A DECADE OF ENDEV

FROM ENERGY ACCESS TO SUSTAINABLE ENERGY PROVISION

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energising development

kerja sama jerman
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Imprint

This Final Report provides a summary of achievements and lessons learned of 10-Years EnDev implementation in Indonesia. Further information can be obtained from GIZ.

In collaboration with:
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Preface

The achievement of 100% electrification ratio target throughout Indonesia is one of the key tasks of the Ministry of Energy and Mineral Resources. The Directorate General of New, Renewable Energy and Energy Conservation (DG NREEC) has an important role in the achievement of the target, in terms of providing access to electricity, especially in the border, outer, underdeveloped and isolated areas through renewable energy utilisation. Various strategies are pursued using a variety of renewable energy technologies, such as micro-hydropower and communal solar battery systems that play important roles in achieving the high electrification ratio.

The universal access of electricity is not only intended for the fulfilment of consumptive needs but also to encourage the improvement of public services quality and the economy in the area to improve people's welfare. This approach was implemented by EnDev (Energising Development) Indonesia, a joint project between the Goverment of the Federal Republic of Indonesia represented by DG NREEC and the Goverment of the Federal Republic of Germany represented by The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

EnDev Indonesia's activities have created a positive impact on the implementation of renewable energy-based mini-grid development. Some noteworthy positive impacts are improved installation quality and the technology used on micro-hydropower plants and communal PV battery systems; the support ecosystem development technical and non-technical aspects of mini-grids in some areas, especially related to the sustainability of mini-grid operations; knowledge products which documented in various publications and guidebooks; as well as the realization of some of the pilot sites os sustainable mini-grid management model.

The closing od EnDev Indonesia in 2019 marked the maturity of new and renewable energy sub-sector in Indonesia. It shows through the achievement of high electricity ratio in Indonesia. It shows through the achievement of high electricity ratio in Indonesia, reached more than 98% in 2019, where renewable energy has an important role in benefits the communities in remote areas and local industrial growth.

The EnDev Indonesia report outlines the various lessons learned from the experiences and activities arried out during the 2009-2019 period. The collection of learnings and recommendations are expected to be an input to strengthen and advance the renewable energy-based rural electricity program in the future.

In the end, we on behalf of the Goverment of the Republic of Indonesia would like to thank you for the cooperation that was strengthened during this time and may the collection of lessons learned from EnDev Indonesia can benefit all parties participating in the development of renewable energy in Indonesia.

Jakarta, October 2019

F.X Sutijastoto
Director General of New, Renewable Energy and Energy Conservation

Preface

Dear Readers,

First of all, Energising Development (EnDev) would like to thank the Government of Indonesia, especially the Ministry of Energy and Mineral Resources, particularly the Directorate General for New and Renewable Energy and Energy Conservation, for its continued support throughout ten years of implementation. In addition, EnDev would like to express its gratitude to all other cooperation partners which have contributed to the success of EnDev in Indonesia.

EnDev was operational in Indonesia for a full decade from 2009 to 2019. The Directorate General of New and Renewable Energy and Mineral Resources as part of the Ministry of Energy and Mineral Resources jointly with GIZ as EnDev's implementing organisation in Indonesia have been able to improve the lives of thousands: EnDev Indonesia has provided energy access to more than 350,000 people, 2,500 public facilities and 3,500 rural businesses. More than 1,000 renewable energy mini-grids were installed with support from EnDev with a total generating capacity of about 30 MW.

EnDev supported the Government of Indonesia to achieve its target for rural electrification through the installation of renewable energy mini-grids mainly based on micro-hydropower and solar PV. A central element of EnDev's global approach is to improve local capacities. Today, EnDev Indonesia is proud to see a matured market for developing, implementing, operating, and maintaining renewable energy mini-grid schemes.

The decision to withdraw from Indonesia after a decade of successful implementation was made by EnDev's group of donors against the backdrop of a highly professionalized sector with market players for renewable energy mini-grids which today are able to run their businesses even without further support by EnDev – what an excellent proof of sustainability!

Therefore, last year's focus was to share lessons learnt from Indonesia with the global energy access community in order to sustain the impact of EnDev in Indonesia as well as to make the wealth of experience and knowledge from EnDev's activities in Indonesia available – thereby helping to contribute to energy sector transitions in other parts of the world, too.

Daniel Busche,
Managing Director, Energizing Development

Preface

In many ways EnDev Indonesia, jointly implemented through EBTKE and GIZ, has been an exceptional project. The key question was how to provide the people in remote areas of the archipelago with electricity? Like all EnDev projects it followed a grassroot approach with clear cut indicators on the number of households electrified, social institutions connected, and number of businesses supplied for productive use. To achieve its indicators EnDev has focused on the needs and capacities of the people and a strategy to make maximum use of local resources, be it the power of water or the sun to generate electricity, villagers to operate the systems, Indonesian manufacturers and installers to set them up in the remotest regions, central and local government to plan, finance and implement rural electrification programmes.

This approach of building local capacities has largely paid off. Not only have all indicators been reached or even surpassed - in the course of 10 years (2009 – 2019) 1,000 village mini grids have been supported, bringing light to over 125,000 households, 295,000 people, 3,800 social institutions and 2,900 productive use applications – but the capacities have been built to plan, install, operate and rehabilitate mini hydro power and PV-battery mini grids. Many innovative applications and business models have been introduced, ranging from solar ice makers and RE-boats to Smart Payment System. This is not only recognized locally but also internationally. Indonesia is the country with the highest number of mini grids in the world. There is an increasing interest from the international community to learn about the Indonesian mini grid experience. What works and what does not work?

This final report of the EnDev Indonesia Project was prepared by the EnDev Knowledge Hub on Mini Grids, a unit of dedicated Indonesian experts financed through the EnDev Global Program with the task to facilitate worldwide learning on mini grids. Together with other knowledge products this report is meant to serve the needs of a growing local and international mini grid community by providing a summary of the main outcomes and achievements of the EnDev Indonesia project. It is very much hoped that this report is fostering south-south-north cooperation in the field of mini grids in order to accelerate rural electrification worldwide.

My special thanks go to the EnDev team, our counterparts, all stakeholders and target groups which have made this project a success as well as to the EnDev Global team for their always generous support. It has been great fun working with you. Without you I never would have seen so many mountain ranges and islands. Not all mini grids might be working yet. To make it more sustainable requires relentless efforts by all and continuous building of local capacities. This is the way to go. The future is renewable and decentralized.

Dr. Rudolf Rauch
Director GIZ Energy Programme Indonesia

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List of Abreviations

PV	Photo voltaic
DJ EBTKE	Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi
EnDev	Energizing Development
ENACTING	Energy Access Beyond Lighting
PUE	Productive Use of Energy
BMZ	German Federal Ministry for Economic Cooperation and Development
MA NL	Dutch Ministry of Foreign Affairs
NORAD	Norwegian Agency for Development Cooperation
DFID	United Kingdom Department for International Development
SDC	Swiss Agency for Development and Cooperation
SIDA	Swedish International Development Cooperation Agency
SE4ALL	Sustainable Energy for All
NDC	Nationally Determined Contributions
MHP	Micro Hydro Power
GIZ	German International Cooperation Agency
NGO	Non-Government Organization
SME	Small Medium Enterprise
KUKM	Ministry of Cooperative and Small Medium Enterprise
KESDM	Ministry of Energy and Mineral Resources
PLN	National Electricity Utility
RUMI	Rural Mini Grid Management
KKP	Ministry of Fisheries and Marine Affair
PRAKARSA	Support Programme for Outer Islands
CSO	Civil Society Organization
BUMDES	Village Owned Enterprise
TSU	Technical Service Unit
VMT	Village Management Team
SHS	Solar Home System
ESMAP	Energy Sector Management Assistance Programme
OWT	Operation Wallacea Trust
CEFE	competency based economies through formation of entrepreneurs
BCD	business competency development
SBS	solar business system
DC	direct current
STT	Technical Higher Education
AC	Alternating Current
RE	Boat Renewable Energy Boat
MSP	Mini Grid Service Package
SPS	smart payment system
ISRE	institutional strengthening for renewable energy
LoRA	Long Range Low Power Wireless Standard
TRANSFORM	Non-Government Organization Based in West Nusa Tenggara
BAPPEDA	Regional Development Planning Agency
BPMD	Regional Community and Village Development Agency
FGD	focused group discussion
WISIONS	Wuppertal Institute for Climate, Environment and Energy
NTB	West Nusa Tenggara Province
OECD	Organisation for Economic Co-operation and Development
SPIMA	Solar Powered Ice Maker
RMS	Remote Monitoring System
TSP	Technical Service Provider
PNPM	National Programme on Community Empowerment
SMS	Short Message services
NAMA	nationally appropriate Mitigation actions
LK	Institute for Air Conditioning and Cooling in Germany
EPC	Engineering Procurement Construction
TSP	Technical Service Provider
GSM	Global System for Mobile Communication
UNM	State University of Malang
IoT	Internet of Things
RESCO	Renewable Energy Service Company
PUSDATIN	Data and Information Agency of Ministry of Energy
SOC	State of Charge of Battery
QI	Quality Infrastructure
BNPP	National Body for Border Management
SNI	Indonesian National Standard
IEC	International Electrotechnical Commission
GPRS	General Packet Radio Service
FTP	File Transfer Protocol
SD	Card Secure Digital Card
SIM	Card Subscriber Identify Module Card
ARE	Alliance for Rural Electrification

1 Introduction

Children in Pegadungan Hamlet, West Nusa Tenggara

EnDev Global History

EnDev Phase 1 Achievements
(2005 – 2009) was to provide sustainable access to modern energy services to 3.1 million people by supporting access for households, social institutions and small businesses in developing countries. However, EnDev was able to provide 5.01 million people with energy access in phase 1, thus was subsequently scaled up.

EnDev Phase 2 Achievements
EnDev's phase 2 started in 2010 and will go on until 2021. Within this project phase, EnDev was able to provide 16.27 million people with sustainable energy access until March 2019, making it 21.3 million people since EnDev started. The aim is to achieve energy access for a minimum of 22 million people worldwide by 2021. For more information about country measures, see Countries.

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

During the 2002 World Summit on Sustainable Development in Johannesburg, the Dutch Government announced to provide access to drinking water and modern energy services to **10 million poor people by 2015**. In order to accomplish the energy goal, the Dutch Ministry of Foreign Affairs (MFA NL) joined forces with the German Federal Ministry for Economic Cooperation and Development (BMZ).

The partnership was called Energising Development and started in 2005. The initiative had strong characteristics: clear outcome targets i.e. the number of people provided with sustainable modern energy services as an indicator, a high commitment of involved governments and a competition between the implementing projects in different countries to reach the outcome targets.

After finishing its first phase in 2009, further donors joined, namely the Norwegian, Australian, British and Swiss government, as well as implementing organisations such as Stichting Nederlandse Vrijwilligers (SNV), MAEVE, Humanistisch Instituut voor Ontwikkelingssamenwerking (Hivos), PracticalAction, Association pour le Développement de l'Energie Solaire (ADES) and Collaborative Labeling and Appliance Standards Program Inc. (CLASP). Since then, harmonisation of donor efforts is a key element to improve the effectiveness of development cooperation and an important contribution to achieving sustainable development, as declared in the OECD/DAC Declaration on Aid Effectiveness.

EnDev is a good example of how donor harmonisation and delegated cooperation can increase the overall impact of interventions by combining resources, avoiding duplication of efforts, and achieving economies of scale.

EnDev Global - Endev Indonesia

The Energising Development (EnDev) programme is a multi-donor partnership, currently financed and governed by the governments of the Germany, Netherlands, Norway, the United Kingdom, Switzerland, and Sweden. The respective institutions are the German Federal Ministry for Economic Cooperation and Development (BMZ), the Dutch Ministry of Foreign Affairs (MFA NL), the Norwegian Agency for Development Cooperation (NORAD), the UK Department for International Development (DFID), the Swiss Agency for Development and Cooperation (SDC) and the Swedish International Development Cooperation Agency (SIDA).

More than one billion people worldwide have no access to electricity. Almost three billion people have to rely on wood, charcoal and plant residues for cooking and heating. Energy poverty has dramatic consequences for the quality of life, the environment, health, education and income opportunities of those affected. The goals of the United Nations 2030 Agenda for Sustainable Development cannot be achieved without access to sustainable energy.

EnDev promotes sustainable access to modern energy services for households, social institutions and small to medium-sized enterprises in developing countries in Africa, Asia and Latin America. The objective of Endev is that by the end of 2021, 20 million people in partner countries will have sustainable access to a more energy-efficient, sustainable and reliable power supply.

Approach

EnDev focuses on the development of local markets for the dissemination of renewable energies and more efficient technologies for households, social institutions and companies. EnDev is currently active in 25 partner countries in Asia, Latin America and Africa. The focus is on the least developed countries and sub-Saharan Africa.

EnDev is aligned with the national energy targets and strategies of the partner countries, such as:

1. **Strategic plans for energy, forestry, health, environment and climate;**

2. **The Sustainable Energy for All (SE4ALL) initiative of the United Nations, which aims to improve access to energy, increase energy efficiency and increase the share of renewable energies in the global energy mix;**

3. **Nationally Determined Contributions (NDCs) for reducing greenhouse gas emissions.**

Endev in Indonesia has been in operation more than 10 years in 2019, the first phase was from 2005 until 2009 and the second phase was from 2009 until 2019. These two phases are for the rural electrification using renewable energy component. The component was implemented by GIZ (German International Cooperation Agency). The activities in this report is relevant for the second phase 2009 to 2019.

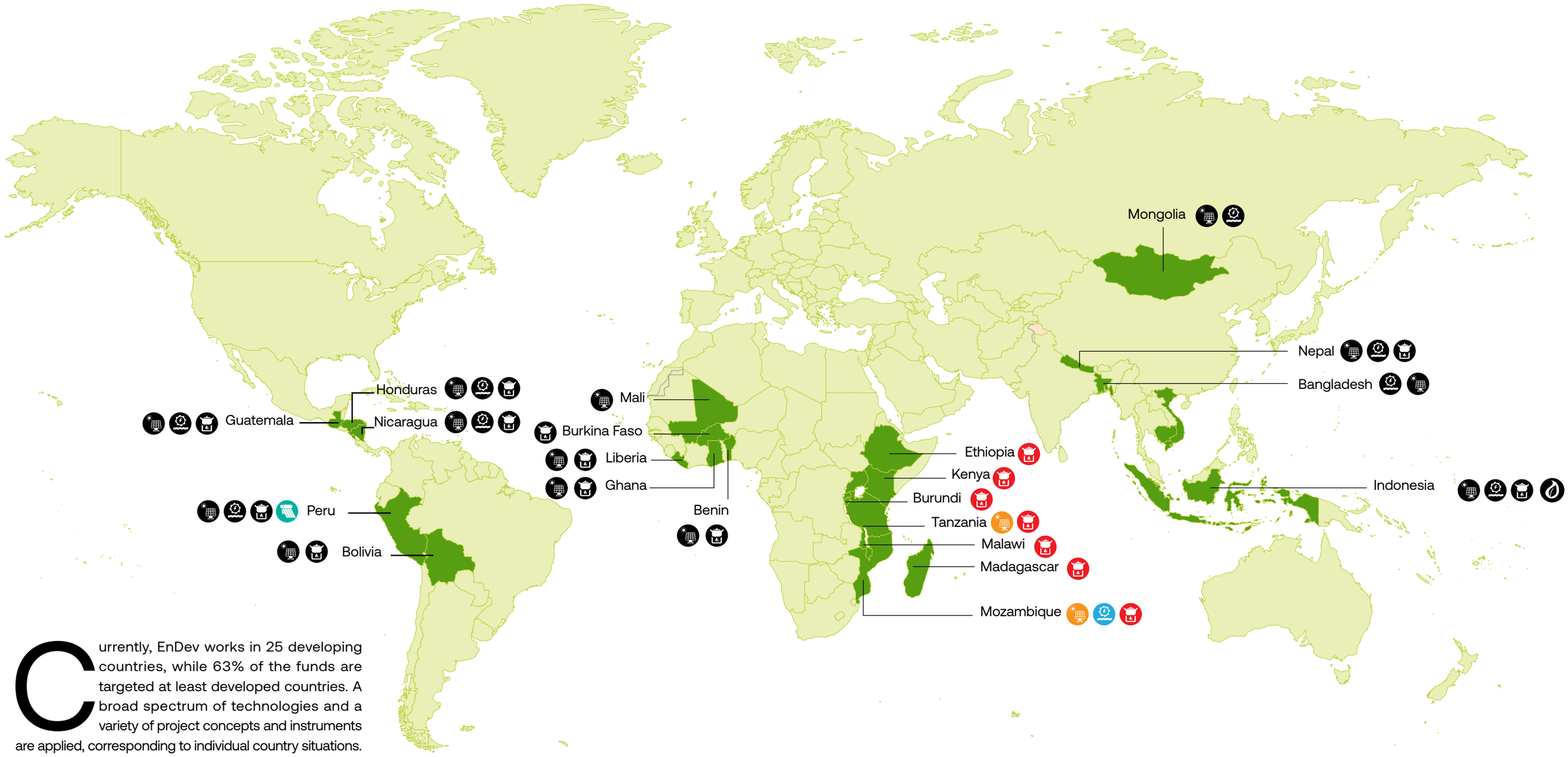
The second component specialised in biogas for domestic use through the Indonesian Domestic Biogas Program (IDBP/BIRU) and was implemented by HIVOS. The dissemination approach is based on the establishment of a market for domestic biogas installations and accessories. Investment incentives provided by EnDev and IDBP would in part be replaced by sustainable local funding sources, including carbon emission financing.

Table 1 Endev Implemented Technologies

COUNTRY	CURRENT TECHNOLOGIES
Bangladesh	PicoPV, SHS, Stoves (+ Biogas under EnDev 1, RBF picoPV
Benin	Grid, Promotion of PV Market by RBF (SHS & picoPV & solar pumps), stoves
Bolivia	Grid, picoPV, improved cookstoves, productive use
Burkina Faso	Stoves
Burundi	PicoPV, SBCS, SHS, Stoves, Others
Cambodia	Biogas
Central America (Nicaragua, Honduras, Guatemala)	Nicaragua: grid, MHPP, SHS (+stoves under EnDev1); Honduras: grid, MHPP, SHS, stoves, other
Ethiopia	Stoves, MHPP, PicoPV, SHS, SWH, RBF stoves
Ghana	Grid, PV pumping systems, cookstoves for productive use
Indonesia	MHPP, Solar Minigrid
Indonesia biogas	Biogas
Kenya	PicoPV, Stoves, Biogas; RBF stoves picoPV mini-grids
Liberia	PicoPV, SHS, Stoves, Solar Mini-grid, Others
Madagascar	Stoves
Malawi	Stoves
Mali	PicoPV, SBCS, SHS, PV-diesel
Mongolia	(+ Grid, MHPP under EnDev 1)
Mozambique	Grid, MHPP, PicoPV, SHS, Stoves
Nepal	Grid, MHPP, RBF stoves
Peru	Grid, PicoPV, SHS, SWH, Stoves, Others, RBF solar and stoves
Rwanda	MHPP (on-grid), picoPV and SHS, mini-grids (solar, hydro), biogas
Senegal	Grid, PV-diesel, SHS, Stoves
Tanzania	PicoPV through RBF, Stoves
Uganda	Grid, MHPP, PicoPV, SHS, Stoves
Vietnam	biogas, RBF

source: https://endev.info/content/Countries

EnDev Global History



Currently, EnDev works in 25 developing countries, while 63% of the funds are targeted at least developed countries. A broad spectrum of technologies and a variety of project concepts and instruments are applied, corresponding to individual country situations.

A thorough monitoring system measures the results on a permanent basis: by March 2019, a total of

21.3 million people **21,150** social institutions and **46,200** small and medium enterprises

PV · Microhydro · Stoves · Solar Water Heater · Biogas

EnDev in Indonesia

EnDev in Indonesia consisted of two components, namely: electrification using micro hydro and solar power, and biogas for domestic use. The former component specialised in rural electrification through small-scale renewable energy powered mini grids, utilising micro hydropower (MHP) and photovoltaic (PV) technologies with the system capacity ranging from 5 to 400 kW.

The systems are operated, maintained, managed and administered directly by the community. The infrastructure is funded by various national programmes while EnDev focuses on two implementation areas: basic technical quality assurance and sustainability enhancement and institutionalising rural electrification support to various local stakeholders. While the partner programmes cover MHP and PV hardware and installation expenses, EnDev Indonesia conducts interventions which comprise of:

1. Technical assistance and policy advice,
2. Capacity building through training, mentoring, and workshops,
3. Encouraging entrepreneurial skills for rural business owners, as well as
4. Promoting a sustainability monitoring approach and respective methods.

EnDev in Indonesia has been in operation more than 10 years in 2019, the first phase was from 2005 until 2009 and the second phase was from 2009 until 2019. These two phases are for the rural electrification using renewable energy component. The component was implemented by GIZ (German International Cooperation Agency). The activities in this report is relevant for the second phase 2009 to 2019.

The second component specialised in biogas for domestic use through the Indonesian Domestic Biogas Program (IDBP/BIRU) and was implemented by HIVOS. The dissemination approach is based on the establishment of a market for domestic biogas installations and accessories. Investment incentives provided by EnDev and IDBP would in part be replaced by sustainable local funding sources, including carbon emission financing. For this report, EnDev will represent the rural electrification using renewable energy component.

Objective and Function

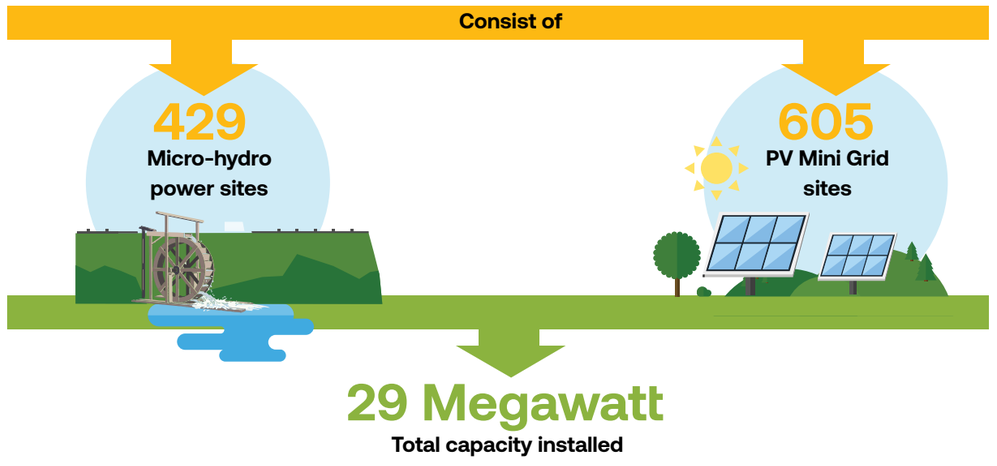
EnDev Indonesia had conducted various measures to ensure that the provision of access to electricity were performed with high quality technology and installation as well as anchoring in a supportive environment which involves diverse local actors and stakeholders. Local actors and stakeholders hold critical role to sustain the access to electricity and enable the beneficiaries to leverage their quality of life.

Acknowledging that the readers will come from diverse backgrounds and interests, thus the report is categorised in four themes: (a) Catalysing economic development, (b) Technology innovation and transfer, (c) Collaboration with public and private, (d) Quality assurance, and (e) Knowledge and data management. Each of the themes is described on five sections:

a. Process to explain sequence of activities and its rationale
b. People who were both actively and passively involved in the activities and being impacted by the outcome
c. Resources that are required to conduct such measures comprise material, budgets and other kind of resources
d. External factors which affected the output and outcomes of the activities. It includes opportunities and threats to the activities in the project
e. Recommendations that highlights guidance on what and how activities in the similar theme or topic can be conducted in a more effective and efficient manner. The suggestions are based on the evaluation and lessons derived from experiences.

