to farmers' needs: Free cooking gas, high-value organic fertilizer, potential fuel for tractors. mall agro-industries, such as palm sugar producers, are shifting to biogas, reducing operational costs while farmers selling organic fertilizers create new livelihood opportunities (Hadji Kalla Foundation). › **Lempangang Village, Gowa**: Solar-powered irrigation pumps directly reduced farmers' production costs—previously, diesel pumps cost approximately IDR 1,000,000 per pumping cycle to irrigate about 1 hectare, requiring 3-4 days of operation at 4-6 hours per day. After the initial solar system investment, operational costs became close to zero. The solar-powered system can irrigate approximately 600 m² per day, operating autonomously during daylight hours, enabling more stable water flow and freeing farmers' time for other agricultural tasks (UNM).	
Institutional Arrangements and Ownership		
Transparent distribution of technical, financial, and administrative responsibilities prevents confusion and maintains operational continuity. Formal structures enable sustained operations even after external funding ends.	› **Muara Enggelam Village, East Kalimantan:** The village-owned enterprise (BUMDes) manages the solar mini-grid, collecting fees, funding maintenance, and reporting to village government and energy offices—ensuring continuity beyond donor support (Solagratia et al., 2024). › **Lenggora Pantai Village, Southeast Sulawesi:** BUMDesa manages both electricity and ice-making businesses with transparent fee structures legalized in Village Regulations. All payments are made regularly, ensuring sustainability, with accumulated savings demonstrating financial viability (UNDP Access). › **Mata Redi and Mata Woga, Central Sumba:** After project handover, BUMDes Hali Dewa manages the solar PV system with active government support—the Ministry of Villages provides ongoing maintenance through Dana Desa (Village Fund) as part of rural electrification efforts, demonstrating multi-level institutional commitment (Mentari). › **Titab Mini Hydro, Bali:** The 1.4 MW project demonstrates formal institutional arrangements between government (dam owner: Ministry of Public Works) and private operator (PT Brantas Energi), enabled through blended financing with PT SMI and UK government support (Mentari). › **Green Energy Village, across South Sulawesi:** Naturally formed groups (kelompok organik) work better than formal village organizations. These groups have internal trust and shared motivations such as fertilizer shortage, rising energy cost (Hadji Kalla Foundation). › **Lempangang Village, Gowa**: The solar-powered irrigation system was initially implemented by Universitas Negeri Makassar (UNM) and granted to two farmers who now own, manage, and maintain the system. The partnership model between academia, local government, and communities was formally supported by subdistrict leaders and village officials, creating an entry point for local management (UNM).	› Formalize mandates and legal status of RE operators (BUMDes, cooperatives, public-community partnerships) › Mandate post-installation provisions in procurement agreements: maintenance funds, warranties, spare parts (per LKPP Regulation No. 12/2021) › Require transparent revenue management and periodic audits › Establish clear coordination mechanisms between village enterprises, local government, and national agencies › Support BUMDes capacity in business management and financial sustainability

Table 3.1 Continuation

Table 3.1 Continuation

Core insights	Evidence	Actionable Steps
	Capacity Building and Social Inclusion	
Skilled operators reduce downtime and costs; inclusive participation builds legitimacy and trust. Women's involvement expands economic opportunities and strengthens social cohesion, creating multiple pathways for community benefit beyond basic electrification.	› **Mata Redi and Mata Woga, Central Sumba:** Ten local operators received certification in solar PV operation and maintenance, building sustainable technical capacity. Women's leadership proved transformative: 15 of 16 new businesses are women-led, demonstrating how involving women champions leads to stronger socio-economic outcomes in rural communities (Solagratia et al., 2024). › **Lenggora Pantai Village, Southeast Sulawesi:** Women's economic participation increased significantly—solar electricity enabled women like Ms. Tawaria to operate micro-businesses at night, buying and processing dried fish from other village women and strengthening household income and resilience (UNDP Access). › **Green Energy Village, across South Sulawesi:** Community Education Centers are central for capacity building and demonstrating visible benefits and practicality. The model spreads through demonstration plots, peer-to-peer learning, and practical evidence (Hadji Kalla Foundation). › **Multiple sites:** Communities with trained operators and embedded learning systems better maintained installations over time (Saribanon et al., 2025; IESR, 2025; Hadji Kalla Foundation). › **Lempangang Village, Gowa**: Two-day technical training for local community members with basic electrical backgrounds, recommended by the village head, proved effective in building technical capacity and fostering ownership. Demonstration-based approaches and practical hands-on training were effective in changing community perceptions about renewable energy.	› Integrate awareness programs through existing channels (agriculture, fisheries, community development, social services) › Partner with vocational schools and polytechnics for operator training and certification › Facilitate peer learning networks among communities with similar RE initiatives › Embed customary governance structures (adat councils, village deliberations) into planning processes › Create mechanisms ensuring women and youth access to training, management, and leadership opportunities.
	Financing and Multi-Stakeholder Collaboration	
Blended financing models and strong multi-level coordination ensure operational continuity beyond initial project phases. Diverse funding mechanisms can unlock significantly larger investments.	› **Titab Mini Hydro, Bali:** The Viability Gap Fund (VGF) mechanism demonstrates how strategic capital grants can unlock commercial financing. UK government contributed IDR 2.6 billion (15% of CAPEX), enabling the project to access PT SMI financing and developer equity. This blended approach (grant + loan + equity) delivered a 1.4 MW plant serving 600 households. Overall, VGF support unlocked potential investment up to 10 times the VGF's cost, demonstrating the multiplier effect of strategic public funding. › **Mata Redi and Mata Woga, Central Sumba:** 100% donor-funded during implementation, but sustainability ensured through post-handover institutional support—Ministry of Villages now provides ongoing maintenance through Dana Desa, demonstrating how government can sustain donor-initiated projects. › **Muara Enggelam and Mata Redi:** BUMDes and cooperatives collect tariffs and reinvest surplus into maintenance and productive use, sustaining operations independently (Solagratia et al., 2024).	› Design financing mechanisms that blend public, donor, and community revenue streams › Establish multi-stakeholder coordination platforms involving energy offices, sectoral agencies, communities, donors, and financial institutions › Support BUMDes and cooperatives in developing financial management capacity