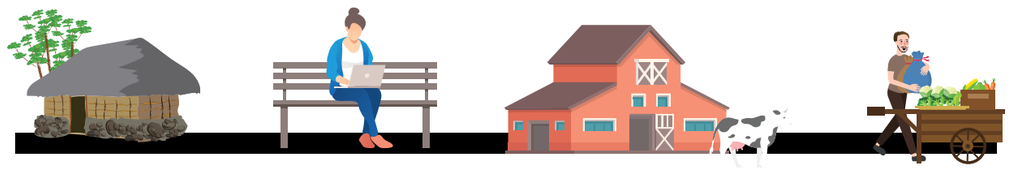
EnDev Fun Facts 2019

1,034 Renewable energy-based power plant's site, supported by EnDev Indonesia

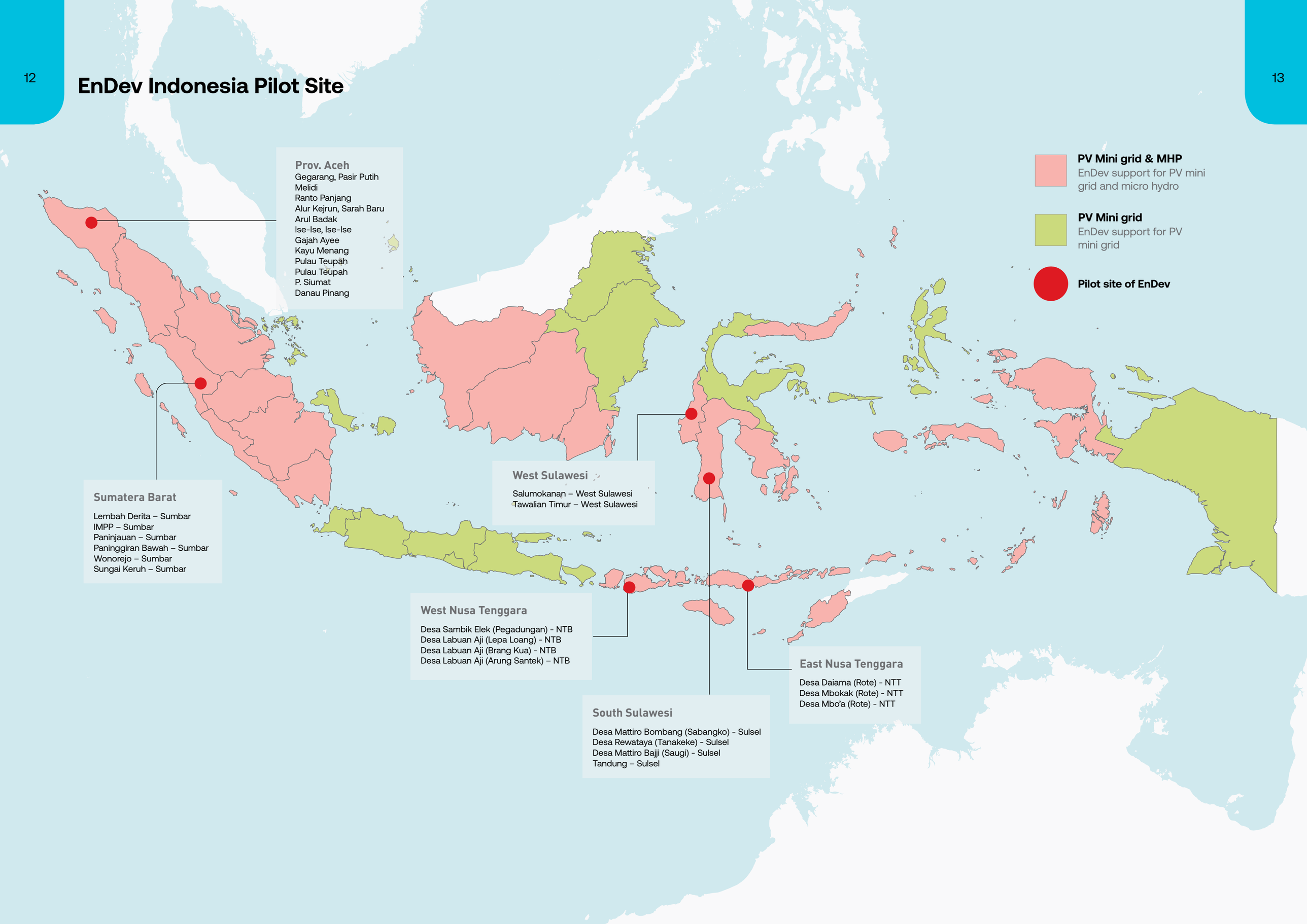


The systems provide electricity for:

125,182	295,607	3,832	2,959
Households	People	Social infastructures	Rural businesses

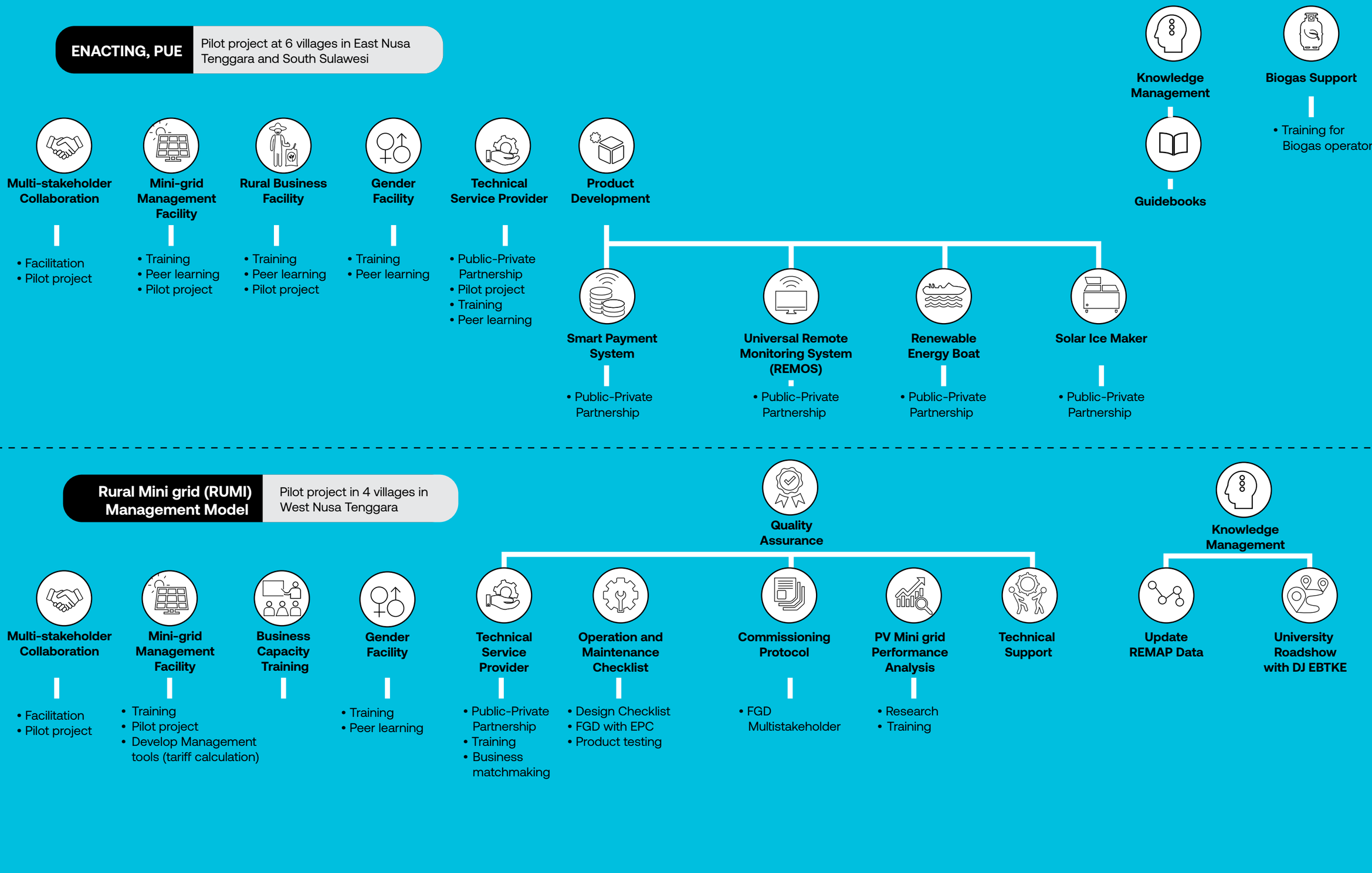


EnDev Indonesia Pilot Site



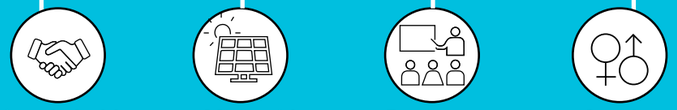
Illustration

– EnDev grand-map (timeline and evolving activities) will be simplified and each chapter will be represented by icons. Detailed timeline-activities will be shown in each respective chapters (based on icons), examples: ENACTING schemes will be shown in chapter “catalysing econ” and “collaboration” etc. high res picture:



Rural Mini grid (RUMI) Management Model

Management Model Pilot project in 4 villages in West Nusa Tenggara



Multi-stakeholder Collaboration

- Workshop economic development

Mini-grid Management Facility

- Training
- Pilot project
- Develop management tools (tariff calculation)

Business Capacity Training

- Training
- Pilot project

Gender Facility

- Training

Technical Service Provider

- Training
- Develop OM services and product knowledge

Training Pejabat Penerima Hasil Pekerjaan (PPHP)

- Module development
- Classroom training
- Field-visit

Review on PV Mini grid Specification

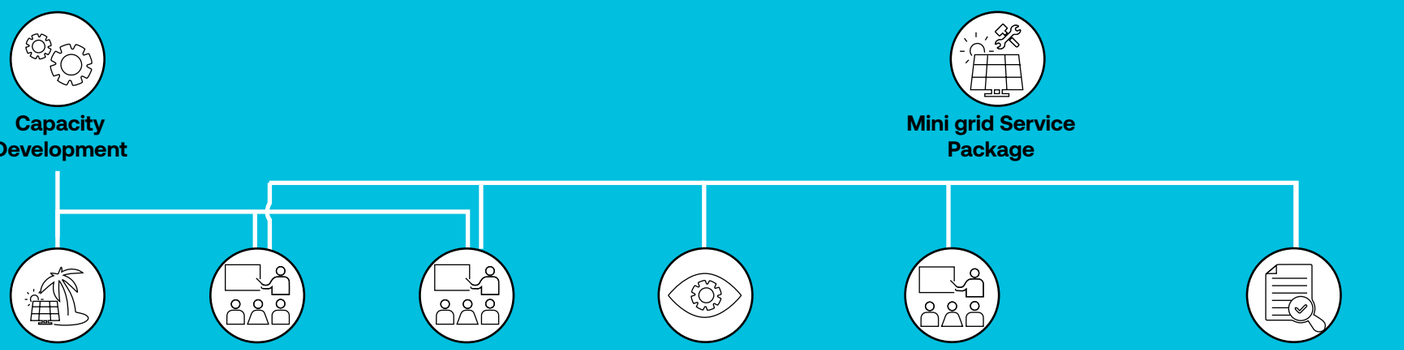
- FGD Multistakeholder
- Data collection
- Inspection visit
- Gap analysis

Develop Guidebook on PV Mini grid Installation (Do's and Don't's)

- Research
- Writing
- Editing and final Production

Support for Revitalisation of PV Mini grid

- Support evaluation



Capacity Development

Facilitation for PV Mini grid in Outer Islands

- Training for community facilitator
- On-the-job training and coaching
- Multi-stakeholder collaboration

Training for PV Mini grid Operators

Training for PV Mini grid Manage-ment Team

Mini grid Service Package

Technical Review

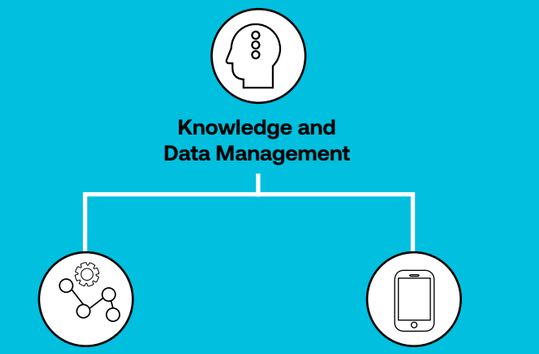
Training for technical reviewers

Evaluation and analysis of installation quality

Monitoring Evaluation

Biannual Monitoring

- Routine phone call with mini grid operators
- Research and analysis



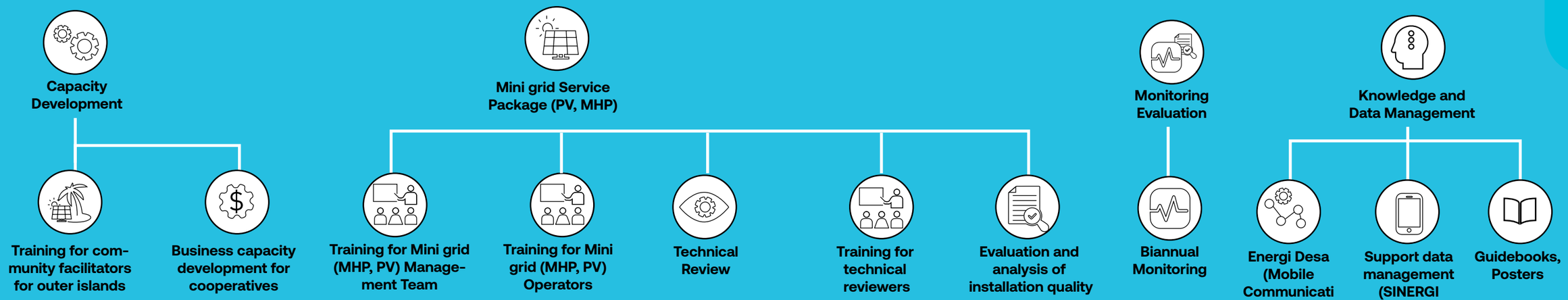
Knowledge and Data Management

Support data management (SINERGI DESA)

- Develop web and process flow
- Training for provincial government
- Develop communication material

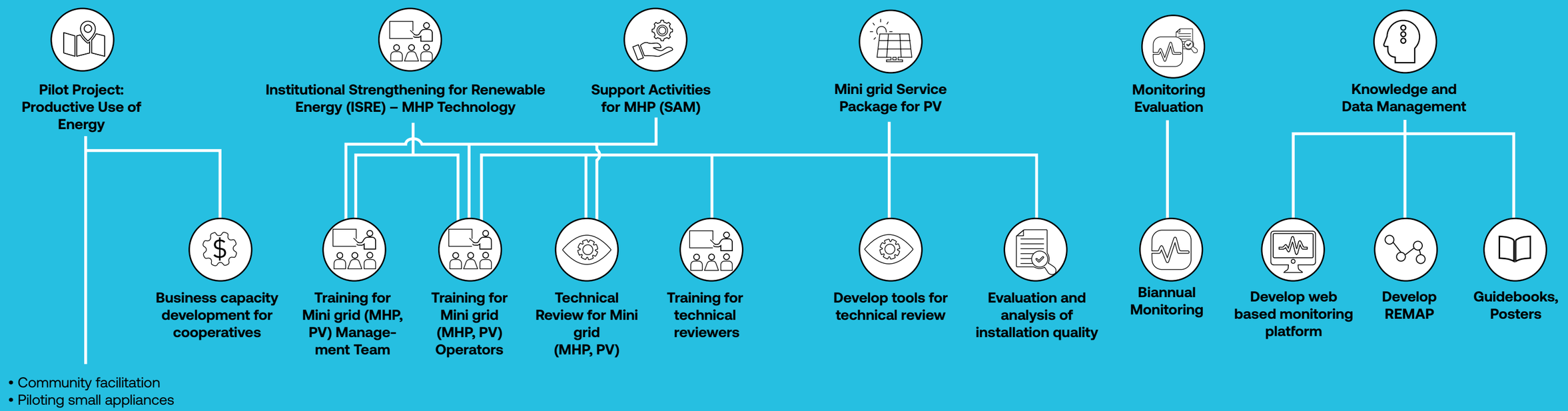
Energi Desa (Mobile Communication Platform)

- Administer forum Q&A, and Articles on RE technology



2015

2015



2014

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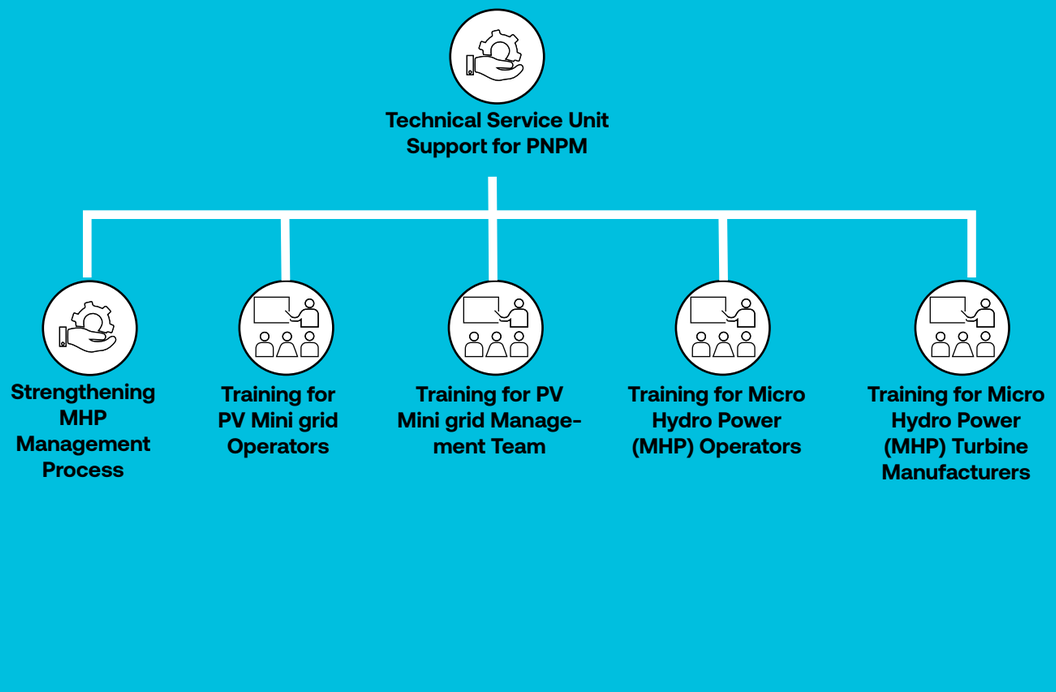
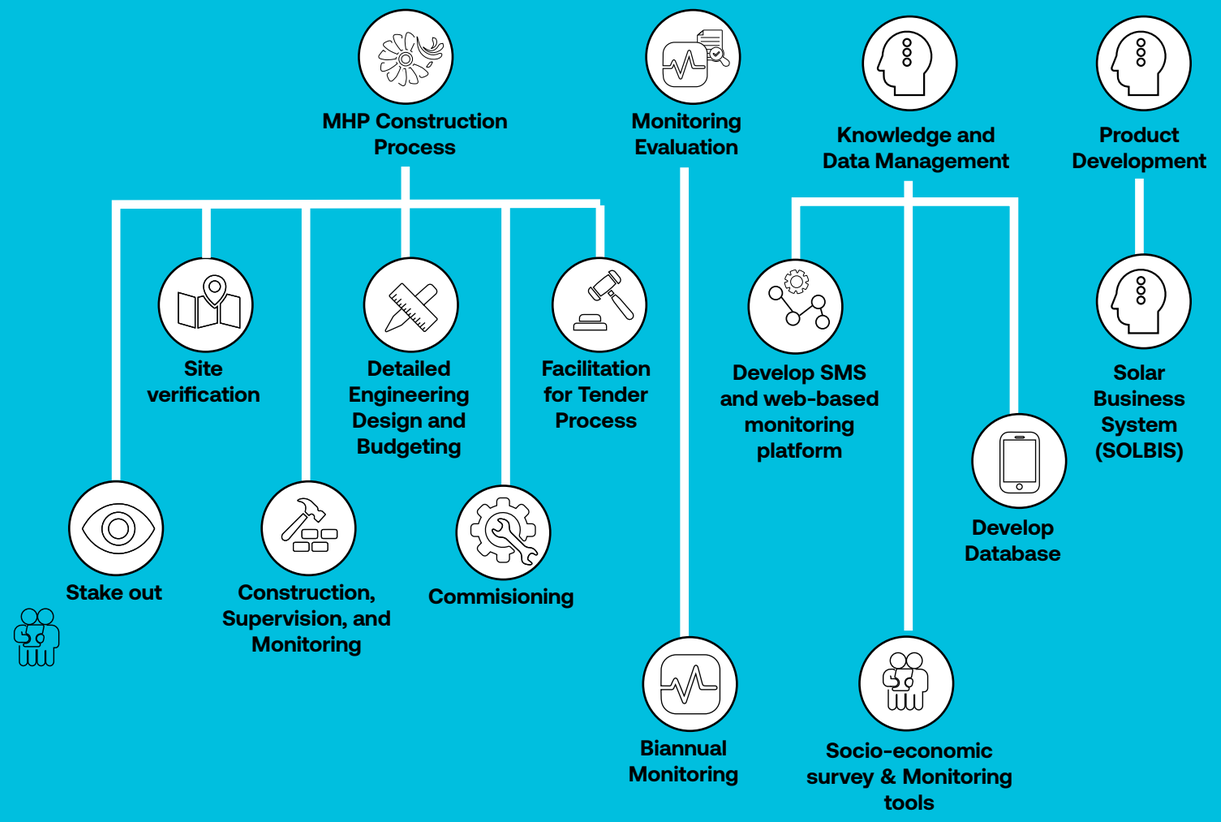

Technical Service Unit Support for PNPM
Strengthening MHP Management Process
Training for PV Mini grid Operators
Training for PV Mini grid Manage-ment Team
Training for Micro Hydro Power (MHP) Operators
Training for Micro Hydro Power (MHP) Turbine Manufacturers


MHP Construction Process
Site verification
Detailed Engineering Design and Budgeting
Facilitation for Tender Process
Stake out
Construction, Supervision, and Monitoring
Commisioning
Monitoring Evaluation
Biannual Monitoring
Knowledge and Data Management
Develop SMS and web-based monitoring platform
Develop Database
Socio-economic survey & Monitoring tools
Product Development
Solar Business System (SOLBIS)

2010-2013

2
Catalysing Economic Development

This chapter highlights EnDev supports to catalyse economic development in pilot areas where renewable energy technologies, namely micro-hydro power and PV mini grids, are present in Indonesia. Energy is a key input to leverage economic activities in an area. Hence, it is highly expected that the economy will be developed in the respective area after the supply of energy is secured, such as the energy that is generated from a PV mini grid. Moreover, it can also advance the existing economic activities to be more effective and efficient by using electrical appliances for their processes.

Catalysing Economic Development

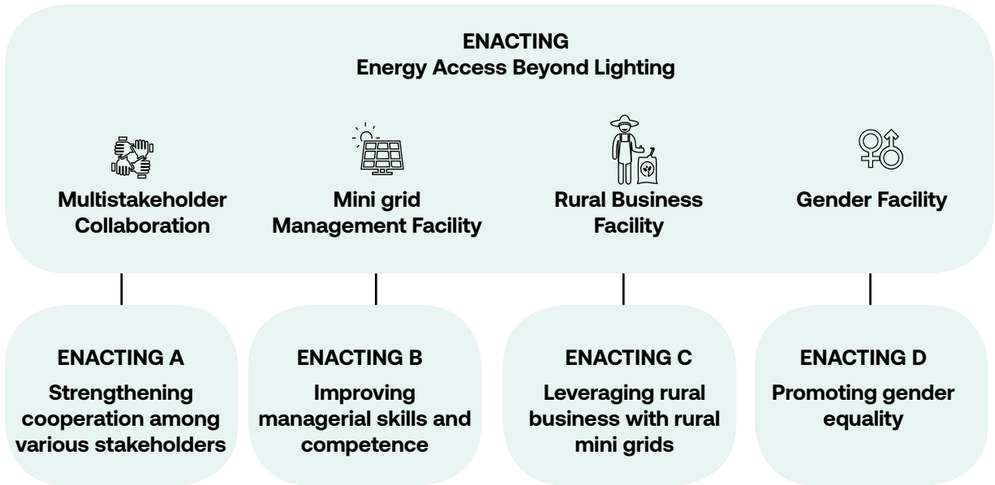
As an archipelagic country, provision of equal access to 24-hour of energy supply is a challenging task coupled with unequal access to education and basic services. Therefore, the Indonesian government rolled out a massive installation of renewable energy mini grids to accelerate the efforts to achieve 100% electrification ratio. The majority of these mini grid systems are sourced from renewable energy and managed by the rural community including the operation, maintenance, and tariff collection. In the long-term perspective, better economic condition of the respective community will improve their ability to pay which subsequently will sustain the installed mini grids. Moreover, basic services will also be improved such as in the education and health services which in turn fuelling long term human development.

EnDev has implemented various measures to catalyse knowledge and skills of the rural communities to identify and harness the available but untapped opportunities. These measures targeted the communities where the mini grids from DJ EBTKE are present. The approaches varied, could be direct for example by delivering business development trainings and financial support to procure production tools. It could also be indirect approaches such as through the installation of smart payment system to automate tariff calculation hence the extra use of energy for economic activities can be more manageable.

EnDev has collaborated closely with different partners for pilot projects implementation. Among others, an Indonesian energy start-up to develop the smart payment system, international manufacturer of outboard electric motor from Germany, and numerous community facilitators as a local mentor for mini-grid operation and management. EnDev has also engaged the relevant government institutions at both provincial and regency levels. The wide range of collaboration was an effective strategy to create and catalyse the available opportunities to ensure greater positive economic impact to the mini grid communities.

Endev Indonesia was also heavily engaged with the relevant government institutions especially at provincial and regency levels. These collaboration measures were an effective strategy to create and catalyse the available opportunities which in turn will ensure greater positive economic impact to the mini grid communities.

Figure 1 Group of activities in ENACTING



Process

Supports to promote and kickstart the implementation of productive use of energy (PUE) in the rural communities had been one of the core elements of EnDev project. PUE is the key to sustainable mini grids as it can increase the energy utilisation whilst also increasing customers' ability and willingness to pay for their energy cost. The PUE-related measures were taken in both direct or indirect intervention which then adapted to various target groups.

Through 10-years of EnDev project in Indonesia, the initiative to support implementation of PUE had been evolved into various forms and involving various stakeholders from many sectors and every layer of government administration. To simplify the explanation in this report, EnDev categorised the supports based on the key areas that play significant roles in catalysing economic opportunities, namely

A
multi-stakeholder collaboration facility;

B
Mini-grid management facility;

C
Business facility; and

D
Gender facility. The following sections will uncover EnDev Indonesia activities in catalysing economic development based on the categorisation.

The following sections will uncover EnDev activities in catalysing economic development based on the categorisation.

A. Multi-stakeholder Collaboration

EnDev had observed many examples that rural mini grids were significantly improved when the served community had a proactive administration and better economic condition to be able to pay for the electricity tariff. To enable the supportive environment for the rural mini grids, EnDev had to connect the dots in various aspects to sustain their operation. Hence it pulled many institutions in the regional and national level to collaborate and align their activities to support the rural mini grids. In the early phase of PUE in MHP, good examples come from West Sumatera where the regency government had positioned themselves approachable by the rural mini grid communities, proactively supported to sustain their operation, as well as the presence of reliable technology providers in the area. Thereby MHP systems in West Sumatera are flourish and well maintained with notable examples such as the community who was able to maintain MHP for more than 15-years and produced prayer sets to be exported to neighbouring countries.

The examples of sustaining MHP invigorated the pilot to catalyse economic activities after rural mini grids operated. The pilot was conducted for communities surrounding micro-hydro power (MHP) in West Sumatera and South Sulawesi. There were 11 businesses supported in total for the first pilot. It was mostly driven by EnDev in collaboration with local NGOs as facilitators. We soon found that the results were encouraging, hence EnDev collaborated with Ministry of Cooperatives and SME (KUKM) to

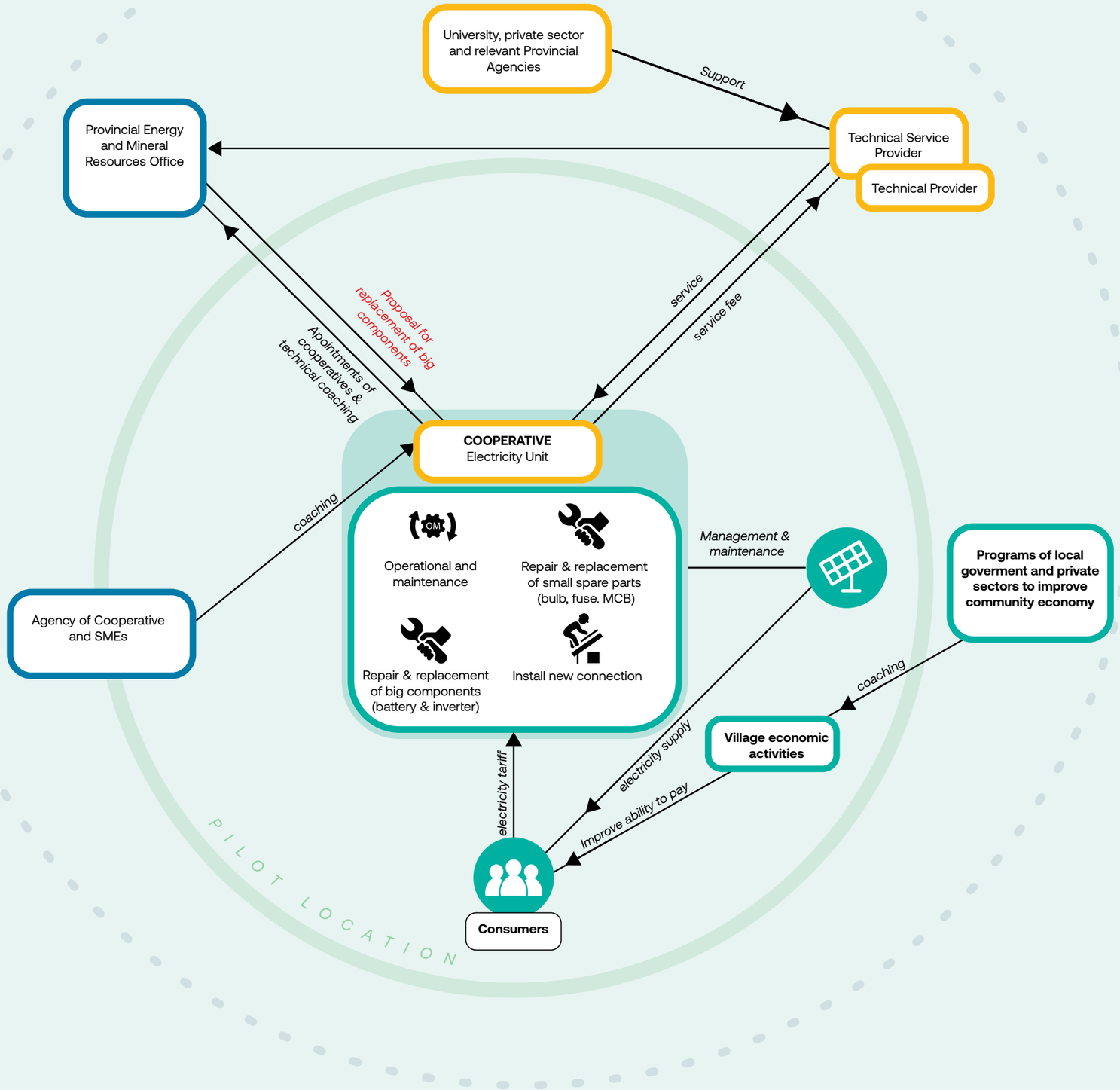
support their MHP programme for cooperatives. The collaboration was conducted within the cooperation framework between KESDM and KUKM.

KUKM granted an MHP system for up to 24 cooperatives as a capital to expand their line of business such as to manage electricity services and power their existing business with electrical tools or machineries. It also aimed to increase their productivity. In the cooperation, EnDev delivered business trainings for cooperatives' management team and members as well as conducted technical review of the MHP systems. The electricity services were possible because all the cooperatives were located at the outskirt of PLN service areas.

Cooperation with KUKM were maintained in the topic of catalysing economic development whilst also conducted support for Ministry of Fisheries and Marine Affairs (KKP). In 2016 to 2018, KKP initiated a programme to send young community facilitators to the defined small and outer islands. They were facilitating development in the village and become partners for the rural communities and village administration for at least eight months which was called PRAKARSA. EnDev roles in this programme were to train the community facilitators before their assignment, deliver on-site coaching as well as documenting learnings from the programme especially in two locations in North Sulawesi and Maluku. The training comprises of technical aspects of PV mini grids, community facilitation techniques and business capacity development. Focus group discussions and workshops were held involving various stakeholders namely village heads, provincial government officials, private sectors who were interested in developing island communities, NGOs, CSOs, and officials from relevant ministries. During the support in PRAKARSA, EnDev was able to closely engage with the provincial and regency officials, especially from the Mining and Energy Office, Cooperatives and SMEs Office, as well as Marine and Fishery Office.

The collaboration between KESDM (through DJ EBTKE), KUKM, and KKP unfolded valuable opportunities to further cooperate between the ministries and highlight the importance to strengthen the roles and capability of provincial governments in catalysing economic development with renewable energy mini grids. Hence, EnDev rolled out a pilot programme to involve more

Figure 2 RUMI Model and Stakeholders



institutions in the relevant sectors and at different levels from national to village administration. The pilot programme was called Rural Mini Grid Management (RUMI) Model with Nusa Tenggara Barat as its pilot site. It aimed to develop a practical management model for government-funded PV mini grids. The decision where the pilot should be conducted were carefully analysed by EnDev team.

RUMI strategy was to approach the problem by facilitating change in the village, especially to formalise the mini grid management team, and influence strong cooperation among institutions in the province level. This strategy was implemented through a-year long community facilitation process, series of trainings for technicians, private sectors, operators, and village communities, as well as many negotiation processes with various relevant institutions through meetings and workshops in the provincial level. Having a running pilot mechanism in the village level posed a great benefit for the multi-stakeholder cooperation. Direct interactions and facilitation in the village provided actual and practical inputs for better cooperation among stakeholders. For example, any changes in the policy or support activities from the relevant institutions can be directly evaluated by the villages which in turn triggered more discussions and collaborations among them. More details and result of the programme can be found in the RUMI Model Report and Factsheet.

The initiative which was started to demonstrate feasible PUE in several locations had evolved into an intense facilitation at many levels of government administrations to catalyse economic development using mini grids from renewable energy. Local based NGO was hired to conduct a-year long facilitation in the province and village level. Equipped by a clear objective and close supervision by EnDev, the local NGO was able to gather supports from various stakeholders and achieve the objectives. Stakeholders involvement were deepened and widened, as illustrated in the diagram of ENACTING. The diagram shows a range of activities taken through different stages and resumed in more comprehensive measures in the latest pilot project by EnDev, called ENACTING.

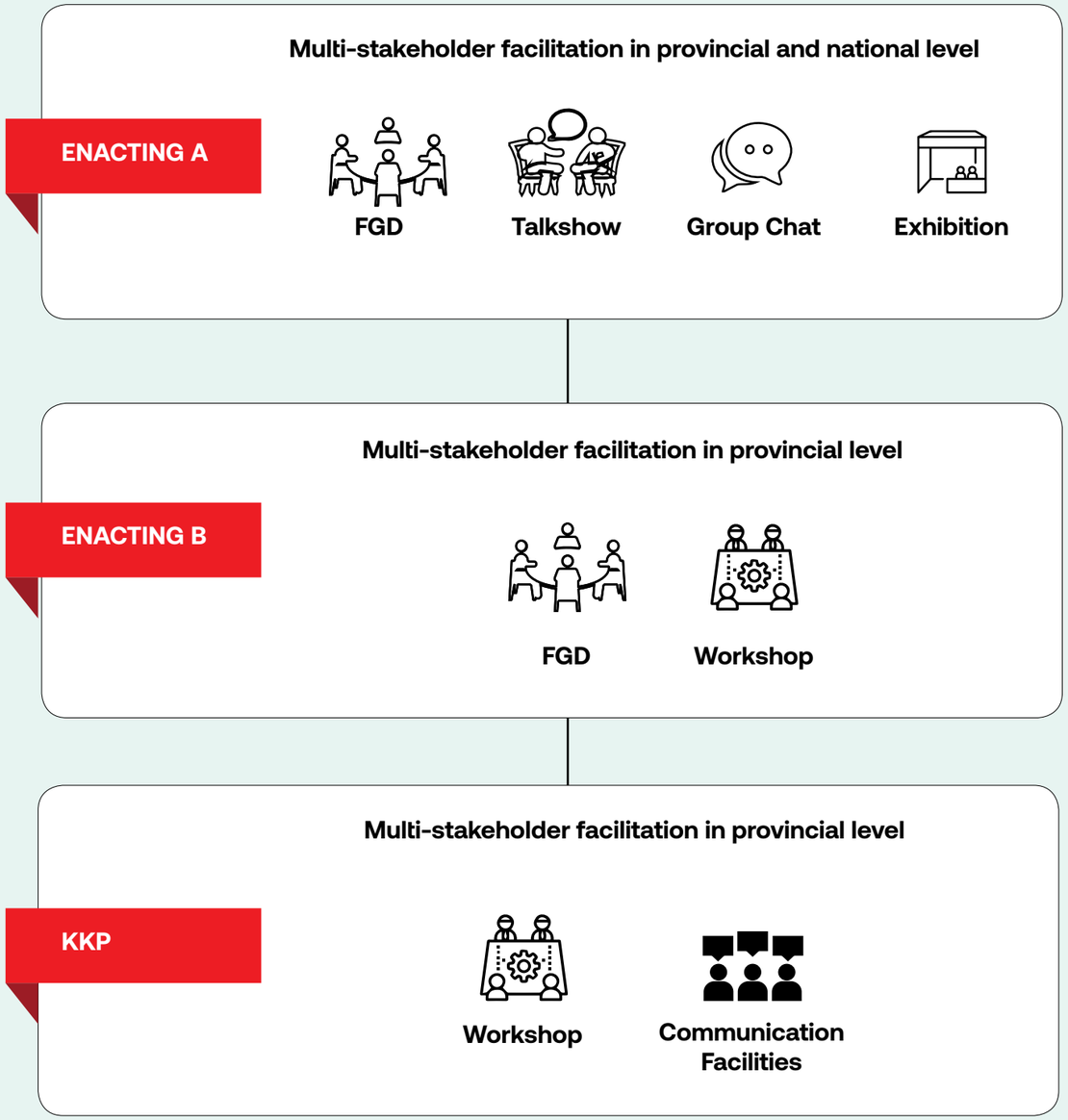
The collaboration between KESDM (through DJ EBTKE), KUKM, and KKP unfolded valuable opportunities to further cooperate between the ministries and highlight the importance to strengthen the roles and capability of provincial governments in catalysing economic development with renewable energy mini grids.

Learning from RUMI Model, EnDev found that facilitating economic development need more measures to create buy-in from the policy makers as well as in-depth business coaching for the rural businesses. Hence, ENACTING program was created and implemented in two provinces with high numbers of PV mini grids namely, Rote Regency in East Nusa Tenggara, and Pangkajene Kepulauan Regency in South Sulawesi. The pilot was implemented in two provinces aimed to exercise how diversity in local customs and circumstances could influence the measures and results. This section explains ENACTING activities in facilitating multi-stakeholder collaboration whilst the other measures will be explained in the next three following sections.

ENACTING which stands for Energy Access Beyond Lighting pulled more stakeholders with aligned objectives to catalyse economic activities using renewable energy power. The stakeholder mobilisation aimed to ensure that the renewable energy based economic activities are taken care by the suitable government units as well as securing the political supports and commitment from the provincial and national governments. EnDev grouped the stakeholders into two as shown in the table.

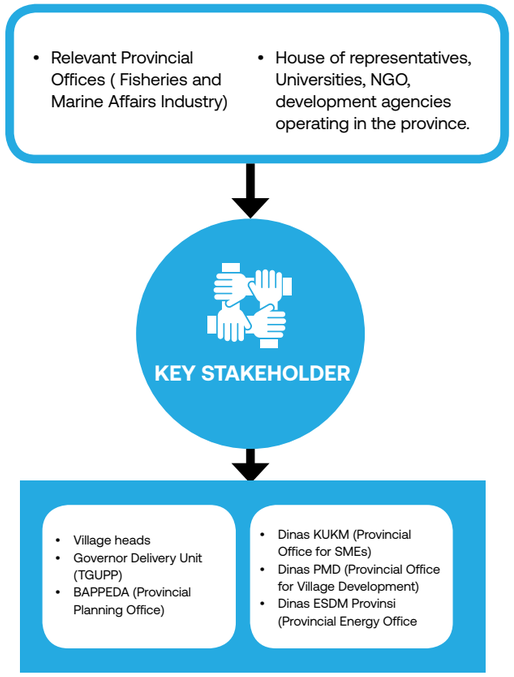
It was pursued by conducting series of formal and informal meeting as well as` focus group discussions at provincial level to bring all relevant stakeholders discussing about alignment and collaboration in their activities to catalyse economic development in the area.

Figure 3 ENACTING A Diagram



Results of these measures were shown in the following activities by the provincial government. In South Sulawesi, the government of Pangkajene Kepulauan and Takalar regencies had continued supports for the communities in the three pilot villages. They provided them with additional trainings, production tools and support in marketing. In East Nusa Tenggara, the communities whom supported by ENACTING pilots were fully aware about rapid development of tourism sector will give them more economic opportunities thus they were very active in promoting their products and using electricity from their PV mini grids to increase productivity. Based on these experiences, EnDev highlights the importance of assistance, trainings and efforts to open the communication between the rural community and stakeholders are keys to empower communities in the disadvantaged villages.

Figure 4 Categorisation of stakeholders



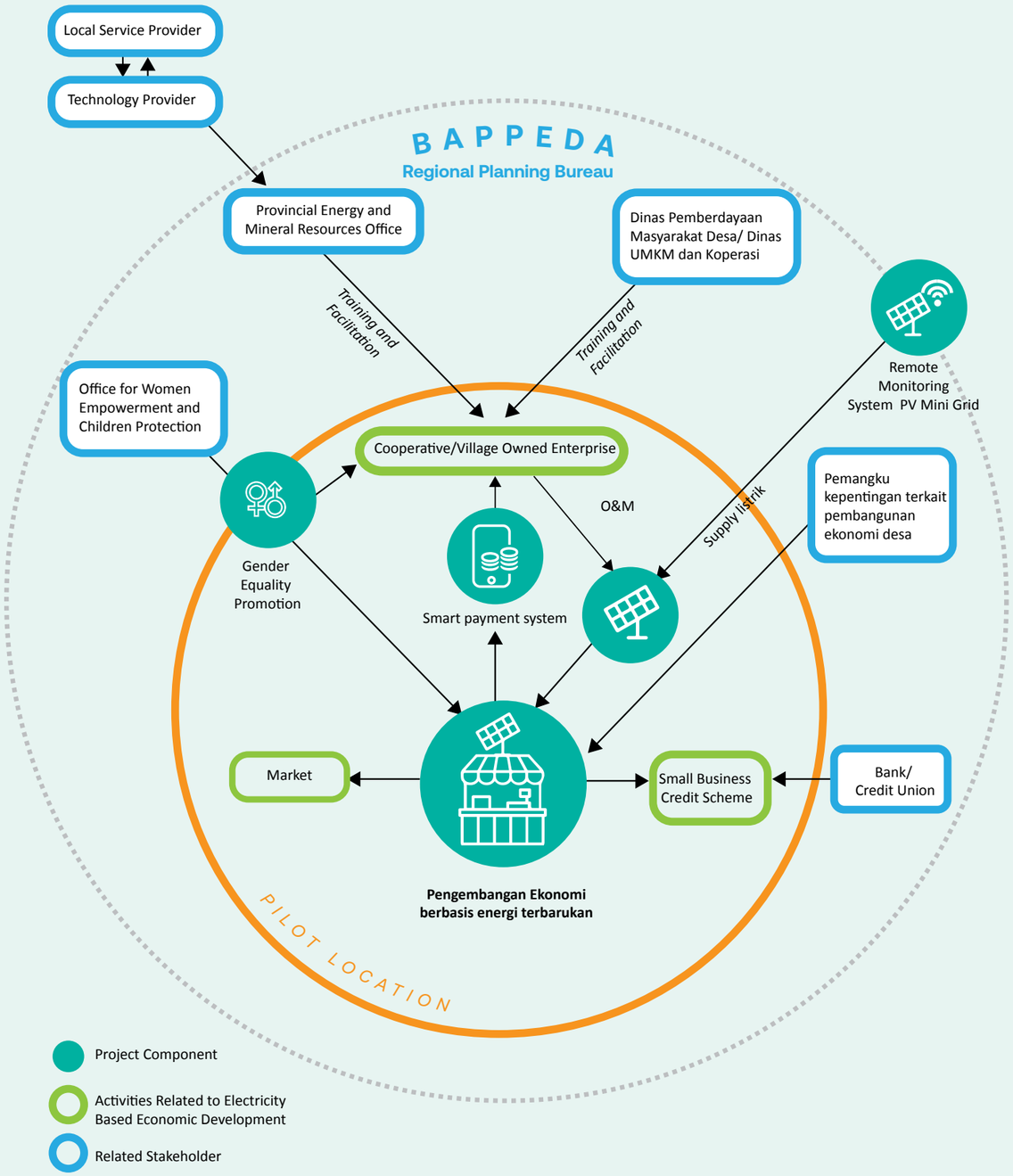
ENACTING DIAGRAM

Multi-stakeholder facilitation in ENACTING had gone beyond provincial level. Leveraging the simultaneous activities in the two provinces, ENACTING facilitated peer-to-peer learnings among the mini grid management teams and rural businesses. The rural businesspersons were sent to learn about food production and marketing in Yogyakarta. In the meantime, PV mini grid management teams and village heads learnt about using PV mini grid to build village-owned business (BUMDES) from an award-winning example in Muara Enggelam, East Kalimantan. Through these interactions, a bonding between them was formed and the network was maintained through a popular group chat platform. The group chat, moderated by the business coach and community facilitators, has enabled them to exchange and foster collaboration among them. These remote interactions emphasize the needs of reliable and proper internet services for the community.

At the end of the piloting period, EnDev highlighted the importance of public awareness about the opportunities in multi-stakeholder collaboration to catalyse economic development, especially with renewable energy mini grids. Therefore, on top of dissemination workshops and public reports, EnDev held series of public talk-show involving our stakeholders as the speakers. They were consisted of a PV technology company, ministries, provincial government, and NGOs. The talk shows were held and aired on RRI (a state radio) in Makassar, and Kupang while for the session in Jakarta was aired through a social media live feature. The public discussions had become a place for renewable energy practitioners, academicians and enthusiasts to exchange about their thoughts and initiatives in the sector and other relevant topic to be collaborated.

Despite multifaceted measures had been taken to overcome the challenges, frequent structural changes and transfer of staffs in the government institutions often disrupt the ongoing cooperation and slowing down the implementation of the supporting activities. These risks are apparent and must be mitigated early in the process.

Figure 5 ENACTING stakeholder landscape and interrelation



B. Mini Grid Management Facility

Economic activities in the rural mini grids can be leveraged when the mini grid systems are able to supply reliable power for the users. This condition only possible if it is managed properly. Most of the government-built mini grids, both for MHP and PV, are managed by informal community groups who were nominated by the village prior to its installation. A large gap in education and skills in rural area required additional trainings and close assistance from the assigned authority. Moreover, complexity in bureaucracy, especially in the asset handover process, had left the community in uncertain conditions whether they were able to conduct repairment when there was any troubleshooting was required. Hence, to prepare the management team about the upcoming responsibilities, EnDev had anchor its work to strengthen their competence and skills in the managerial aspects and introduced various alternatives for them to improve their operation.

EnDev commenced by delivering trainings for MHP practitioners, which comprised of the management teams, operators, and local turbine manufacturers. Trainings for village management team and operator were consistently delivered which comprised of modules basic administration, basic MHP and PV mini grid, and community development techniques to formulate rules and agreement. The trainings comprised of classroom sessions, and practical trainings in the village. The trainings were delivered by experts and practitioners in MHP and PV mini grid. During support for MHP in 2009-2013, EnDev had a local structure called Technical Service Unit (TSU) with provincial offices in West Sumatera and South Sulawesi. All the trainings material and documentation were documented in several publications and multimedia products. Resumes of all the key aspects in the mini grid management were formulated in a book “Best Practice Guideline of Off-Grid Micro Hydro Power Schemes for Rural Electrification” which involved various MHP experts and practitioners in Indonesia. During 2013 – 2019, the training modules for MHP which had been adapted into PV mini grid context were used by the local trainers. One of the complex challenges in the rural mini grid management lays in the mechanism for tariff collection. The tariff in the rural mini grid was not yet reflective to the actual development cost because the initial development costs were grant funded by the government. Hence, there were multiple interpretation whether the community should pay for the electricity or not. In practice, implementing tariff is necessary to cover managerial and operational expenses for the management team to sustain the electricity supply. To solve this puzzle, EnDev formulated a tariff calculation tool to equip the management team finding a proper tariff for their service. The tool recommended a flat tariff calculation and pay per usage tariff.