Table 3.1 Continuation

Table 3.1 Continuation

Core insights	Evidence	Actionable Steps
	› **Green Energy Village, across South Sulawesi**: Ownership clarity is essential for system longevity. Community Education Centers require clear land ownership through a formal donation statement (grant/*hibah*) (Hadji Kalla Foundation). › **Lempangang Village, Gowa**: Despite strong community acceptance, weak coordination with regency and provincial governments limited replication and policy support. The system was not supported by local financial mechanisms or incentives (e.g., BUMDes, Village Funds), which contributed to one of three units becoming non-functional. Village Funds and BUMDes could be potential options to support farmers in sustaining the system and its operations and maintenance along with opportunities to attract financing for scale (UNM).	› Build maintenance reserves into tariff structures from project inception › Explore innovative mechanisms like VGF to de-risk projects and attract commercial financing › Maintain post-project relationships with key stakeholders (BUMDes, local government, ministries) to safeguard long-term sustainability › Align project timelines with available funding windows and institutional capacities.
Government Policy Support and Replication		
Government support transforms pilot projects into scalable models, ensures long-term maintenance funding, and embeds lessons into policy frameworks. Multi-level government engagement (village, district, provincial, national) creates resilience against changes.	› **Mata Redi and Mata Woga, Central Sumba:** The Indonesian Ministry of Villages is scaling the MENTARI model to 42 additional communities across Sumba, demonstrating government buy-in and replication potential. The ministry actively supports maintenance through Dana Desa allocation. › **Titab Mini Hydro, Bali:** Strong buy-in from PT SMI (state infrastructure financier) and government of Indonesia, with PT SMI using the VGF approach as a blended finance case study for other projects. › **NTT Regional Energy Planning:** GEDSI mainstreaming was integrated into RUED, institutionalizing inclusive approaches beyond individual projects. › **Lempangang Village, Gowa:** The project's success motivated the village government to support installations in two additional locations using their own resources, although the technology and equipment were still supplied by UNM through the grant programme. This demonstrates local government willingness to invest when benefits are visible and practical (UNM).	› National: Develop enabling policies and financing mechanisms (like VGF) that support small-scale RE projects › Provincial: Integrate RE and GEDSI principles into regional energy planning › District: Coordinate across sectoral offices to align energy access with productive sector development › Provincial and District: Support village government in allocating budget for small-scale RE projects (ie. budget planning and nomenclature). › Village: Strengthen BUMDes governance and establish transparent financial management systems

Cross-Cutting Lessons

Successful small-scale RE projects are not just technical installations—they are socio-economic systems. Evidence from Lenggora Pantai, Mata Redi, Titab Dam, and other sites demonstrates that sustainability depends on:

1. **Productive use alignment** generating income and economic value
2. **Local institutional embedding** (especially BUMDes) with clear governance
3. **Inclusive capacity building** particularly of women and youth
4. **Blended financing** combining public, donor, and community resources
5. **Multi-level government commitment** from village to national agencies

When these five enablers work together, communities don't just receive energy—they own it, operate it, and use it to transform their economic prospects. Moreover, for socio-economic benefits to emerge, these enablers must be intentionally embedded in the project design. The evidence shows remarkable impacts: from ice-making businesses that eliminate losses in the fish value chains, to women-led enterprises processing agricultural products, to solar irrigation systems that eliminate diesel costs, to biogas systems providing free cooking gas and organic fertilizer, to government replication of successful models across dozens of new communities. These projects succeed because they integrate technical solutions with economic opportunity, social inclusion, and institutional sustainability.

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