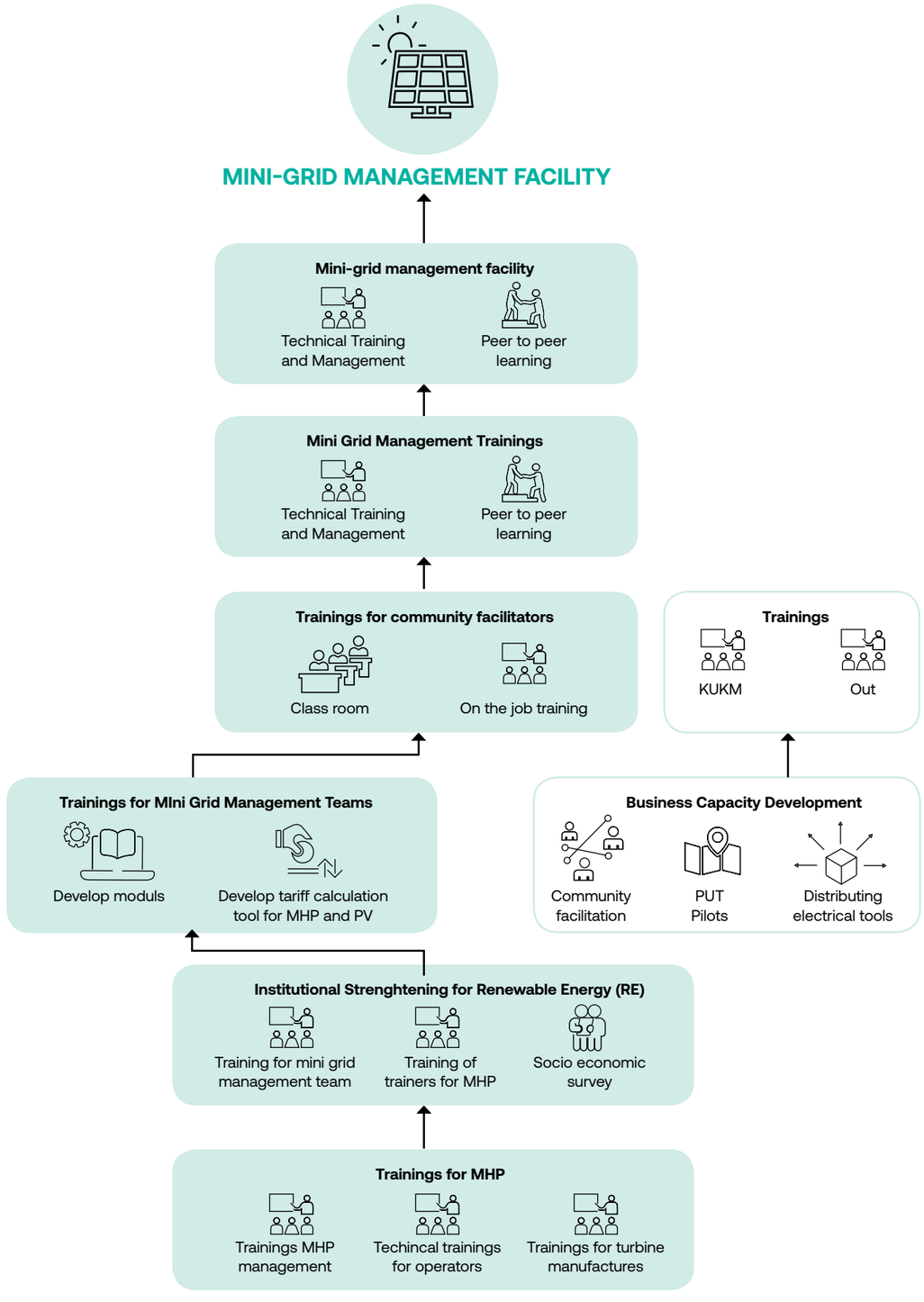
EnDev had anchored its work to strengthen their competence and skills in the managerial aspects and introduced various alternatives for them to improve their operation.

RUMI Model

A flagship programme to strengthen the management quality of rural mini grids was called Rural Mini grid Management (RUMI) Model which then followed by ENACTING pilot in the two provinces. RUMI mission was to formalise the village management team (VMT) into an organisation with legal basis, such as village-owned company (BUMDES), or cooperatives. Prior to RUMI pilot, the mini grid management teams were organised organically without legal basis except for an official letter from the Governor Office and implemented modest and traditional rules to manage the operation. The setup was found not effective to sustain the mini grid operation and handicapped them from expanding the services to encourage more economic activities in the village. The situation Is not particular to NTB, it happened in most rural mini grids where EnDev had been monitored. Hence, the result from RUMI pilot activities become a reference to be adopted by other stakeholders to improve and sustain rural mini grids.

Formalities are important for the management team to be acknowledged of their works and accessing various supports from the government institutions, donors and private entities. Moreover, formal

Figure 6 Mini Grid Management Facility



organisation will improve their accountability and be able to access financing schemes available to sustain and expand their services. The diagram below shows the interlinkages of activities with the relevant stakeholders to strengthen the village management team (VMT).

Activities in RUMI are explained in the diagram of implementation process below. RUMI model had proved that the VMTs were eager to improve and proactively expand their services. Those four sites in NTB had already completed their legal process to become a cooperative and still operating well whilst more rural businesses are emerged. In RUMI Model, trainings were routinely held with different topics for the rural communities, local practitioners and technicians. Followed by coaching or mentoring sessions which usually more informal and relevant to the context of their daily challenges in managing the rural mini grid. Contextualising the management techniques through daily discussions and supports had helped the trainees to implement better and improved the effectiveness of trainings.

Results from RUMI Model had enriched our knowledge and experiences on how to formalise the VMT. In addition to lessons from RUMI Model, our past activities with PRAKARSA had also given deep insights from the facilitating activities on site. Hence EnDev set focus to catalyse economic development by renewable energy mini grids in the rural area. The focus was a response to the Government direction to use the installed PV mini grids and solar home system (SHS) from them to only serve the needs for lighting and very small numbers of other appliances, which are equal to the first tier of electricity access based on the ESMAP report.

Learning experiences about rural mini grid management were enhanced for the activities in ENACTING. The VMT from the pilot sites were travelled with EnDev to learn from the award-winning management team

for PV mini grids, BUMDES Bersinar Desaku, in Muara Enggelam, East Kalimantan. In 2018, the BUMDES Bersinar Desaku had expanded the capacity of their PV mini grid by 12 kWp that was fully funded by their savings. The benchmark visits had given very positive impacts in the participants by expanding their horizon and increase their confident level to manage their PV mini grid. The interaction has been continued through a popular chat application and they have been actively exchanging experiences in many topics around managing the rural mini grid and economic development. Some of the follow ups from the peer learning activities were community gathering to plan integration of the PV mini grid management team to village-owned company (BUMDES), structure, electricity tariff, and strengthen their statutes and bylaws.

In RUMI Model, trainings were routinely held with different topics for the rural communities, local practitioners and technicians. Followed by coaching or mentoring sessions which usually more informal and relevant to the context of their daily challenges in managing the rural mini grid. Contextualising the management techniques through daily discussions and supports had helped the trainees to implement better and improved the effectiveness of trainings.

Figure 7 Implementation Process

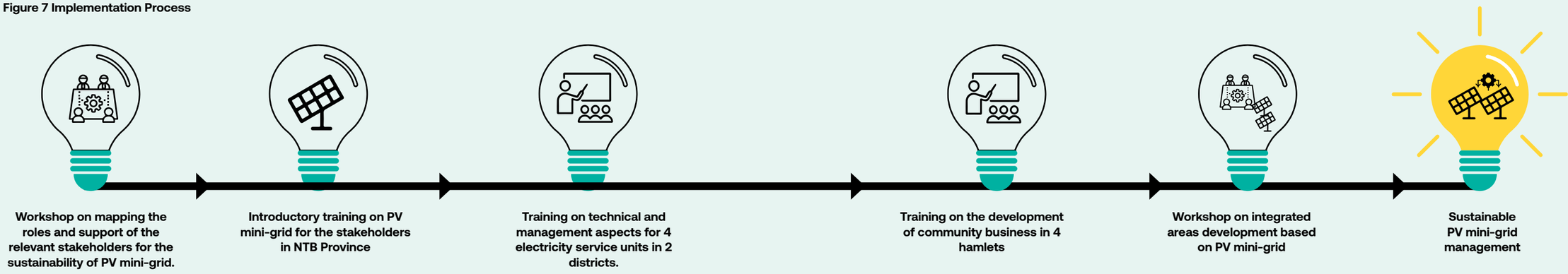
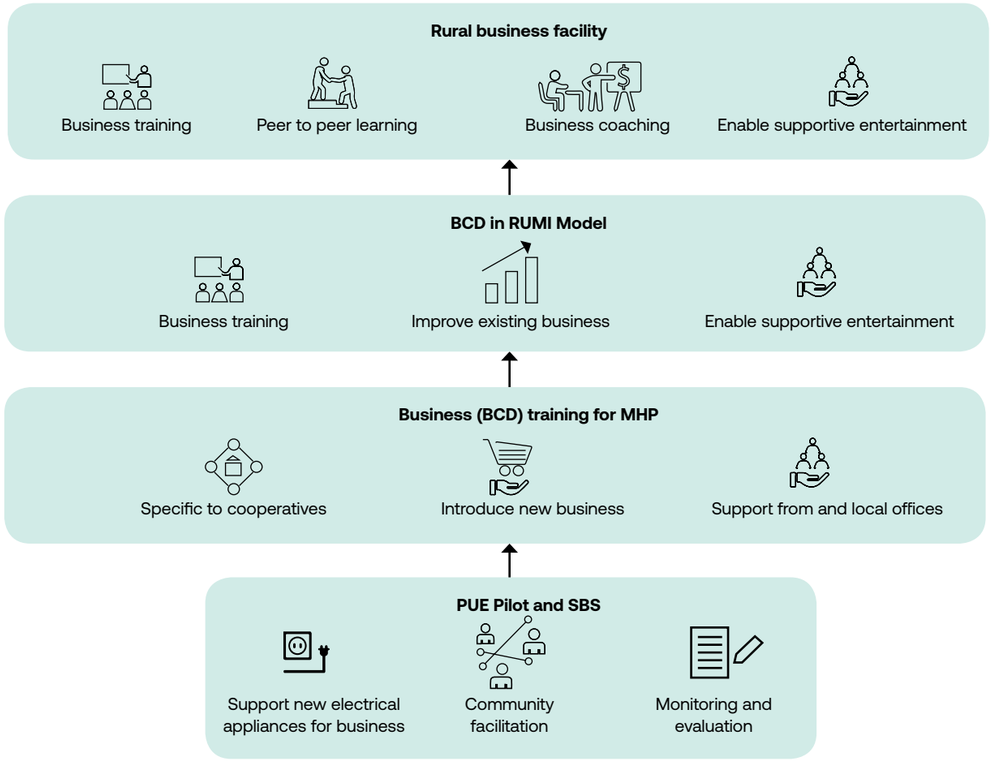


Figure 8 Mini-grid management facility



C. Rural Business Facility

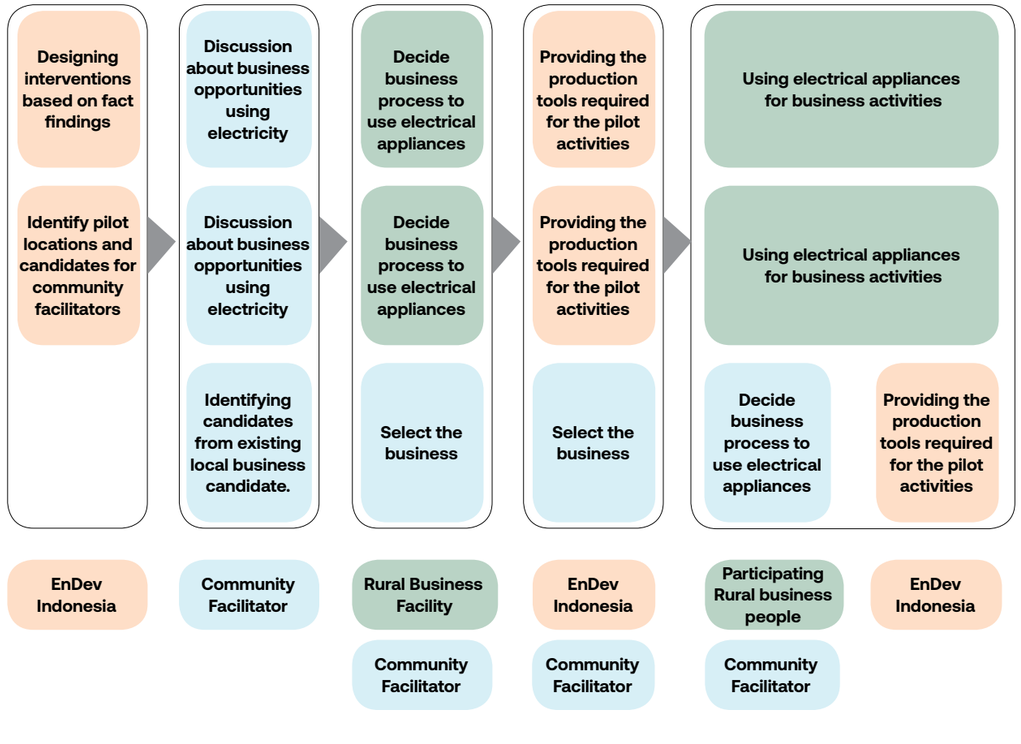
1. Productive Use of Energy in Micro Hydro Power Schemes

During its support to MHP schemes, the project promoted the development of PUE in five MHP systems as pilots. The project had implemented various options of economic activities that are powered by electricity which took different forms ranging from egg hatchery to woodworking. The target groups were villagers in the pilot areas and had already run a business. They were mostly self-employed.

The project provided supports to the community by providing simple production tools and business trainings to diversify their existing business. They had to present their simple business plan and their requirements for additional tools. In the meantime, the community facilitators provided advices and supports directly to them and monitor their progress after electrical appliances were introduced to their business process. Pilot sites were established in West Sumatera, South and West Sulawesi and covered 53 rural businesses. Most of the businesses reported increasing revenue, namely in mechanical workshop, carpentry and tailor businesses. In the meantime, agro-processing, blacksmith, and food processing had potential to be developed further.

In the preparation phase of the PUE pilot, EnDev design and identify suitable pilot locations and community facilitators to run the pilot. The community facilitators were selected based on their experience in the location and skills that were required to do the tasks. Hence, EnDev selected Prowater for West Sumatera and Operation Wallacea Trust (OWT) for South Sulawesi whom already known with their works with the community and micro hydro power. The facilitators and micro hydro experts explained and discussed with the community, especially the existing entrepreneurs in the villages, about the potential economic

Figure 9 Activities in PUE pilot project



Woman during business capacity development training in Lombok.

activities to be leveraged with electrical appliances. In the meantime, EnDev prepared the list of possible electrical appliances that were available. Through the facilitation process, the rural entrepreneurs were able to decide which tools were required for their business.

EnDev had planned to provide the electrical tools as revolving items which would require the selected entrepreneurs to pay back the tools to the appointed financial institutions. The mechanism aimed to finance procurement of tools for other business. Unfortunately, the project could not find local financial institutions to cooperate with and there was a miscommunication between the facilitators and the community who had already perceived the tools as grants. Changing the terms during implementation could break trust from the community, hence, EnDev continued to the pilot project and provided the production tools as grants only for the eligible proposal or ideas.

The PUE pilot project in West Sumatera and South and West Sulawesi had generated valuable practical experiences which were important lessons learnt that greatly influence on how EnDev conduct the next economic development initiatives through renewable energy mini grids. The key interventions for PUE were:

Changing the terms during implementation could break trust from the community, hence, EnDev continued to the pilot project and provided the production tools as grants only for the eligible proposal or ideas.

Ensure reliable energy are supplied from the MHP or other sources as well as suitable technical arrangements are prepared to adequately separate load from PUE and household activities.

Start small with the existing business and economic activities in the village. Leveraging existing business are more effective than initiating new business ideas which might be unfamiliar with the community and will shorten the learning curve for the entrepreneurs.

Identify possible value chain to be enriched by electricity. Analyse the production or service processes to be leveraged by electricity.

Build strong networks to support the entrepreneurs from various aspects, especially business coaching and access to market.

2. Supporting Cooperatives with MHP - Ministry of Cooperative and SME

EnDev supported the Ministry of Cooperative and Small Medium Enterprises (KUKM) enabling supportive environments to the development of PUE through various activities. The MHP was an additional capital to develop new services to supply electricity and other services to leverage the value of their agricultural commodities. The electricity was intended to be used for production activities and boosting their productivity.

The supports focused to:

- Develop knowledge and skills of the cooperative managers and operators who had received an MHP from the ministry. It covered topics on management, business, and technicalities of MHP system
- Technical review for the installed MHP to ensure smooth operation in the long run
- Trainings to develop business skills and knowledge were held in the village where the MHP installed. The content was developed from the CEFE training model which stands for Competency based Economies through Formation of Entrepreneurs. The trainings were delivered to ten cooperatives in Sumatera, Nusa Tenggara, and Sulawesi.

The second phase of the cooperation with KUKM, the supports were separated to KUKM and KESDM (DJ EBTKE). KUKM and KESDM had arranged an effective cooperation between the institutions. KUKM focused to strengthen the business skills and other aspects in the economic development, while KESDM role was to build the MHP facilities and technical supports. Hence, EnDev performed separated activities to adapt to the arrangement. The business capacity development (BCD) trainings were conducted separately from the technical review of MHP (Support Activities for MHP) which affected to all project management aspects.

Bussiness capacity development training for cooperatives

BOX 1: CEFE (THE COMPETENCY BASED ECONOMIES THROUGH FORMATION OF ENTREPRENEURS) MODEL is long known as a training method for business development. It was developed by GTZ (now known as GIZ) in 1983 and since 2003, CEFE was institutionalized as a private company. For the training in Indonesia, the project hired CEFE certified trainers. Those trainers were also responsible to monitor and evaluate the business development progress.

The CEFE business canvas model simplifies complex business model to simple four aspects: production, marketing, financing and organization. With simplified method, target groups could easily plan their actions in developing their businesses.

The cooperation with KUKM had successfully established numbers of cooperatives that are able to increase their revenue. One of them was *Koperasi Serba Usaha Puncak Ngengas* who had won the ASEAN Energy Award in 2017. The award expressed appreciation from the international community about the promising results from a cooperation between the cooperatives, EnDev, and the Ministries both KUKM and KESDM. A *key lesson from the assistance to cooperatives is the importance of leadership quality embedded in the team and their leader who is respected and trusted by the community, committed to greater good, open minded and able to speak eloquently to deliver their messages to the community and stakeholders.*

The productive use of energy activities focused on developing locally available potential such as basic food, services and production processes especially wood working, and food products. There were 10 sites which had been supported. The second phase of support involved nine cooperatives.

The trainings were appreciated by the participants and KUKM based on their feedback after the training sessions. The participatory method and uplifting mood had made the learning more enjoyable and effective for the participants. The humour and empathy had helped creating a mutual trust between trainers and participants. Hence, the trainers were always ready to support and asked questions from the participants even beyond the training sessions.

3. Innovating in product: Solar Business System (SBS/SolBis)

Adopting practices in Africa where people were charging their phones and small appliances through a kiosk that was powered by PV technology, Solbis (Solar Business) concept was created by EnDev. The aim is to provide the government with various options to provide basic energy access to rural communities instead of solar home system. The alternative should be cost efficient and able to generate revenue for the beneficiaries.

The SBS concept was developed by EnDev and manufactured by a PV technology company in Indonesia. The SBS itself was a PV-powered and plug-play system to be used as a charging station for rechargeable electric lanterns and small DC appliances. The activities in the SBS pilot comprised of evaluation of its technical performance and the business viability of the concept. Hence, EnDev collaborated with a Technical College of PLN (STT PLN) to install and monitor the aspects on site.

A kiosk in a fishermen community in Cirata, West Java hosted the pilot project. He lent the lanterns and charge fees for the service. After a month of monitoring by STT PLN, although the technical performance was satisfactory, but the concept was not financially feasible. There were five customers who were also run a business, namely food sellers and motorbike repair workshop. Challenges in the operation were broken lightbulbs, low charging tariff or number of customers were too small.

The comparison between solar home system and SBS is presented in the diagram below. Nonetheless, both options have their advantage and disadvantages to be considered by the users.

PV Mini grid system in small island.

Figure 10 A Difference in Cost Effiectiviness

Pilot Project of Solar Business system at Cirata, West Java.

4. RUMI Model

Rural Mini Grid Management (RUMI) Model was commenced to improve the previous activities about productive use of energy. Strengthening management of the rural mini grids should be done simultaneously with the support to lever rural businesses by introducing new products or services. Improvements were implemented through:

- Careful selection of the existing rural businesses in the pilot site based on their existing businesses and character traits. The village heads and the facilitators were actively engaged the businesses to join and learn effectively.
- Series of business trainings were enriched with continuous and customised assistance to the rural businesses. Each business had challenges that are particular to their situation thus enabling a supportive environment, such as connecting to relevant market and institutions, would open relevant access to the specific issues in their business. In RUMI, the facilitators were able to connect the rural businesses to many other trainings which were available in the province, such as baking, and other skills.
- Restrain ourselves to grant some tools or other hardware for the rural businesses. The concept is that hardware would be easily p rocured once the businesspersons are able to grow their businesses and conduct good administration. Hence improving skills and networks become the priority.
- In parallel with formal mini grid management team, reliable electricity supply from the mini grid had strengthened trust between them and the rural businessperson. Community facilitators stayed in the villages and available in daily basis to support the rural businesspersons on almost everything related to their needs to grow business with electricity.

The mini grid management teams in the pilot areas had been registered as formal cooperatives and obtained their certificate from KUKM. The current status will hopefully help them to be more accountable and open the access to receive supports from various schemes and institutions. In RUMI, the participating rural businesses were mainly in their early stage thus there are few were advancing in the businesses during RUMI.

Learning about food processing in Yogyakarta.

5. ENACTING

After almost a year of support in RUMI, the rural businesses were not yet taking off in the expected direction. EnDev evaluated that the scope of work in RUMI was not sufficiently support the rural businesses. Hence, EnDev focused toward the initiatives to use renewable energy for revenue-generating activities more than a lighting purpose, called Energy Access Beyond Lighting (ENACTING).

The activities under the support for rural businesses were designed and implemented in a more holistic manner than the activities in RUMI. In addition to the usual BCD training modules and selected participants, EnDev held:

Practical training for marketing and food production such as production of brown sugar, chocolate drink, and snacks in a production centre for SME thus the participants were able to try making food products and learn about good production processes

Reached out and engaged to more government institutions and private sectors

Enable wider network through peer-to-peer learning and connection to other SMEs in Yogyakarta. The network was intended to open the market for the participating rural businesses.

Business coaching that catered specific questions from the participating rural businesses.

The PUE supports found that granted production tools was not effective to build a sustainable business. ENACTING focused to deliver complete trainings and coaching sessions to develop practical skills to run their businesses. Procuring tools can be done independently when the businesspersons have a clearer direction on their business plan.

ENACTING was implemented in six different locations which covered two provinces. The locations were curated to have different geographical and socio-cultural profiles. Three sites are located on small islands in an archipelagic regency in South Sulawesi and had seven groups of rural business. The other three villages are sited on Rote Island, East Nusa Tenggara, with eight groups of businesspersons.

Peer-to-peer learning was performed during practical training. The participating businesspersons from different locations were gathered and learned together. Driven mostly by women and mothers, the rural businesses were thriving and built upon their existing initiatives. Some of the participants were performing better than others as a result of their accumulated knowledge from joining various learning occasions. The trait was apparent from their enthusiasm to learn new lessons and assertiveness to grab the opportunities to improve. Through the process, it was found that exchanging and learning from peers had lift their spirit and confidence to continue running their businesses.

Some of the participants were performing better than others as a result of their accumulated knowledge from joining various learning occasions. The trait was apparent from their enthusiasm to learn new lessons and assertiveness to grab the opportunities to improve.

Discussing about financial management for PV Mini grid

6. Innovating in product: Renewable Energy Boat

During the implementation of ENACTING, EnDev developed Renewable Energy Boat (RE Boat) and Smart Payment System (SPS). RE Boat was built around the concept that that in daytime, PV mini grid will produce excess energy as soon as the batteries were fully charged. The excess energy would be turned to heat if no utilization was made. RE Boat aimed to utilise the excess energy thus the battery system could fulfil the household demand on electricity.

Based on data from the technical review of more than 300 PV mini grids (MSP), it had found that less than 50% of PV energy was utilised. The number showed low energy utilisation at the PV mini grid sites whilst also exhibited high amount of excess energy that had not been used properly. Hence, the abundant amount of excess energy had offered opportunities for better energy utilisation, for example to be used in systems with bigger capacity such as battery for electrical mobility. This finding had further strengthened the RE Boat concept and idea.

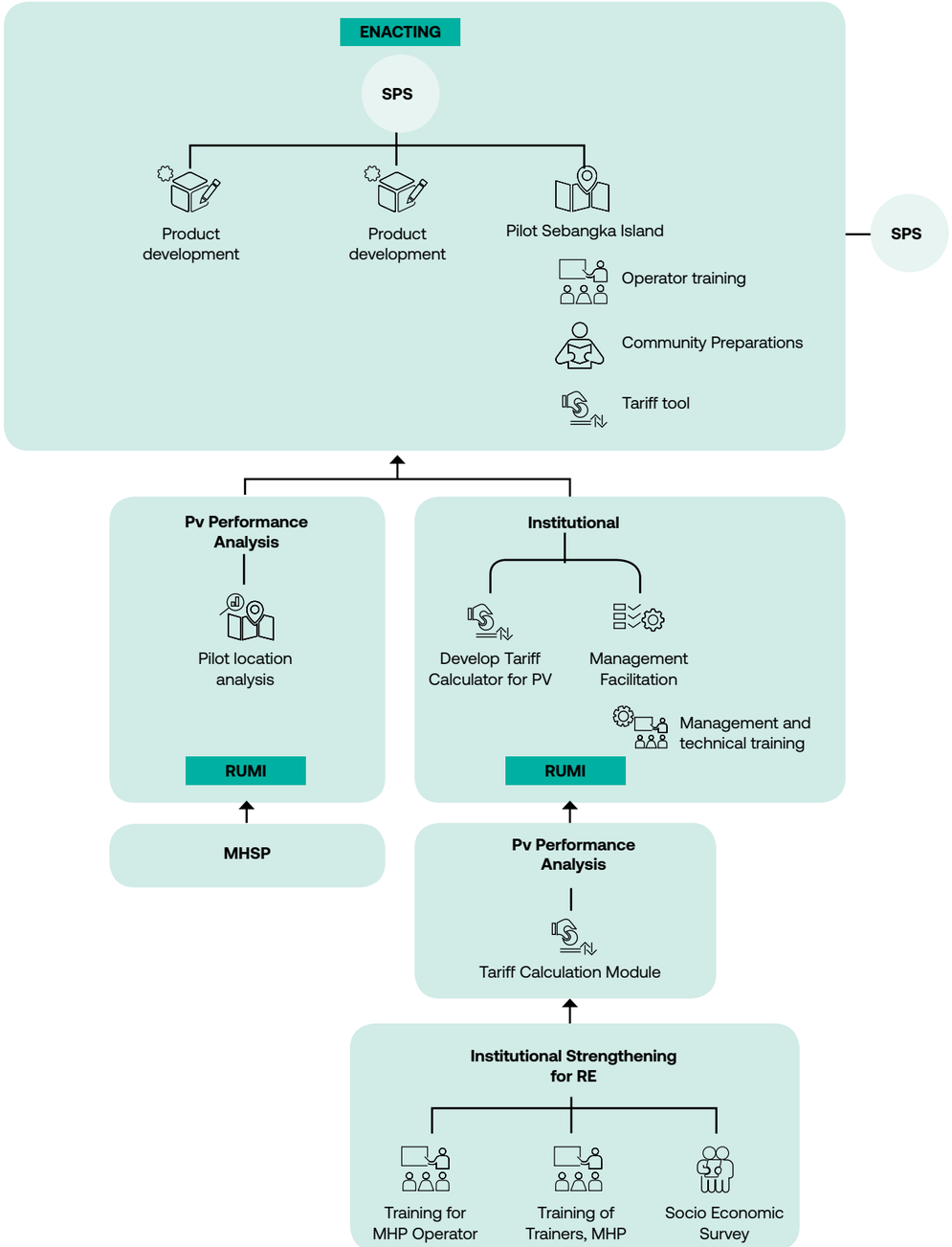
The innovation was in the RE Boat product and the business model. The RE Boat needed batteries for power thus charging facilities should be ready to serve the demand. The battery charging station or battery rental is still one of the promising business models to be exercised. The PV mini grid management can open charging service or rent their batteries to the boat owners or electric outboard motors. The services were adopted from smaller cell phone charging stations that are very common in African countries.

Battery powered outboard motors can replace combustion engines. It also offers efficiency in cost compared to normal outboard motor. Hence, the avoided cost can be used for other purposes to improve the life quality of the fishermen such as in their economic, health, and education situation. Using electrical outboard motors will improve the environmental and economic situation at the pilot site. RE boat activity was only implemented in Sabangko Island, South Sulawesi.

7. Innovating in product: Smart Payment System

EnDev had been an active promoter for better energy utilisation to sustain the operation of PV mini grids and achieve economic growth. Numbers of pilot projects, business capacity developments, and on-the-job trainings were implemented in the past decade. Based on these experiences, EnDev implemented a Smart Payment System (SPS). Figure 11 indicates how previous activities contributed before SPS could be implemented. Figure 11 also depicted that SPS were acting as an enabler for productive use of energy (PUE).

Figure 11 Building Blocks of SPS



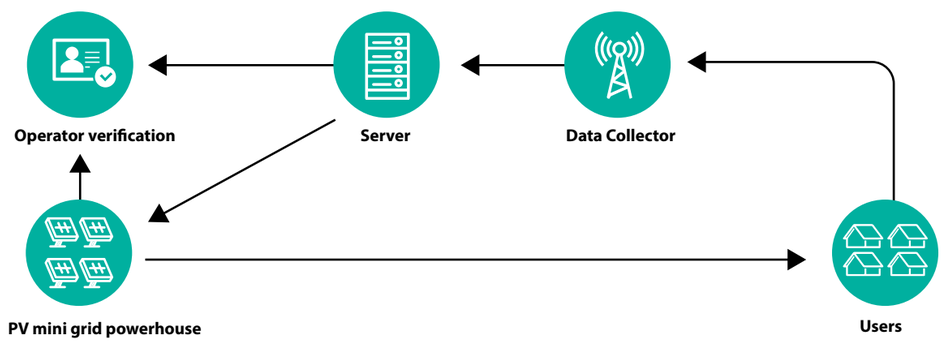
Institutional Strengthening for Renewable Energy (ISRE) activity provided support to build the capacity of Village Management Team (VMT) members in managing, operating and maintaining MHP scheme independently. Developing the capacity of VMT was at the centre of ISRE targeted output, indicated by three main activities namely training for MHP operators, training of trainers, and socio-economic survey. One of the outcomes was the importance of tariff calculation module. The need to apply adequate tariff schemes for rural mini grids was essential to ensure that the community had enough funds to operate and maintain the system. Another activity, the Mini grid Service Package (MSP) had provided significant insights regarding the performance of PV mini grids. For example, MSP provided substantial findings regarding the real PV performance on site.

Rural Mini grid Management (RUMI) model took lessons from ISRE, VMT training, and MSP activities. RUMI was based on the idea that a sustainable operation of mini grid was affected by several factors such as good quality installation, legal form and proper capacity of the VMT, sufficient tariff scheme, and availability and accessibility of spare parts and service provider.

One of the insights from RUMI pilot project was to develop a new enabler to optimise utilisation of the PV mini grids and to increase the sustainability of PV mini grids. By 2018-2019, EnDev committed to advance their measures by introducing a smart payment system (SPS) for PV mini grids. It aimed to tackle challenges that hinders the utilisation of PV mini grid for productive uses, such as:

- Irregular payment from the users despite their continuous supply of electricity from PV mini grid
- Fixed and less flexible daily energy allocation, albeit availability of excess energy in some PV mini grid locations.

Figure 12 Smart Payment System Scheme



The SPS is designed to automate energy management in a such way that excess energy can be used by households who have subscribed to utilise the excess energy. It has an algorithm that provided several options for daily energy limit in each household, which enables several households to consume excess energy that is available during daytime.

A more detailed concept of smart payment system is illustrated in Figure 12. Firstly, a remote monitoring system are installed in the PV mini grid. It will send information regarding the status of the batteries, and send the information to SPS server. Based on this information an algorithm will calculate how much daily and excess energy that each household can receive. Each household, which has paid the tariff in advance, will receive a daily energy limit and excess energy – only if they have subscribed to buy excess energy. The command from the server to the smart meter will subsequently be sent via LoRA technology. LoRA technology is used based on its essential offers of low power consumption and wide coverage range which are suitable for the system installation in remote area. The smart meter will send feedback to server in which will monitor the system.

Gender Facility

Result from the GIZ's gender study in 2015 found that only 6% of the VMT members were women. Low participation rate from the women had also seen in the pilot locations, despite the benefits of having active women team members in the VMT. The situation was caused by their lack of confidence and limited skills to be contributed to.

EnDev consistently applied a minimum quota of two women from each village to join the trainings. The women candidates for the training were decided through discussion with the village head. The arrangement is important to get formal acknowledgment from the village administration and hopefully will be continued by them for further training arrangement.

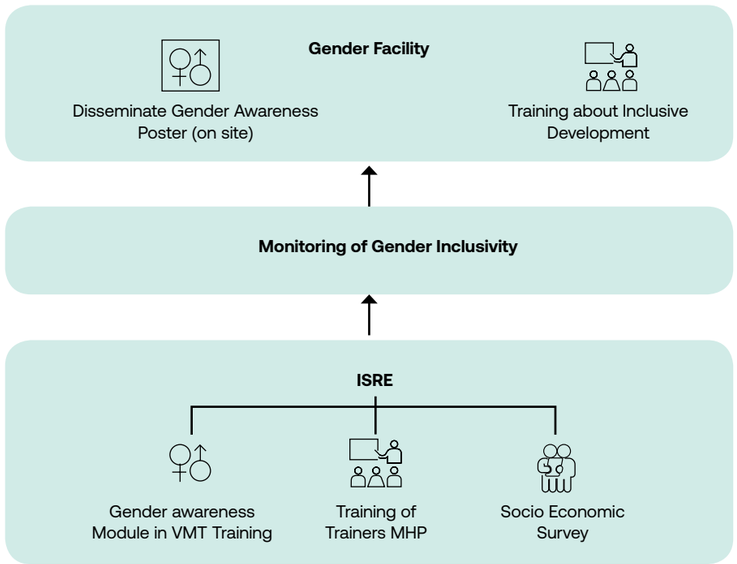
The training on gender equality comprised of (1) Definition of sexuality and gender; (2) Gender equality and justice; (3) Benefits of equal contribution of women and men in managing the PV mini grid. On top of the training sessions, facilitators conduct persuasive engagement to the women to participate on discussion about PV mini grid management during the community meeting. Facilitators were also demonstrating on how electricity can help them to be more productive and the benefits of good management of PV mini grid.

Continuous works to enable gender equality had shown promising results, namely:

- Women participation in many meetings had strengthened empathy and commitments to actively contribute in managing the PV mini grid
- Both men and women should actively support the women participation in PV mini grid management and productive use of energy

Shifting mindset and behaviour can be done through formal and informal discussions as well as opening access to relevant information which are moderated by the facilitators

Figure 13 Measures to incorporate gender equality



People

People had always been at the centre of the project achievement. This aspect covered not only about the works of the internal project structure, which consisted of KESDM and GIZ, but also the role of the relevant partners, stakeholders, and beneficiaries who were enthusiastically contribute and support the project toward the common goal.

Tabel 2 Involvement of various parties at different stages of EnDev

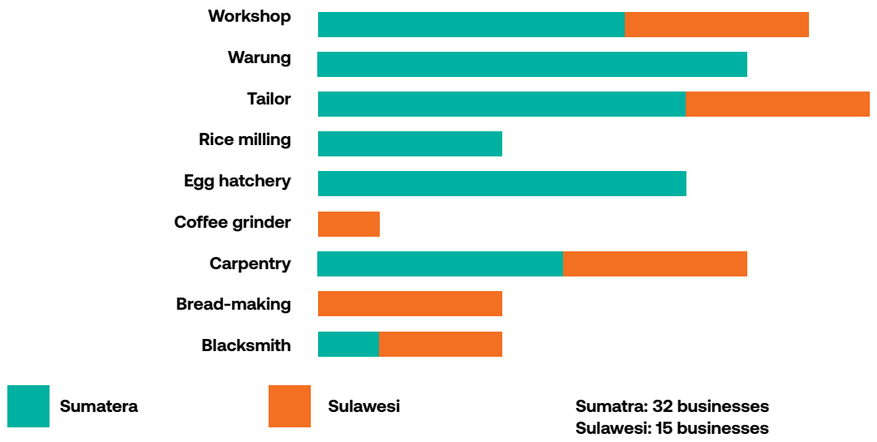
Activities/ Projects	Role			
	Community Facilitators	Trainers	Contributing Partners	Beneficiaries
PUE Pilot for MHP	Operation Wallacea Trust (OWT) – Sulawesi Area Prowater – West Sumatra Each team consisted of four persons	Operation Wallacea Trust (OWT) – Sulawesi Area Prowater – West Sumatra		15 businesspersons in Sulawesi Area 32 businesspersons in West Sumatra
PUE for KUKM	None	2 CEFE trainers	KUKM, Local Office for Cooperatives	49 participants in 10 villages
		4 CEFE trainers	KUKM, Local Office for Cooperatives	150 participants in 9 villages
RUMI	TRANSFORM 1 coordinator (provincial) 2 facilitators (regency - village)	2 CEFE trainers	KUKM, Provincial Government (BAPPEDA), Provincial Energy Office (Regional Mining and Energy Office), Local Office for Cooperatives, NGO, Companies	49 businesspersons (29 of them were women) in four villages
ENACTING	Each Province have a team of facilitators, consisted of: 1 coordinator (provincial) 2 facilitators (regency - village)	2 CEFE Trainers Centre of SMEs for practical training	Provincial Energy Office (Regional Mining and Energy Office) Regency: BAPPEDA, BPMD, other relevant offices	22 businesspersons were trained (20 of them were women) in six villages

1. Supports for the MHP schemes

PUE supports for MHP were implemented in Sulawesi and West Sumatra, each area was handled by a team who was carefully selected based on their experiences in the topic and with the area. The organisations, Operation Wallacea Trust and Prowater deployed a team of four experts for micro hydro, community facilitation and business development topics. The involvement of local NGOs was meant for capacity development and they were expected to build better skills and competence in conducting works on developing PUE activities in different areas.

There were 47 businesspersons of which 32 businesses from Sumatera and 15 businesses from Sulawesi who had been impacted by the project. Here is the breakdown of them from the target areas.

Figure 14 Results on rural business development in two main provinces



The number stated in the charts represents the number of businesspersons who had run their businesses in the village and used MHP as their source of power. The chart shows that the villages in West Sumatra had more businesses than their peers in Sulawesi. Women owned Warung (grocery kiosks) and culinary businesses which showed active participation of women to develop the economy.

2. Supports to Ministry of Cooperative and SME

EnDev supported KUKM in two phases and gave assistances to 19 locations in total. During the first stage of supports, there were 49 participants from ten villages. The targeted participants were only the management team of the cooperatives. Improved measures from the first phase, there were in total 150 training participants from the nine pilot sites. The participants were willing to follow through all the training modules which showed high interests from them. The people were curious about the training and the potential to increase their economic condition by using local resources and renewable energy. Attendance lists of the three-days training as follow:

3. Solar Business System (SBS/Solbis)

The solar business system (SBS/Solbis) concept was designed to involve private sector since the beginning. In 2012-2013, PV technology companies in Indonesia were still very limited. Some of them developed

Tabel 3 Results on rural business development in two main provinces

No	Location	Implementation	Total		
			Day 1	Day 2	Day 3
1	KSU Mute Lestari, Gunung Komba, Manggarai Timur	10 - 12 Nov 2015	18	18	18
2	Kopmen Manggarai Timur Sejahtera, Rana Loba, Borong, Manggarai Timur	10 - 12 Nov 2015	14	17	19
3	KSU Ankara, Rawak Hulu, Sekadau Hulu, Sekadau	15 - 17 Des 2015	22	26	23
4	KSU Kamosope Permai, Kamosope, Pasir Puti	18 - 20 Mei 2015	13	13	12
5	KUD Sumber Meratus Jaya, Cantun Kanan	18 - 20 Mei 2016	23	19	20
6	Koperasi Cinta Indonesia, Kota KOmba Manggarai Timur	27 - 29 Mei 2016	18	19	16
7	KSU Bukit Indah Baturontok, Batulanteh, Sumbawa	27 - 29 Mei 2016	19	19	19
8	KSU Tanu Samba, Ambapa Tinondo Kolaka Timur	27 - 29 Mei 2016	15	14	14
9	KSU Uesi Bersinar, Uesi, Uesi , Kolaka Timur	27 - 29 Mei 2016	13	13	13
Total attendees			155	158	154

products around panels and PV applications that offered alternatives to Solar (PV) Home System. The SBS was adopted from practices in Africa which then brought by EnDev to the companies to make the prototype for Indonesia. The design was simple and straightforward thus it did not take long to materialise.

To test the prototype and the business concept, EnDev cooperated with STT PLN to install and monitor its technical performance and the PUE implementation at the pilot site. The target group was a fisher community at Cirata water dam. The fishermen cooperative agreed to test the rental model for LED lamps or lanterns. The users consisted of three food sellers and a motorbike repair shop. The monitoring took a month and it found that the rental business had only generated revenue around 10 USD for the SBS operator.

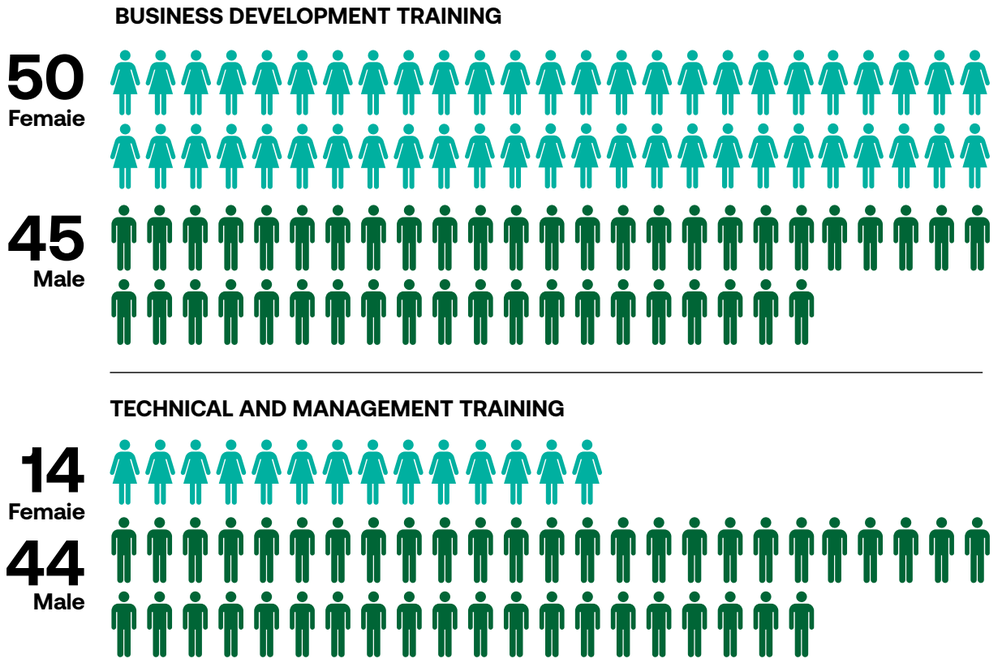
4. RUMI Model

For the RUMI project, EnDev employed three facilitators to support the four pilot locations in West Nusa Tenggara province. One facilitator became the coordinator and liaison with the provincial government while the other two worked closely with the communities. In the meantime, BCD trainings were delivered by two CEFE-certified trainers.

One of the most notable achievement of RUMI was the high numbers of women participating in the RUMI activities. There were 19 women out of 45 participants in the VMT training, whilst 29 women out of 49 participants were joining the business trainings. The composition of participants indicated high interest from women group to participate in the PV mini grid management and business trainings.

The involvement of women in training has succeeded in encouraging women's participation in various activities, ranging from attending socialization activities, participating in village meetings to taking part in PV Management. If previously there were no women involved in PV management, but after training there were 9 women who were members of the village electricity management cooperativeThe RUMI activities involved various government offices in West Nusa Tenggara such as the Regional

Figure 15 Composition of men and women in the trainings - RUMI



Development Planning Agency (BAPPEDA), Energy and Mineral Office (Dinas ESDM), Community and Village Development Agency (BPMD) and Cooperative and SME Office (Dinas Koperasi). There was at least one person from each institution who were involved in the RUMI initiative. Although not all of them were actively participating in the facilitation process, but they had understood about the importance of good PV mini grid management and productive use of energy to catalyse economic development.

5. ENACTING

ENACTING drew many parties to be actively involved in the activities. It hired 6 facilitators whom divided into two team for each province. The structure was similar to the RUMI project where two facilitators worked directly in the field with communities and one coordinator to facilitate coordination among the government and stakeholders in the provincial level. The facilitators must have proven work experiences in the task, good communicator, and familiar with the culture in the area. The afore mentioned qualities were required to build trust and work effectively between facilitators and the targeted communities.

ENACTING worked with government from the provincial and at the regency level. At provincial level, the key partner was the Regional Mining and Energy Office. In both provinces, at least one person had actively involved in the facilitation processes. The government in the regency level come from various offices, such as from planning agency, village development office, and other relevant offices. The representatives were mostly involved themselves in the workshops or (FGD) focused group discussions. Representatives from NGO and academics were also involved in the workshops or FGDs.

The involvement of government institutions in various stakeholder workshops had opened communication access between the agencies and the mini grid recipient communities. This had encouraged local government to be more active in overcoming problems with PV management or PUE development through various field facilitation in the pilot villages, there were 15 businesses and they only had to send their representatives to the BCD trainings. Hence, 22 people had been trained which only had 2 males in the group. The numbers were interesting which showed women had high aspiration to grow their businesses.

6. Renewable Energy Boat

In the development of Renewable Energy Boat (RE Boat) the project employed two interns from Swiss-German University to test the concept and conduct researches. The result of the research became their final project for the university. Both have successfully graduated from the university with flying colours.

The batteries for RE Boat were assembled by a PV manufacturer, Sundaya. The batteries were used in the testing and during pilot in Sabangko Island with the fishermen. There were two stages of testing. The first stage was conducted in Muara Karang, Jakarta before it was deployed in the pilot island. The testing involved two boats from the fishermen whom made a cooperation agreement with GIZ for the pilot.

During the implementation, the project provided two electric outboard motors (e-motors) to be used in two fishermen boats in Sabangko Island, South Sulawesi. In the implementation process, the people involved from the island were:

Operator of the PV mini grid who will operate the battery charging station that was installed in the powerhouse

Treasurer of the PV mini grid who will collect the tariff from renting the e-motor

The fishermen the ones using the e-motors. During the testing phase there were three fishermen involved and each using different kind of motors.

GIZ deployed one of the undergraduate interns to work on the solar charging stations and further testing the performance of electric motors with the fishermen.

Training Operation and Maintenance for PV Mini grid (top). Women entrepreneurs in the making (below).

7. Smart Payment System

The development of Smart Payment System (SPS) took more than 6 months to produce an SPS. The partner, Newlight, had employed at least four experts in their company. They are:

1. Project Manager
2. Hardware development expert
3. Software/application development expert, and
4. System integrator.

For the implementation of SPS, the project partner, Newlight, deployed three experts to the island to install the smart meters and the system. They also tested the systems and rectify any issues with the hardware and software. On site, all customers of the PV mini grids in Sabangko were served with the SPS. The PV mini grid operator also supported the process of installations of SPS.

For RE Boat and SPS, it was unfortunate that only few women were involved in the process of RE boat and SPS implementation. The project was actually very open if there were women interested in joining the activities of RE Boat and SPS.

Resource

The PUE supports to MHP sites needed resources to conduct the activities, which were consisted of the survey tool to identify potential productive use of energy; survey tool which was a refinement from the previous survey tools in EnDev; and for some activities it needed electrical appliances to stimulate the PUE pilots. In the support to KUKM, the project utilizes various measurement tools to conduct technical reviews for MHP, namely flow meters, head measurement tools, AVO meter (ampere voltage ohm) and metering tapes. A camera was mandatory to document evidences in technical review and observation on PUE activities in the village.

Tabel 4 Resources for various EnDev activities

Activities/ Project	Internal Resource	External Resource	Joint Resource
PUE Pilot for MHP	• Training activities • Community facilitators • Hardware: small electrical appliances	None	N/A
PUE for KUKM	• BCD training activities • Trainers	KUKM: • Installed MHP • Coordination with Regional Mining and Energy Office	N/A
	• BCD training activities • Trainers	KUKM: Coordination with Regional Cooperative and SME Office KESDM: Installed MHPs	N/A
RUMI	• Training activities • Community facilitators • Workshops and FGD events	Baking trainings from provincial government	• Training for entrepreneurs by Regional Cooperative and SME Office • Technical trainers
ENACTING	• Training activities • Community facilitators • Workshops and FGD events • Prototype of RE Boat and SPS • Data from Remote Monitoring System	• Additional electrical appliances for production were procured by the businesses themselves • Torqeedo, a manufacturing company, have been lending their electrical outboard motors to be used for the pilot • Two fishermen boats	N/A

External resources used in developing SBS/Solbis was the report from Namibia that was specifically explained various potentials of similar concept for rural electrification. It mentioned that business owners could make good business from solar charging service. The report was prepared for Wuppertal Institute for Climate, Environment and Energy (WISIONS) in 2010.

For RUMI Model implementation, the resources needed were the training materials for VMT (Village Management Team) and CEFE training modules for the local businesses. There was no hardware supports for the communities. The training materials for VMT had been continuously improved from the past training materials thus RUMI activities used the most updated version. It already included key lessons from the past and adopt to the specific context of rural mini grids. CEFE training modules follows international practice of CEFE training. The project used a survey tool to identify potential rural businesses to be developed in the area which then used as business cases in CEFE training.

The support from local government at pilot areas is essential. Their supports had been a motor to achieve the targeted outcomes. Supports from Provincial Energy and Mining Office and Provincial Development Planning Agency were proven to be influential to the success of the all the initiatives in the project.

CEFE training material was basically pretty standard following the international practice of CEFE training. For productive use identification, the project also used the survey tool that was derived from the past survey tool. The identified productive use potentials were then used as case in the CEFE TraininIn ENACTING, the businesspersons need to invest on their production tools and create their promotion using their own tools such as handphone cameras and their social media accounts, if they have any, to promote their products. The RE Boat project used an electric outboard motor lent by Torqeedo which aimed to test the concept and to make a comparison study with normal combustion outboard motor. EnDev also procured another electric outboard motor for the comparison study.

Installing Smart Payment System at Sabangko Island, South Sulawesi

The fishermen's boat for testing the concept was also considered as the resources for the development of RE Boat. There were two boats involved in the testing of electric outboard motors. During testing different tools were used such as GPS to measure the speed of the boat, accelerometer to measure the wave heights, fuel flow meters to measure the fuel flow in the combustion engines, and the analytical methods to calculate the efficiency of the electric outboard motors. The students took their data and then analyse the results to decide which option worked the best.

Advancing the technology also need different kind of resources, such as reliable data. Development of RE boat and smart payment system was inevitably highlighted the importance of effective reliable data management and effective interconnection.

To assess the effectiveness of the charging station, the project utilized different charging strategies. The selected charging strategy requiress input from the remote monitoring system that provides battery state of charge and soalr irradiance at a particular pilot site. Based on the signal from remote monitoring system, excess energy can be tapped to charge the batteries.

To enable the algorithm that could dynamically calculate different daily energy allocation and excess energy, SPS must be equipped with a monitoring system that could collect the PV mini grid performance. Battery state of charge is the most fundamental information for SPS to decide how much energy can be delivered to each household.

External Factor

EnDev faced some external factors that had significantly affected the progress of the project. These external factors were powerful so that the course of an activity could change or may change in the future, such as:

- Asset ownership had been a major external factor that handicapped many interventions to sustain the government-owned rural mini grids. As an example, a PV mini grid in a village in Rote Island had not been handed over to local government or to the village. The unclear ownership status of the facility had put the VMT in dilemma which hold them from making any repair or add more capacity. The actions were considered against the law. The mini grid is by law still owned by KESDM who financed the installation.
- Common practice from the government to provide grants in the form of hardware, especially for agricultural or farming activities, thus the targeted communities had different expectation with the PUE pilot from EnDev. The unmatched expectation hampered the idea to implement a loan scheme to get their production tools. Grant scheme was preferable instead of a soft loan. The project was planned to use loan scheme with expectation that the recipient will be more responsible and more committed to the PUE activities. It took longer time to shift the expectation thus EnDev decided to grant the hardware to the select businesspersons.
- Most of the beneficiaries were unbanked, thus there was no financial institution available to make a partnership providing loan for the rural businesses.
- KUKM had a very high commitment to support the cooperation which was apparent from their broad and full supports to cooperatives in the form of assistance, trainings, and regulation. This condition had helped paving the path to implement the activities in the pilot sites and had full supports from both Regional Cooperative and SMEs Office. There were strong evidences that Regional Cooperative and SME Office proactively involved themselves in the capacity building process
- Framework condition for SBS/Solbis was not yet available. During that period, the government was still in the initial phase to shift from SHS to other form of rural electrification with renewable energy. Experiences and practical knowledge in Indonesia were still limited thus adoption of Solbis model would take additional policy about modalities of rural electrification.
- Limited access to good quality products, such as LED lamps for SBS/Solbis prototype. The monitoring of Solbis pilot showed that some LED lamps were already broken although they were just installed in a couple of weeks. Causal possibilities were low quality of LED lamps, electrical glitches that have negative impact to those LED lamps. The experience might have influenced the decision not to disseminate the concept wider
- Natural disaster had hit the pilot area of RUMI Model. A huge earthquake occurred in Lombok Island in 2018 which had affected one of the pilot sites, Pegadungan. There was no major damage to hardware of the PV mini grid, but the system did not operate properly anymore. Nonetheless, provincial budget had been allocated to recovery and put other activities on hold, including the maintenance and repair of some PV mini grids in NTB. It also changed people's priorities, such as budget for productive use of energy was shifted to recovery from earthquake. Hence, it delayed the implementation of PUE in the pilot area. framework condition for the implementation of Solbis was not available. The government, especially the ministry of energy, during the time provided solar home systems to remote off grid areas. Adoption of Solbis model would take additional policy about modalities of rural electrification. This would take time. It is however important to introduce the idea to the government.
- Local political situation got worsened had affected our activities in Mbokak village, East Nusa Tenggara. The conflict had forced EnDev to relocate the community facilitators to the other village and reduced the interventions to only work on PUE aspect.
- Other community assistance projects contributed to achieve better result in ENACTING. Two pilot areas in Sulawesi, Saugi and Sabangko Islands, had been exposed to several trainings and community development initiatives. The good experience had led to higher trust to ENACTING initiatives and the communities were more open for newcomers and new ideas especially about PUE.
- Limited supply chain infrastructure of the required components, such as electric outboard motors, PV panels, batteries, and other components. There is no local distributor available for the components which might hinder any repairment or troubleshooting measures to sustain its operation. For the smart payment system, design engineering was done fully by Indonesian engineer but most of the components were still imported.

Recommendations

Public and private organisations who are going to develop mini grid solutions from renewable energy in off-grid areas should expand their development objective beyond access to lighting and small appliances or only to achieve the electrification ratio. High electrification ratio value will lose its values when the energy facilities could not sustain its operation in long period of time. It is important to consider how energy can benefit more aspects in the sustainable development goals and target more integrated objectives beyond energy access. SDG targets can be used as an overarching target for future mini grid developments such as SDG 1, 3, 4, 5, 6, 7, 8, and 13.

1. **There is a strong alignment between energy and economic development particularly in SDG target 1.** Higher energy consumption usually leads to better economic development. Economic development can trigger improvement of other essential services such as health, education, sanitation and even gender equality. The causal relationship between them are complex but there are evidences of positive relationship, as reported in PRODUSE in 2013.

   OECD reported in the "Linking Renewable Energy to Rural Development: Executive

Summary Brief for Policy Makers" that there are benefits of rural renewable energy but there is a need to integrate energy strategy to local economic development strategies. With this statement, economic development strategy comes first and not vice versa. Provision of energy can but does not always result in positive economic development (e.g. increase jobs or business opportunities) especially if the initiatives for energy access is not carefully planned and only focus on technocratic parameters.

Referring to SDG's targets, energy access in the rural renewable mini grids can serve as supporting infrastructure and be considered similar to road access for a specific area. The government should use bigger perspective about the role of energy access in the economic development strategy and how are the interactions between the sectors involved.

The approach highlights that collaborative and multi-stakeholder programmes offers promising results. A coordinating ministry can lead the orchestrated programmes which involves all the relevant ministries and institutions. Energy is a cross cutting issue thus improvement in the energy access program will lever many aspects of development. However, a shift in the development paradigm, organizational arrangement and even a different fiscal policy are required to implement such programme.

2. **The plan to develop productive use of energy** have to be included early in the energy access planning. Private individual use of renewable energy is happening in rural areas, for example a solar pumping for irrigation. This approach provides direct productive energy load to renewable energy plants. Due to limited budget and private use, it is rarely expanded to be a mini grid serving more households.

   The rural energy planning that is centred in productive use of energy should be tested and monitored whether there is an increasing chances of such system to sustain with different planning approach.

3. **As one of basic services, there are various stakeholders that ties their development objectives in the success of universal energy access**. Hence, it is highly recommended to pursue multi-stakeholder collaboration which able to lay out the strategy to achieve targets in economic developmentVarious ministries and private sectors should be partnered and shared the role in developing the economy and its relation with universal energy access. It also needs different set of regulation framework that enables such working condition.

4. **Encourage peer learning and increase interconnectivity in rural economic development.** For rural people, their village is their universe. The case is even stronger for a small island community. EnDev had experienced peer exchange is able to increase learning effectiveness and boot their self-confidence. It is advised for any rural support programmes to include peer learning activities in their training. As a prerequisite, identify or create an example of system that fulfils the sustainability criteria. Such condition can influence local partners (e.g. local governments) to have clear focus by being able to visualise their future on rural economic development. The efforts should be aligned, well-orchestrated and implemented by professional team or individuals.

5. **Promote partnership between public and private organisations.** Rural areas have been considered as new market for many products whilst also source of material for many. Partnership can be formed between local government with private sector which fulfils the criteria. Local government should be able to identify value chain on their product and commodities and defined how companies can contribute to increase the value of local products. As an example, increasing the product value means that pre-processing or half-ready products can be supplied to bigger producer that will pack and market the products.

   However, the cooperation can also be in different form such as marketing cooperation. If a specific rural area has a specific product that can only be produced or serviced locally, then product marketing cooperation can be a solution. Cooperation with marketing professional in private sector can help defined proper marketing and sales strategy and expand access to the market.

Microhydro power has leveraged economic activities in West Sumatra

3 Technology Innovation and Transfer

This chapter highlights how EnDev had supported technological innovations especially in the mini grid sector. Mini grids technology has been growing from simple mini grids which consisted of simple generator and cables to more complex PV battery system mini grids that involve various high technology parts and possibilities of hybrid system involving different source of power and set of technologies.

Technical performance verification of batteries for solar ice maker

In the early stages of EnDev, micro hydro power (MHP) was the only technology for rural electrification. The project supported the dissemination of technologies to many different parties which located in almost 34 provinces in Indonesia. The initiatives had contributed in developing local competence rural renewable technology which affected in the achievement of higher electrification ratio in Indonesia. EnDev had supported the technology transfer for cross-flow turbines and digital electric load controller that were suitable for rural micro hydro schemes in Indonesia. EnDev also worked with committed MHP companies in advancing appropriate technology of MHP.

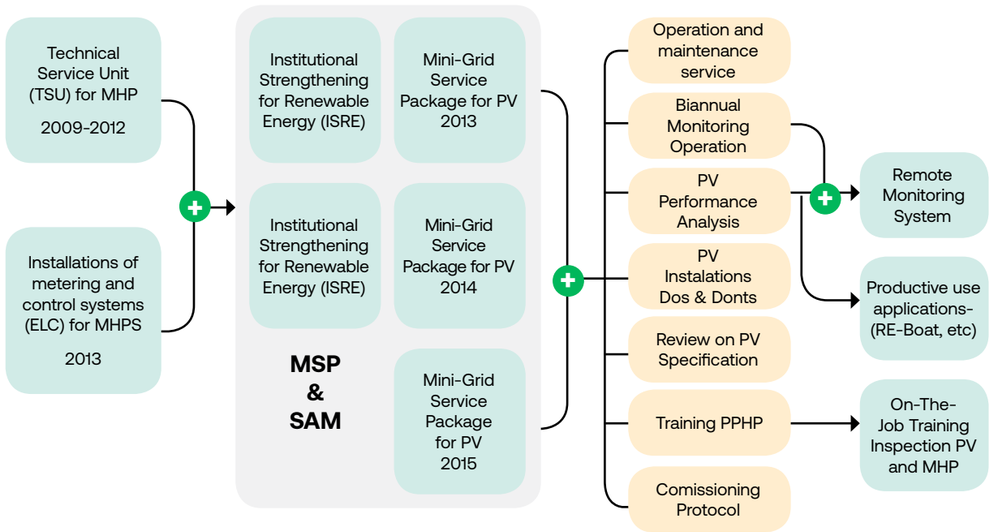
Beyond mini grid technologies, EnDev developing various technologies for better energy utilization, monitoring, and practical productive use appliances. The initiative had incorporated broad spectrum of supports for technology innovations in Indonesia especially in the framework of rural electrification. Innovations such as SPIMA (Solar Powered Ice Maker), universal Remote Monitoring System (RMS), Smart Payment System (SPS) and Renewable Energy (RE) Boat were some examples of genuine innovations in and for Indonesia.

Innovation is not just about hardware but also on how the technology will be adopted and scaled through businesses. Hence, EnDev supported different business innovations such as SBS/SolBis (Solar Bisnis), TSP (technical service providers), and Solar Powered Ice Maker (SPIMA). Solbis experimented with modest solution for rural electrification which showed early engagement to private sector contribution. However, there are more aspects to be prepared before the new business concept can be accepted widely.

Similar challenges happened with the idea to establish a local technical service provider (TSP) for PV mini grids. TSPs are needed to support the mini grids which spread all over Indonesia. Ideally this network of skilled technicians will be able to provide technical supports to mini grid operators and prevent the schemes from failures. TSP concept was an integrated part of RUMI and continued to be an integrated part of ENACTING.

During the last period of EnDev supports in Indonesia, there were three key technological innovations. Those are the universal Remote Monitoring System (RMS), Smart Payment System (SPS) and Renewable Energy Boat (RE Boat). The innovations aimed to answer previous challenges which had found during the implementation of past activities.

Figure 16 Interlinkages between activities supporting technology innovation



Innovating in EnDev

Technology innovation had been an important part in EnDev to achieve the target and desirable outcomes of the project. EnDev had always been into testing new ideas and approaches in the framework of rural electrification with renewable energy. The forms of innovation can take shape as incremental innovation that aimed to conduct activities differently and improvement from past activities, as well as innovating in new technology and business models. During the journey of EnDev, technological innovation in hardware had delivered more promising results in the implementation.

Figure 17 Sequence of technology innovation in EnDev

A. Technology Transfer on Micro-Hydro Power

Process

EnDev commenced its cooperation in Indonesia by supporting the technical assistance for MHP projects. It followed the policy of Government of Indonesia to deploy MHP in remote villages for rural electrification. MHP was considered as a good solution because of the vast potential in hydro power and availability of local component suppliers.

GIZ through various projects in energy have supported technology transfer for MHP. One of the examples is the crossflow turbine which is widely used in MHP. Manufacturers and technicians were trained aiming that they can produce and scale the products to benefit more people. The technology transfer to local players has sparked innovations in many regions in Indonesia, especially those having traditional culture of water energy utilisation such as in South Sulawesi and West Sumatera. The strong commitment and competency of the local entrepreneurs in business and technology has been the important driver to achieve successful technology transfer of the turbine and control technology for MHP. Moreover, EnDev consistently expand the dissemination of those technologies through various channels such as the Green PNPM Project (Program Nasional Pemberdayaan Masyarakat) in the two key regions Sulawesi and Sumatera.

During the implementation, EnDev had two structures, the Micro-Hydro Power Technical Support Unit (MHP-TSU) and Micro-Hydro Power Project (MHPP[2]) for Capacity Development. MHP-TSU which had provincial offices was more active in conducting on-site training and supervising works which was benefited by their location. To anchor the knowledge to wider local actors, during the last period of MHP-TSU, MHPP[2] was implemented to document and disseminate the practical knowledge that had been built during MHP-TSU assistances.

For capacity development measures, the projects implemented both classroom and on the job trainings especially for the local technicians and operators of MHP. It was expected that conceptual and practical methods had helped the training participants to have better understanding about the MHP system.

EnDev was further involved in PV mini grids which opened new challenges for new way to achieve universal energy access. In 2012 to 2016, KESDM had deployed approximately 100 PV mini grid per

year to electrify remote villages in Indonesia which was quickly supported by EnDev. The experiences in conducting technical assistance for MHP had developed a proper knowledge bank for EnDev to understand the challenges and potential improvement in the process. Since the technology for PV mini grid is an off-the-shelf product, the innovation pursued by EnDev took different forms and focuses on quality assurance of the installation. The choice was later expanded to various initiatives.

People

In support to micro hydro power (MHP) technology transfer, EnDev had conducted numerous trainings for local technicians. In the course of 2012=2013, there were 12 trainings conducted in Sumatera and Sulawesi areas which were attended by 299 training participants. The training participants were field facilitators that worked day to day on MHP projects. All parties were involved to make sure that the knowledge transfer was well implemented.

The project cooperated with ENTEC Indonesia together with local service providers to conduct the trainings. ENTEC Indonesia was a subsidiary of ENTEC AG of Switzerland who was well-known for their works on small hydro systems. The company had involved in various technology transfer activities with GTZ in different countries such as Indonesia and Nepal. GTZ reorganised the company and changed its name to GIZ in 2011. Local technicians were flourishing during this time, in parallel with many government budgets was pouring into micro-hydro power to electrify rural areas.

There was a minimum of three experts for each location, which made a total of six experts in Sulawesi and Sumatera. The team consisted of engineers on civil, electromechanical, and turbine. Each training session had a full-week session that combined classroom and practical sessions. The trainees also had a chance to be have on-the-job sessions at project sites. During the latter session, the participants were trained the practical skills and knowledge about the civil works, electromechanical, electricity distribution, and operation of an MHP. Government partners in the MHP knowledge transfer process were village governments, sub-district governments and Ministry of Home Affairs (MoHA).

Resource

The training for technicians from Sumatra and Sulawesi required operating MHPs which were used as the model system for the training activities. The project worked closely with Green PNPM Project and used their sites as exemplary sites for the practical training. eveloped training materials for the training of technicians. In the field Entec provided working tools such as flow meters, GPS, measuring tapes, electrical testing equipment such as AVO meter, clamp meter, test pen and other tools. Entec Indonesia also provided reference modules that were given to the training participants for their reference in future MHP works.

External Factor

Micro hydro power has been installed in Indonesia since the colonial era. MHP technology has been developed further through many initiatives in Indonesia. It is also one of the most popular technology to be installed by the communities in rural area due to its simplicity and accessibility. GTZ, the prior name of GIZ, itself had been supporting development of MHP since 1990s and contributed to the birth of turbine manufacturers and electrical control. There were also many success stories from MHP development in Indonesia thus many ministries and organisations were in favour to use MHP for their community empowerment programmes. Hence, many MHP manufacturers and contractors were working on MHP projects both from government, private entities, and community initiatives. The condition had further influenced the need for capable technicians for field implementation as well as shown promising opportunities for the technicians.

Visit from African and Asian countries to Microhydro Competence Center (HYCOM) in Bandung 2015 (top). Complete system of Microhydro power (below).

B. Solar Business System (SBS/Solbis)

Process

EnDev initiated an innovative business model for off grid solar solution through SBS/Solbis. The idea came out based on the successful model in Africa especially in Namibia. The PV system consisted of a small PV battery system that is used for charging solar lanterns or cell phones and can power some small AC appliances for productive use of energy. It was successfully implemented in Namibia especially in remote areas where main grid will be more likely to not arrive. Based on the Indonesian context, the model looks promising because it would reduce the cost of implementation and optimally provide energy services (which is limited to lighting and small appliances) to remote off the grid areas.

EnDev partnered with private sectors, who were already experienced in solar PV business. EnDev and the company developed a different solution for small communal PV systems that was more cost efficient and able to promote productive use of energy compared to individual solar home systems. The idea was quite unique, but it was maybe too advanced for basic rural electrification at that current stage. Moreover, a scalable business model should be based on the existing consumer behaviour. Namibia's success might be credited to the existing ways of people to get their basic service, such as water, and how people live. Hence, the SBS/Solbis pilot had provided satisfactory performance of the technical design while the business model was not yet workable in the community. It was piloted in the fishermen community in Cirata Dam, West Java.

The key of innovation here was the business model. With the normal SHS, each house was given a system and the user might overused it and the system might broke in a relatively short time.

The key of innovation here was the business model. With the normal SHS, each house was given a system and the user might overused it and the system might broke in a relatively short time. With the Solbis, tier 0 customers can charge their solar lanterns or cell phones. The business owner can provide additional services such as entertainment, hair cutting (with trimmer) or other services that needs low power.

People

The main partners in piloting SBS/Solbis were manufacturer of PV, grocery kiosk, and academician. Advisors from EnDev reached out to several companies about the possibility to develop an SBS/Solbis concept which then followed up by call to join the work. There were two companies signed up to the challenge and invested in time and people to develop the product. During pilot implementation, the project involved STT PLN to implement and monitor the project in Cirata Dam, West Java.

Resource

For Solar Business System (SBS) or Solbis, the technology was simple, and the hardware were readily available. The system consists of:

- Solar PV panel – to capture the energy from the sun
- Battery control and regulator – this is to control the charging and discharging
- Battery (deep cycle battery) – battery is used to store energy
- Inverter – the convert DC current to AC current
- LED lamps – the lamps were rented as part of business model
- Box to contain the system, cables and other electrical accessories.

The system was cost effective to achieve minimum electrification need (lighting and small appliances) compared to solar home systems.

External Factor

People readiness to adopt new technology needs momentum and how the technology solution fit into their daily challenges. In 2013, PV technology had just started to be popular in Indonesia and few manufacturers in PV were existed. The situation was far from now which PV technology have gained popularity in the last few years. Therefore, the idea of PV application other than SHS was still foreign for many. The overall situation of PV had affected on how fast people received the idea of Solar Business System (SBS/Solbis) during that period. In recent years, the concept of charging lamps had adopted in Sumba where many forms of PV application are implemented.

Pilot Project of Solar Business system at Cirata, West Java.

C. Knowledge and Communication Platform for Rural Electrification (ENERGI DESA)

Energi Desa is a knowledge dissemination platform about renewable energy-based mini grids comprises MHP and PV mini grids. The platform had been developed since 2014 and targeted users from the operators of MHP and PV mini-grid, local government officials, academicians, as well as practitioners of renewable energy. Interactions in the platform were using SMS and mobile apps for Android system. The users got basic knowledge and practical advices to maintain the mini grids and improve their basic understanding about the systems. To build the system, EnDev started with a basic SMS-gateway which then evolved into a mobile application which was developed with an information technology-based company. The company also developed a communication platform for farmers.

In the latest development, Energi Desa used short-messaging-service (SMS) to asked and got answered for their questions. The SMS linked to mobile application for smartphones that could be used by the participants who were able to access data network. The users can ask and answer questions in the forum through SMS and mobile application without charges. Since the service was using the special number to be contacted, the SMS fee was covered by the project. Access by SMS was used to facilitate the users who had low accessibility to 3G and data network who were experienced by most of the users.

EnDev managed the content for regular articles and moderated question and answers in the platform. The articles posted in the platform were explaining about various aspects of the mini grids in the context of rural community. The questions posted in the platform were answered by practitioners who were voluntarily engaged in the platform. EnDev also deliver simplified article in SMS format to reach the operator of mini grids.

During the operation of Energi Desa, 2013-2016, there were challenges that were not relevant in today situation. The challenges were:

- Low engagement and interactions between participants thus several questions were left unanswered;
- Most of the mini grid operators did not have knowledge on basic electricity concept and spoke different local languages which made interactions more complicated in text form. Many questions had been submitted by the mini grid operator but the expected solutions were not always happened due to low level of engagement and language barriers.
- Energi Desa platform used a subscription plan to the technology provider to ensure that the platform was maintained by the experts and sustained its operation. Nonetheless, an agreement about who and how it would be operated were not reached yet between partners. Hence, EnDev decided to close the service since no local partner was ready to adopt Energi Desa and operate it continuously.
- During the period of Energi Desa, number of practitioners for PV mini grid were very limited and lesser to engage with practitioners who were willing to volunteer their time to interact with the operators of mini grids.

The texting method might have to be enhanced by an option to call the platform to conform with the behaviour of the users and increase interaction among them. The need of the mini grid operators was skilful technicians to come and did the repair work. A tele-diagnose service was not their immediate need. Hence, the idea of Energi Desa had been the trigger to establish a local technical service provider to conduct the maintenance and repair works which will be explained further in the chapter of Quality Assurance.

Training for PV minigrid management team from South Sulawesi (top and below).

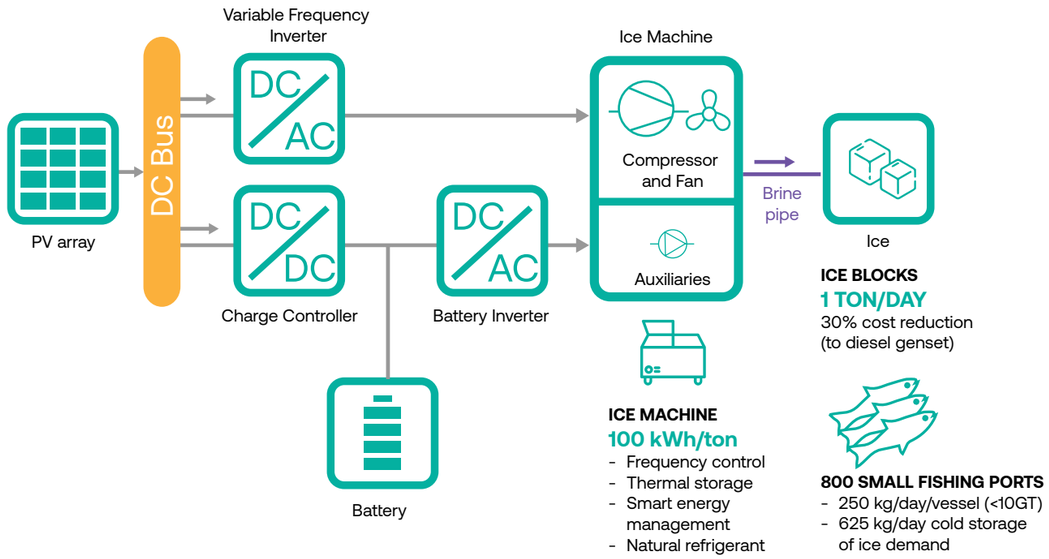
D. Solar Powered Ice Maker (SPIMA)

Process

Next technological innovation was a solar-powered ice block maker or SPIMA, a collaboration project between different GIZ-supported energy projects and private companies. It demonstrates the ability of public and private entities to come up with new solution for optimal solar energy utilisation that meets the needs for better fishery supply chain in small islands. Both international and national private companies were involved to develop the SPIMA especially in building the prototype. It was a good collaborative effort between GIZ projects and private companies which and had become one of the promising examples of private and public partnership.

The idea came from the facts that fishery products in small islands are not properly preserved with cooling technology. It results in declining price of the products and shrinking the welfare of the fishermen. Insufficient energy supply in remote islands has limited the possibilities to install cold storage in those islands. Nonetheless, solar energy is abundant and solar powered ice maker is found to be a good solution. The key innovation in the technology is the use of dynamic system that allows the machine to be fully powered by solar energy and limits the use of bulky batteries to run the compressor steadily. The arrangement makes the machine more efficient. There is no need to have 24 hours power thereby SPIMA can be installed in the small islands, reduce its diesel consumption, and help the fishers to keep their catches fresh.

Figure 18 Principle concept of Solar Ice Maker



GIZ-supported projects namely Green Chiller NAMA for cooling technology, EnDev Indonesia in energy access, and promotion of renewable energy with LCORE-EXPLORE, have been providing with project management, facilitations and technical assistance. Expertise for the product development was provided by ILK (Institute for Air and Cooling) from Dresden, Germany. ILK had worked on the design of the solar ice maker and assistance in constructing and testing the prototype. In the meantime, manufacturers had contributed their components to develop the first prototype. Companies who had provided parts for the solar ice maker among others are AIREF, ATW Solar, REC Solar, BAE, Bitzer, Ziehl-Abegg, Studer, OMRON and Pertamina. Pertamina provided an environmentally friendly refrigerant, Musicool.

Preparing brine tank for solar ice maker system.

The new technology needs new approach to the users. SPIMA is an innovation in hardware but also needs a workable business model innovation to reach the users and create more positive impact to their quality of life. It involves a business who want to generate decent revenue stream and coupled with positive impact to the surrounding community for the implementation at the pilot site. At this stage, GIZ cooperates with BIDCAB, a local company resided in Kupang, East Nusa Tenggara. At the current state SPIMA is in the installation phase at the pilot location in East Nusa Tenggara.

Some of the lessons derived from the project, were:

- The parties in the cooperation should communicate their expectation and how they want to proceed when there is any unforeseen risks or disturbances during the piloting process at the earliest stage.
- In the prototyping stage, the company who want to adopt the technology will bear various risks to keep the machine operating such as technical, financial, and operational risks. The parties in the cooperation should equally aware of these risks and properly distribute the risks among the parties involved.
- Technology transfer between international institutions and the local manufacturers should be moderated or facilitated by a team of engineers from electrical and refrigeration technology. This is important to translate the new conceptual design to manufacturing practices. Engineers and technicians in the manufacturing company might not familiar with the new approach or unavailable tools, as they often stick to business as usual methodology.

People

The SPIMA project had diverse expertise contributing to the product development and implementation that involved multi-GIZ projects to work on. Each project contributed from their scope of work, such as Local manufacturer who built the prototype had dedicated a team to develop and adjust for improvement. ILK Dresden (Institute for Air Conditioning and Cooling) provided experts to design and formulate manufacturing instructions for manufacturing.

The private sector partners contributed to the projects were: AIREF, ATW Solar, REC Solar, BAE, Bitzer, Ziehl-Abegg, Studer, OMRON and Pertamina. For the installation, SPIMA will be installed in Sulamu Village, East Nusa Tenggara and cooperated with a local company as the host, named BIDCAB. A community facilitation had been conducted prior to the installation to identify and mapped the current socio-economic situation in the surrounding community and as a baseline to measure impact.

Figure 19 Collaboration for Solar Ice Maker

Resources

Development of SPIMA had been a research and design journey. All parties involved had to be agile and quickly adopt changes in the process. Hence, it would take considerable amount of resources from all parties, including time, expertise, people and capital. Started in 2016 from a scratchy idea, it took almost four years to materialise. EnDev joined the collaboration to make the product fit to the targeted users, the fishers, who had been one of the beneficiaries of EnDev activities.

External Factor

Development of SPIMA involved many partners from different industries with diverse interests and expectations. Moreover, there were language barrier, as well as knowledge and skills gap between the system designers from Germany and the Indonesian technicians at the manufacturing plant. The challenges were mitigated by deploying an engineer from EnDev to moderate the exchange, but it was not a smooth sailing journey because the assistance had to be done remotely.

Limited number of companies that had a stronghold in remote locations or small islands. For the pilot project to be effective, the company should have the sufficient fund to invest in the construction works and initial operation for several months until revenues from the ice maker starting to flow in. The company should also have thorough understanding about the targeted market, such as based on the target location or nearby town and had been serving the targeted market with product or service. access to fund the prototyping activities.

Women Fish sellers in Labuan Bajo fish market using small ice pack.

E. Local Technical Service Provider (TSP)

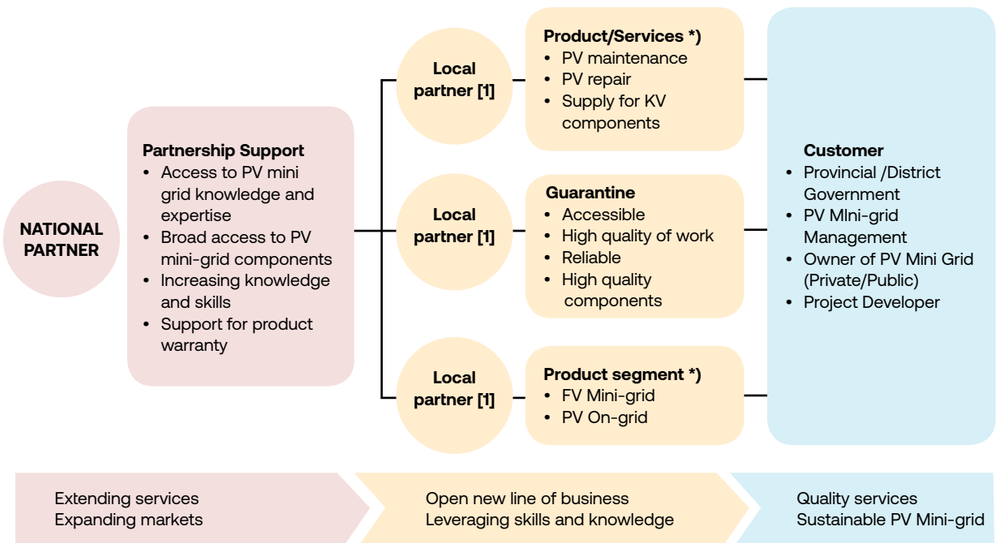
Process

Third one on the list is Local Technical Service Provider model. Local technical service provider (TSP) for mini grids are inevitably important and emerging as soon as renewable energy use are increasing. The service shall be professional and is able to handle troubleshooting of renewable energy technology. In Indonesian case, TSP for micro-hydro power is readily available in various locations due to its familiarity and extensive number of installations from small to big capacity of hydropower. Local players of MHP are also competent and already creating solid network within themselves.

In the meantime, solar power technology is relatively new to Indonesia and still in its emerging technology phase. Compare to micro hydro power which had already introduced in Indonesia since the 19th centuries, solar power technology through Solar Home System was introduced in 1990es by the Ministry of Research and Technology and experienced a slow growth until recent global trend on solar power technology. Since 2012, DJEBTKE from KESDM had installed mini grids to electrify rural communities in remote areas which had reached more than 600 PV mini grid systems. Considering the high number of the mini grid installations throughout Indonesia, after sales supports and professional technical services are required to sustain their operation and anticipating further expansion in renewable energy sector.

National partner is a company who already has experiences to work on nation-wide renewable energy projects and has a higher engineering competence. Hence, they will be able to deliver in-house training for the local partners based on vast numbers of experiences in the projects and update them with the latest technology and services. They are also more likely to invest time and resources to open new market for their business. The project's national partner was PT. TMLEnergy, an engineering, procurement and construction (EPC) company with broad experiences in PV systems installations in Indonesia. The partnership was made after EnDev communicated with several EPC companies who had big portfolio on rural PV mini grid in Indonesia. TMLEnergy then expressed interests and alignment of strategy with the concept. It was also backed by the experience serving operation and maintenance contract for a company in East Nusa Tenggara.

Figure 20 the concept of Technical Service Provide



*) Possibility to be developed occasionally based on market condition and cooperation between partners.

TSP needs local partners whom will be partnered with the national partner to deliver the technical services. A partnership is chosen because PV technology are still relying on imported components and has higher degree of complexity compare to MHP. Therefore, a partner selection was held for the partnership. During the cooperation, EnDev and the national partner formulated a service package for operation and maintenance services, defined the criteria for local partners, selection and matchmaking with the local partners.

The TSP concept was piloted in West Nusa Tenggara (NTB) Province. There were 45 trained technicians in the topic of PV Mini Grid operation and maintenance. The training was held for three days including classroom training, and practical training for the high-performed technicians. The next step was to test the TSP concept and the provincial government had agreed to support the pilot in several locations. Unfortunately, a natural disaster was occurred and had forced the government to prioritise budget for recovery. Hence the plan to implement TSP for PV mini grid was cancelled.

However, the concept is still being followed up by the national partner. They plan to create network of partners in different regions and provide services to PV mini grids or other PV system installations in the area.

People

EnDev partnered with an EPC company with nation-wide portfolio, as a national partner, in the development of local Technical Service Providers (TSP). In the partnership, the national partner contributed in training for technicians and prepared their business processes for additional services to nurture their technical service provider and partnership with local technicians. The project conducted trainings to the technicians in the first pilot province of West Nusa Tenggara. The training was held in 2017 for 45 technicians which were combination of individual technicians, technical vocational students and university students. The female participants were able to outperform their fellow technicians based on the post-test result. Provincial government of NTB was eager to implement TSP in their area which was expressed by their proactive response to the activities and plan to allocate budget for operation and maintenance for their rural mini grids.

Resource

For local technical service provider, there was no specific hardware resources used. The important resource is training modules for technicians. The training modules were developed internally by the project based on the experiences from the past such as from MSP (mini grid service package) activities and training for operators. The experiences from MSP activity had provided valuable inputs to the training material so that it became very actual and showed real problems in the field. The training method was also involving site visit, so the second important resource was the actual PV mini grid itself. The project used PV mini grid in Pegadungan Village, NTB, as the venue for field training. The system installed represented generic PV mini grid setup in Indonesia.

External Factor

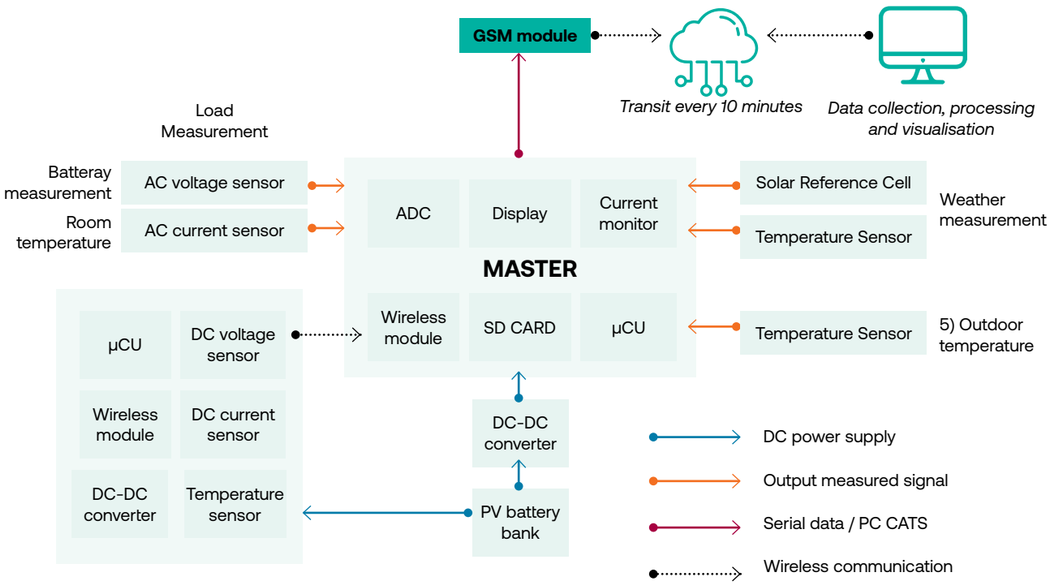
Local TSP concept was developed within the RUMI framework. The project had convinced the Government of West Nusa Tenggara Province to test the concept at their mini grids in Lombok Island or in other islands. The project had trained local technicians to provide services to the government. Nonetheless, there was a huge earthquake in Lombok Island in 2018 which has shifted all the priorities from the government. The budget was shifted for disaster reliefs so the pilot implementation of TSP was cancelled. However, this innovative business idea is continued with the National Partner. It takes different form compared to the original concept.

F. Universal Remote Monitoring System

Process

The MSP (mini grid service package) had resulted many lessons learnt for EnDev. One of the findings was a lack of monitoring of PV mini grids which were financed by the government. Data gathering was not possible due to different data formats sent by various types of remote monitoring system (RMS) systems from different brands. Hence, the centralised data collection system cannot collect the data. The problems had sparked the idea to create a universal RMS. Universal RMS aimed to solve the issues so the government can monitor performance of the PV mini grids regardless of the installation setup and manufacturers.

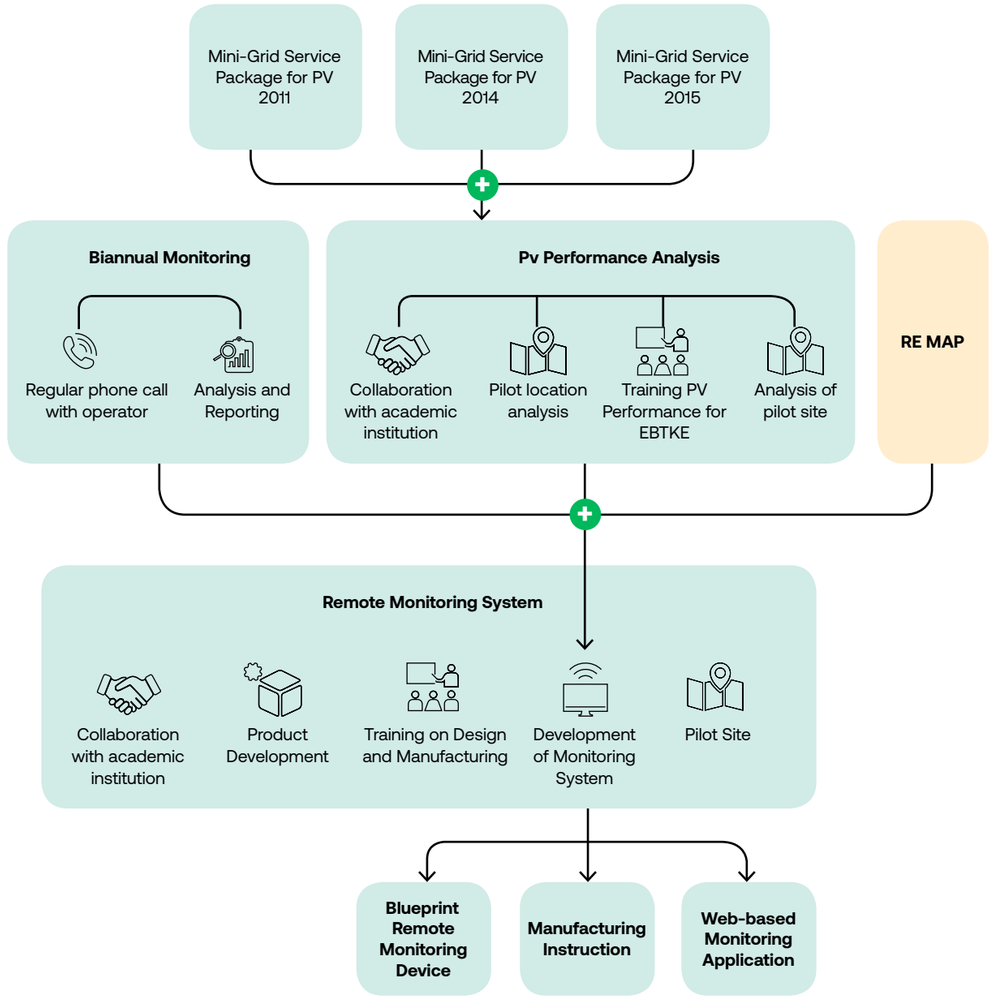
Figure 21 Functional diagram of universal remote monitoring system



The technology was developed in house including the algorithm and software for data analysis. The solution is found interesting by other countries, such as in Africa, and willing to adopt and apply the Universal RMS in their country. EnDev had been workin with local university to manufacture the first version of universal RMS. The arrangement was intended to ensure that the knowledge was locally kept, and they can further develop the technology to various models. The RMS system consists of sensor modules to collect raw data, master module to send the data and server to collect the data and analyse it. RMS relies on GSM cellular network to send its data to server.

The project involves different partners in the development and pilot implementation. The key partner was the Ministry of Energy and Mineral Resources (KESDM) who is the beneficiary of the system i.e. getting the monitoring results. Other partners are education institution, State University of Malang (UNM), who manufactured or replicated the RMS prototype. This will position the university as the agent for further replication in the future. Installation partners are UNM and RESCO Sumba. They will benefit from the experience to install the RMS and get better understanding of PV mini grid system. In the long term, cooperation with different partners may ensure the sustainability of supports for RMS technology.

Figure 22 Innovation journey of universal monitoring system (REMOS)



People

Development of universal remote monitoring system (RMS) was mainly done by engineering team in EnDev who developed the idea and the prototype. The engineers programmed the chip inside the RMS while programming for the RMS dashboard was outsourced for time efficiency. Nonetheless, EnDev provided them with design of the software and logic for the calculation. Prototype had been installed in the PV mini grid on the rooftop of DJEBTKE building to test the usability and performance of the prototype. RMS uses a mobile phone card which is designed for IoT appliances. Hence, EnDev and partners can control and monitor the SIM card remotely, whether we would like to turn it on or off when there is any disruption on site.

The RMS will be installed to PV mini grid sites. Replication of the RMS and the installation are implemented by third party. The strategy aimed to transfer the knowledge and skill in the technology. The partner to manufacture the RMS hardware was Malang State University (UNM) who had signed an MoU with

EnDev to produce and further develop and replicate the RMS. In the process, the project had reached out to various academic institutions whom UNM had responded well and willing to commit. There works involved two lecturers and ten students to assemble the RMS.

Knowledge and skill transfer also happens in the installation of RMS in some provinces in Indonesia. The installation was conducted by UNM and RESCO of Sumba. This will give them better understanding on how RMS works. For data connections, the project uses provider with the widest coverage in Indonesia. EnDev is responsible for the first phase of the RMS operation and covers the subscription plan for the mobile data. For the next phase, KESDM through its directorates is responsible to allocate budget for the RMS. Currently, PUSDATIN from KESDM hosts the software for data collection and the data from installed RMS are sent to PUSDATIN server. PUSDATIN is an organisation inside KESDM who is responsible for data and information about energy and mineral resources.

Resource

The universal remote monitoring system will need different inputs to work properly. It needs a PV mini grid system that is still active or in operation. Without an operating PV mini grid, the RMS will be meaningless. Data input for RMS are weather condition such as temperature and irradiation; room condition especially the temperature; battery condition especially voltage and current; and PV data such as current and voltage. The raw information is then sent through GSM cellular network to a central server in the ministry where the software takes the role to gather, analyse and visualize the performance of specific PV mini grid.

G. Renewable Energy Boat

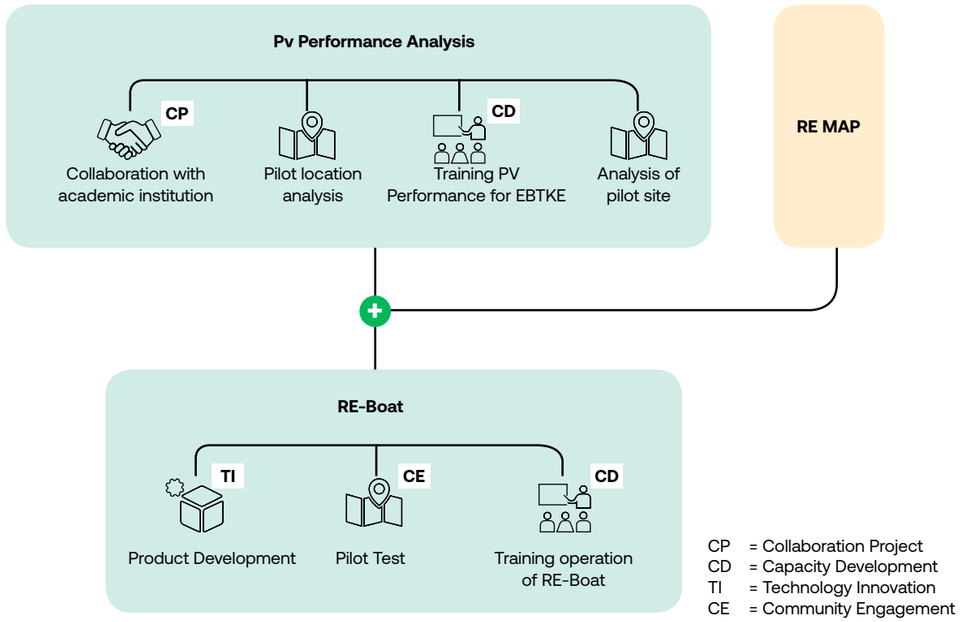
Process

A notable innovation was a Renewable Energy Boat (RE Boat) which can contribute to better utilisation of PV mini grid in rural communities. There are different solutions available for electric boat which one can buy from the market. However, the particular function is that the RE Boat is a complete system that utilises excess energy from a small PV mini grid. In many small islands, artisanal fishermen and seaweeds growers are relying on fossil based outboard motor. The price of fuel in remote small islands is usually high with a high risk of environmental pollution. They do not travel far from the island also without carrying heavy loads in the boat which make the perfect users for the first generation of RE Boat. The implementation is currently limited to 1 Gross Ton boat and potentially increased with bigger motor and battery sizes. The RE boat is utilizing the abundant solar power to reduce operational cost from buying fuel, increase resiliency by using local energy source, protect the environment and further improving the livelihood of those fishermen. The solution intents to meet the need of artisanal fishermen and the implementation is currently limited to boat with the capacity of 1 gross Ton and potentially increased with bigger motor and battery sizes.

New technology needs different approach to be adopted by the users. Hence, the RE Boat introduced the concept of battery rental. Modifying the common charging concept for lamps to battery charging for electric boat was the incremental innovation that would give an alternative of business for PV mini grids management. Pilot implementation was performed in Sabangko Island, South Sulawesi.

The RE boat project development involved different steps, such as comparison of different outboard motors, researched on the optimal charging system and studied on the optimal battery system configuration. Readymade solutions are available, especially for battery, but come at higher cost. Achieving comparable efficiency with fossil fuel requires the battery system to be customised for cost efficiency. Although the current usage is still limited but the options for future usages are wide open for example for further research, health, tourism and other education purposes.

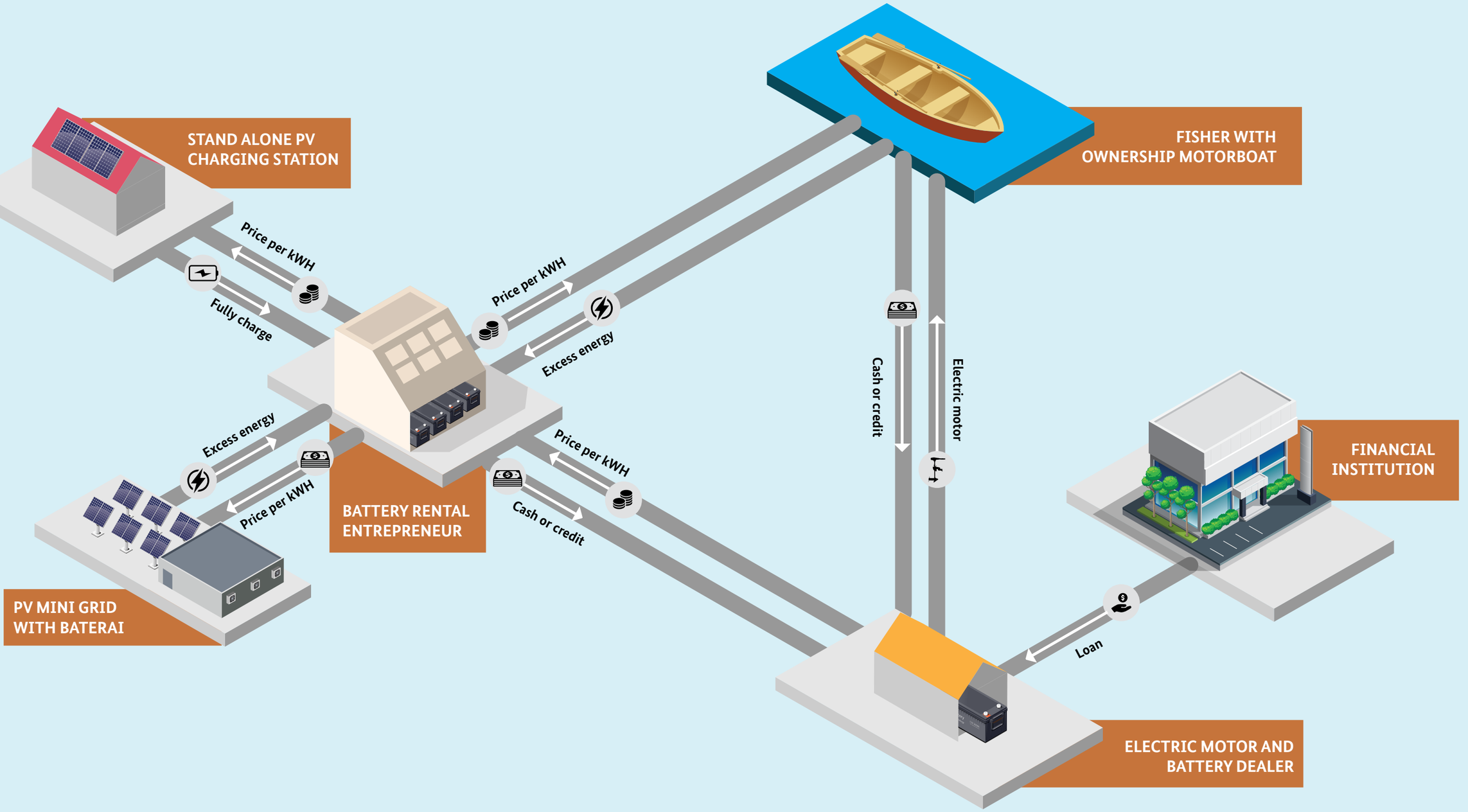
Figure 23 Interlinkages between EnDev activities supporting Renewable Energy Boat development



Renewable Energy Boat in action at Sabangko Island

UTILISATION OF EXCESS ENERGY

Figure 24 Utilisation of excess energy from the existing PV mini-grid and baterai rental scheme with existing PV mini-grid and stand-alone charging service



People

RE boat project involved students to conduct the research and private sectors who supplied the outboard motors and battery systems. In the concept testing phase the project hired two undergraduate interns who made the RE Boat as their final project. One student comparing different electric motors with normal combustion outboard motor while the other one studied the charging station and the business model for battery rental. Both students have completed their studies well. In the concept testing, the project tried to work with Ministry of Marine and Fisheries (KKP) but eventually the test was conducted together with fishermen cooperative in nearby Jakarta. There were two boat owners involved in the test.

Resource

The important resource for the RE Boat activity is the type of fisher boats. During the experimentation, the project found that certain boat design had reduced the effectiveness of the electric outboard motor and reduced its competitiveness with the normal combustion outboard motor. This one was measured based on the speed of the boat.

Second major influence to the RE Boat concept was the RMS system. The RMS should be able to tell the mini grid management when there was an excess energy. It was because only during excess energy period that the batteries for the RE Boat could be charged. Without a working RMS, charging battery might put more burden to the mini grid system.

H. Smart Payment System

Process

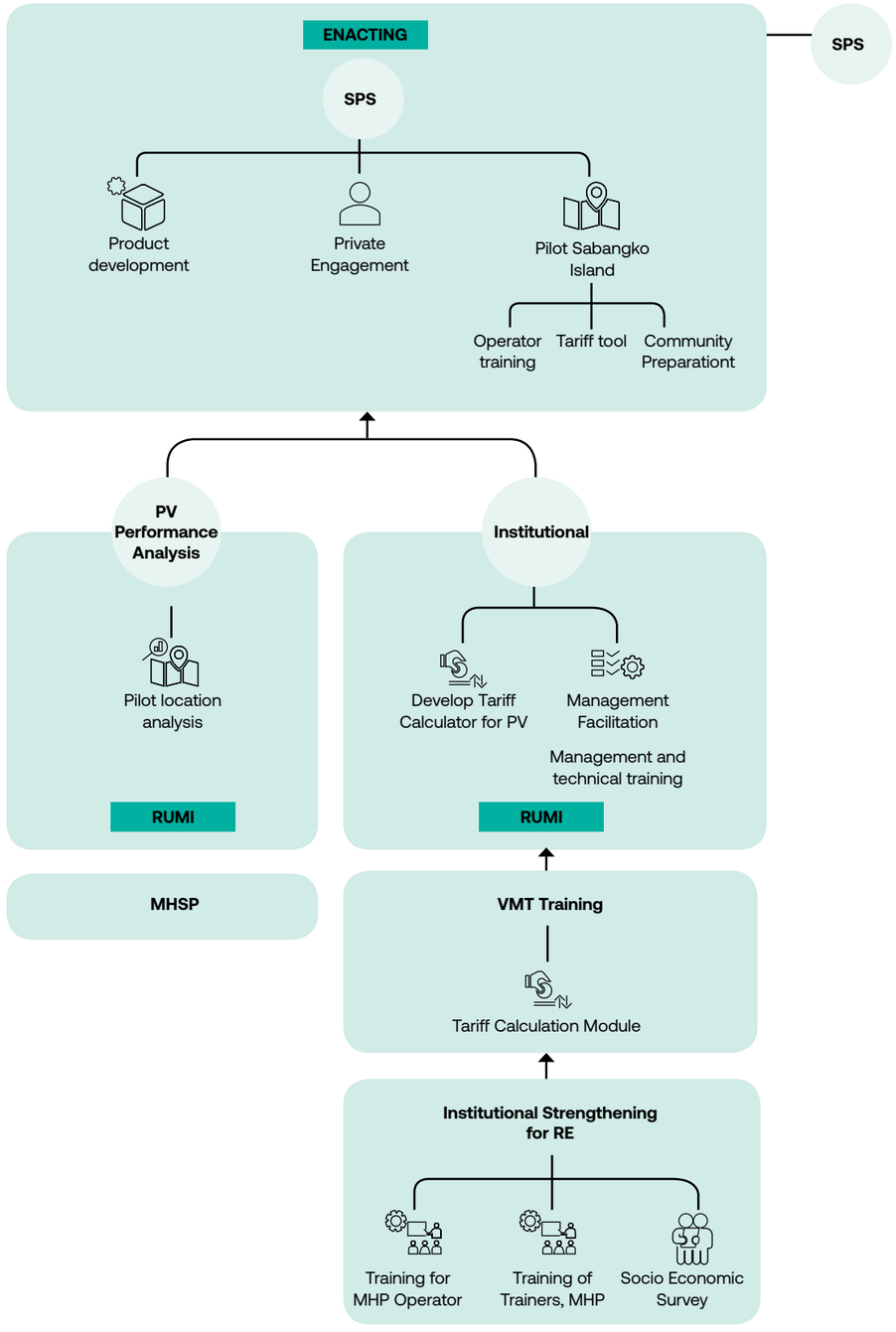
Technological innovation could act as an enabler to optimise the utilisation of PV mini grid with goal to increase sustainability of the system. EnDev had been an active promoter of optimising PV mini grid through technological innovation. During 2018-2019, EnDev implemented a pilot project to achieve better management of PV mini grid utilisation in rural areas, a Smart Payment System (SPS). Figure 1 indicates how projects were interconnected before SPS could be implemented.

Institutional Strengthening for Renewable Energy (ISRE) activity provided support to build the capacity of Village Management Team (VMT) members in managing, operating and maintaining MHP scheme independently. Developing the capacity of VMT was at the centre of ISRE targeted output which was indicated by three main activities training for MHP operator, training of trainers, and socio-economic survey. One of the outcomes was the importance of tariff calculation module to formulate an adequate tariff system to ensure enough amount of fund was reserved by the community to operate and maintain the system.

On the other side, the Mini grid Service Package (MSP) provided significant insights regarding the performance of mini grid, particularly on PV mini grid. MSP was started as a mean to assess the quality of installation, component compliance, and mini grid performance. It had contributed to improve the sustainability of the system, indicated by an improvement of the quality of installation in the following year after MSP result was submitted to the government. Moreover, MSP provided substantial findings regarding the real PV performance on site and how the users utilise the energy available from PV mini grid.

Rural Mini grid Management (RUMI) model took some lesson learned from ISRE, VMT training, and MSP activities. RUMI was based on the idea that sustainable operation of mini grid was affected by several factors such as good installation, legal form and capacity of VMT, proper tariff scheme, and availability and accessibility of spare parts and service provider. RUMI then initiated an effort to exercise on finding management model that could support the sustainable operation of PV mini grids. Operation and maintenance training, management training, tariff scheme, and PV performance were analysed further in RUMI pilot project.

Figure 25 Building Blocks of SPS



RUMI pilot project provided insight to develop a new enabler to optimise the PV mini grid that yet to be fully utilised and to increase the sustainability of PV mini grid. In the course of 2018-2019, EnDev committed to continue developing the rural areas through renewable energy by introducing smart payment system (SPS) for PV mini grid. EnDev had found several challenges that potentially could be solved by implementing Smart Payment System, which are:

1. Unavailability of reserve fund to replace the damaged components
2. Non transparent bookkeeping for energy sales
3. Minimal monitoring and protection in energy supply and demand

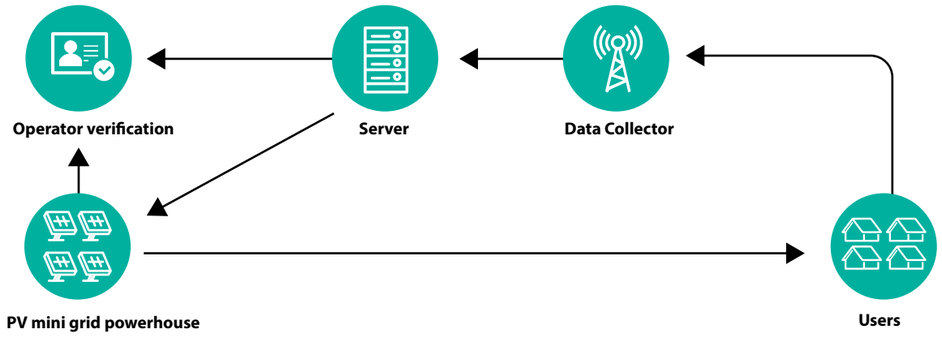
The SPS is designed to fulfil several functions, namely:

1. To automate energy management that only enable energy to be used by the households who have paid the tariff
2. To serve a fair energy usage and purchase with pay-as-you-go (PAYGO) scheme, thus a would be available as user should never lost the energy that they have paid
3. Algorithm that provided several options for daily energy limit in each household, thus several households might consume excess energy that is available during daytime. These smart payment features are expected to help mitigating the risk that possibly occurs by the abovementioned challenges

A more detailed concept of smart payment system is illustrated in the scheme. PV mini grid will send information regarding the status of the battery, based on this information an algorithm will calculate how much daily and excess energy of each household can receive. Every household have to pay the tariff in advance and receive daily energy limit and excess energy. In the meantime, the daily excess energy will only be sent to household who has subscribed to buy excess energy to control the usage. Furthermore, the system will also protect the batteries by allowing dynamic energy allocation based on the battery status. For example, a 100% battery state-of-charge (SOC) will give each household 500 Watt-hour daily limit, while in 60% SOC will only give households 300 Watt-hour. These collected information in the server in PV mini grid powerhouse will be sent to smart meter in each household. Communication between smart meter and server uses LoRA technology because it has a low power consumption and wide coverage range which is suitable for installation in remote area. The smart meter will send feedback to server in which will monitor the system.

The Smart Payment System scheme illustrates the key resources that are used by the SPS. Three devices are fundamental in SPS: server, smart meter, and LoRA technology. The server acts as the brain of SPS technology. Data acquisition and control algorithm were programmed in the server. The information will be processed in the server and the respective command – according to collected information from

Figure 26 Smart Payment System Scheme



the PV mini grid and the smart meters – will be sent to each smart meter. The smart meter will receive information about daily and excess energy limit and battery status. It will record daily energy consumption, power, and payment status of the users of which will be sent to the server. The communication between the server and smart meter is done via LoRA technology.

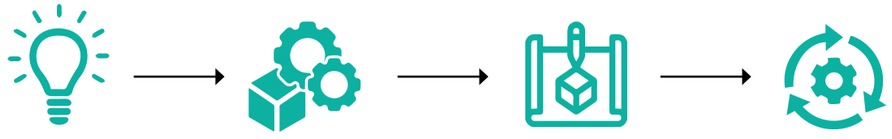
LoRA technology consists of three main parts, LoRA devices/sensors, LoRA gateway, and network services. The LoRA sensor that has been embedded in the server and smart meter will transmit data to LoRA gateway. The data will be manipulated, transmitted, and stored by the network services. SPS will never be able to function without these three main components.

People

The SPS underwent four stages of development process: ideas generation, product development, prototyping, and pilot implementation.

The first stage, ideas generation, was performed internally in EnDev based on experiences in PV mini grid combined with input from other activities as seen in diagram below. Product development, prototyping, and pilot implementation were done collaboratively with other stakeholders which consisted of a technology start-up company, field facilitator, and operator. They were actively contributing in the development of SPS.

In realising the ideas, EnDev collaborate with a technology start-up company called Newlight. Product development, prototyping, and pilot implementation that included operator training and installation were executed by Newlight. EnDev supervised the project by co-developing the design and algorithm. The prototype testing was conducted by Newlight while EnDev focused on verifying functionality of the prototype. During the testing, user-centred approach was used in designing the web application, especially for the user interface and user experience. The design was tested directly to the operator and adjusted accordingly based on the input from the operator. The field facilitator was also starting to introduce the SPS to ensure new technology can be adopted without difficulties by the community. Subsequently, the prototype was manufactured and installed in 65 households by Newlight. During the installation, group discussion also held in the Sabangko island to inform the community about SPS, including its features. In addition, operator was trained by Newlight to use the SPS web-application.



The involvement of a local technology company was intended to ensure that the technology was anchored properly in Indonesia. Moreover, with the proper business conduct, the company could generate revenue with their build up competence and skills after the pilot implementation.

Resources

Resources for smart payment system were similar to the universal RMS, with an addition to conduct community preparation so that the connected houses could be installed by the SPS. All preparation and activities were covered under EnDev.

External Factor

During the manufacturing phase, some components needed to be sourced from abroad as the components are locally unavailable. There was a three weeks delay in the custom clearing processes during the purchase. As a result, the assembly process of these components was accelerated to catching up with the timeline. In the installation process, it was found that in four (4) households, the LoRA signal was undetected as the houses were using a metal (zinc)-roof. To solve the problem, a signal repeater was installed in the household to amplify and extend the signal coverage.

Recommendation

1 **Get more people involved in the project.** Innovation is more than just research and development of a product or service. It requires not only technical expertise to realise the idea, but also non-technical aspect to bring the developed product to be implemented and adopted by beneficiaries. A good innovation project requires a multidisciplinary team to plan effectively and run the pilot project. Consult frequently with different stakeholders to get more inputs and different perspectives.

- **Innovation should be based on the what demand needs**. Bottom up approach or human-centred design should always be considered when thinking of an innovation. Always start with defining the problem from the field, identify the opportunities, collecting raw ideas, brainstorm the possible solutions, piloting and adapting, transferring the technology, and upscaling the solution. Conduct a comprehensive survey to obtain more useful information before starting to have very complex design. Involving the prospective users during the development will ease the adoption process of the technology.

2. **Expect the unexpected**. During the project implementation, there were plenty of challenges and changes in plan. From the experience, procurement and testing are always the time-consuming phases within the development process. The time plan might be delayed during these phases. Product developer should limit the expectation and not to strike for perfection. Focus on the functionality that the users need. Always conduct a high-level risk analysis when starting the pilot project to be prepared with another plan.

- **A perfect prototype does not exist.** Give the time for the product to evolve. Get the feedback from the users during the pilot phase to develop further. However, system should be proven functional before ready for mass production and being installed in the field.

3. **Very good product is meaningless when it is not being used by the beneficiaries.** The product developers are mostly taking the technology-first approach and forgetting about the business development. Technology and demand creation should be developed in parallel to ensure the future adoption of the products.

- **Innovate with the best quality or not at all.** People need a good showcase to believe in the usability and reliability of the product. Always use the acceptable resources (hardware and people), design, and build it properly and professionally according relevant standards to obtain a good quality products or services. Keep in mind in the after sales service and availability of spare parts that have to be provided especially if the product is to be deployed in rural areas and required troubleshooting during operation.

4. **Keep the products simple**. The biggest mistake when developing a product or service is that people try to solve all the problems in one project. People try to put everything they know and produce an overkill and complex solution. The more complex system the more problem that may arise which might be time consuming to get the results out of it.

5. **Sharing is caring**. Share the results from the development and implementation process to the relevant stakeholders. They should be updated frequently to remind them that there are progresses and some solutions will be out there soon.

- **Collaborate with relevant partners with the same interest when developing a product.** It is not only to share the resources but also transferring technology know-how. A good partner also plays a key role in a successful upscaling process. The partner should be competent in manufacturing the product or continuing the services and working in the same sector to better reach their market. Cooperation agreement between the parties should be agreed before the conducting works to define the roles of each party.

- **Determine the best transfer technology method based on the combination of specific innovation or product and the partner institution**. For example, transferring knowledge or technology to private sector and academician requires different approaches. The transferring the knowledge to private sector aims for commercialization of the product, while the academician is targeting the continuation of further development. Effectiveness of technology transfer should be measured to figure out that the methods effectively helps to make the progress towards the technology adoption and input for future development.

6. **One of the key requirements of a successful transferring knowledge process is a good documentation.** Documentation includes design concept, technical drawing, manufacturing instructions, user manual, as well as the challenges faced during the development process.

7. **Capacity development program is essential during the transferring the technology.** Gather the resources from the team to support the technology transfer activities, not necessarily people with technical expertise. Continuous support and facilitation are required during the design and manufacturing processes. The gap in the knowledge and understanding should be fulfilled before the transferring process to stand on the same perspective. On the job training are often a good method to transfer to knowledge to the partner.

8. **Technology adoption takes time and facilitation, even for the early adopters.** Close and daily facilitation during the implementation in the field is necessary to introduce the system, ensure the correct usage, and more importantly get the feedback from the adopters.

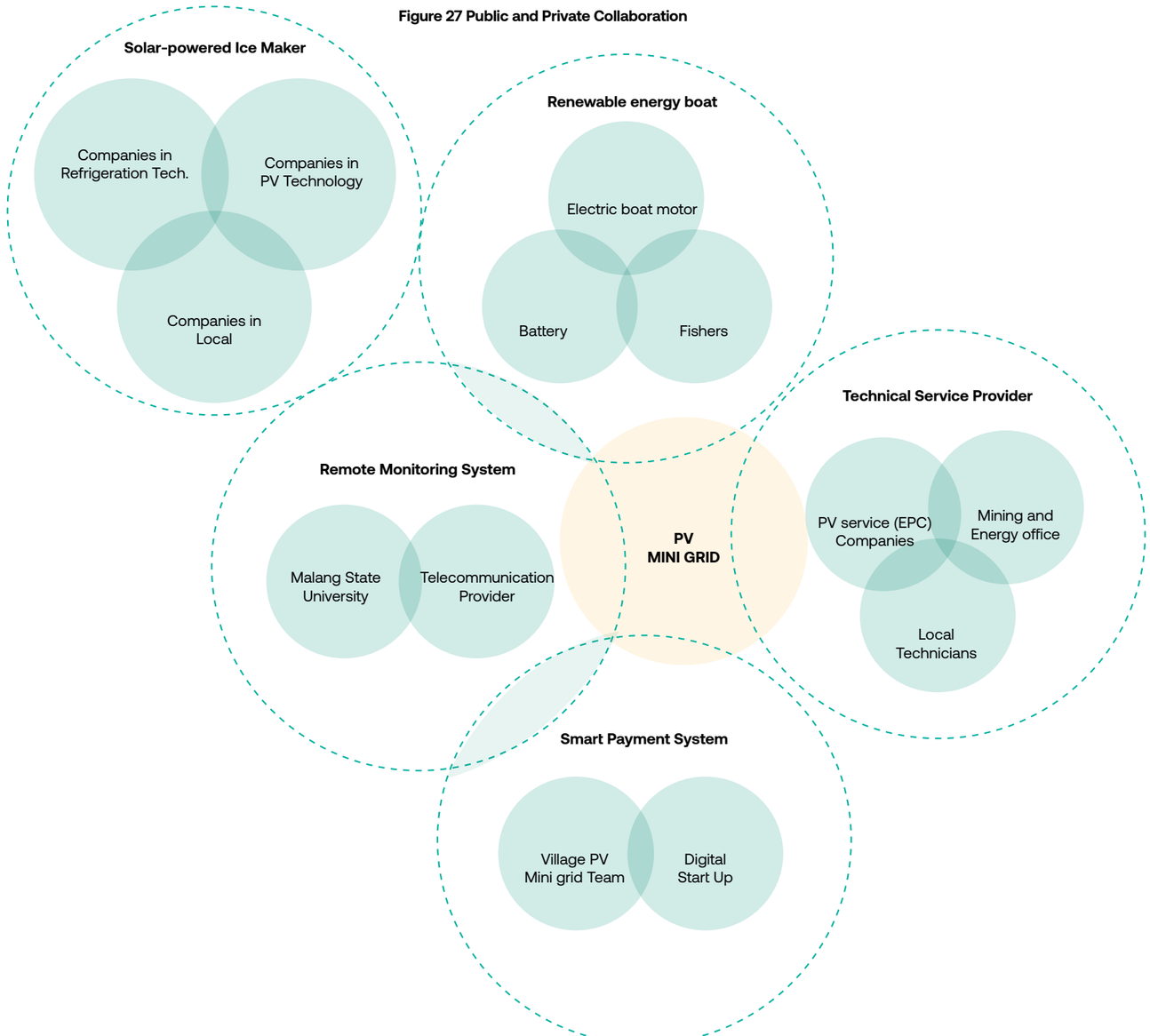
4
Collaboration with public and private institutions

This chapter will provide a context on the importance of collaborating with public and private sector to improve the sustainability of rural mini grid. A sustainable mini grid can hopefully lead to maintain a better living and economic condition for rural communities. In achieving the goals, it is imperative to strengthen various aspects that affects the sustainability of mini grid. Mini grid management, technical know-how, and socio-economic situation are some examples of the affecting factors. Not only strengthening each of the aspects alone but also creating a good environment that enables an efficient interaction among these aspects is crucial to reach a sustainable mini grid. To create such a good environment, EnDev could neither work alone nor depend to work with one institution as there is a need of a wide range of expertise. Therefore, EnDev had collaborated with both public and private sector to improve sustainability of mini grid that leads to a sustainable development.

Making microhydro power turbine in Padang, West Sumatra.

EnDev had been working intensively with DJEBTKE since it was formed. Electrification with renewable energy requires both public and private efforts to develop the sector. EnDev involved private sectors from the early on with intention that companies will develop the renewable energy sector further sustain the rural mini grid facilities with their better quality of services. For example, in 2017 EnDev initiated a Rural Mini Grid Management Model – with a pilot project in Nusa Tenggara Barat – that aimed to: (1) strengthen the mini grids by formulating a legal and capable management team and (2) develop a technical service provider that locally available to support operation and maintenance. EnDev worked closely with provincial energy agency, TRANSFORM (a foundation that focus on natural resources management), and with provincial agency of cooperative and small medium enterprise. EnDev also collaborated with TML energy – an EPC company in national level – to develop a technical service provider in NTB. Meanwhile, in 2019, EnDev completed a pilot project called ENACTING (Energy Access Beyond Lighting) that focus on promoting productive use of energy. The pilot in ENACTING was completed with collaboration with various public and private sectors based on their field of expertise, such as a digital start-up company worked on Smart Payment System, universal RMS (REMOS) was developed together with Malang State University (UNM), RE Boat was supported by an electric board motor and battery manufacturer, and the list continues.

Figure 27 Public and Private Collaboration



Process

In the project implementation, EnDev had been working closely with numerous public and private organisations. The main counterpart of EnDev for almost a decade was DJEBTKE to support them with their energy access program. In addition, given to the complexity and diversity of the projects, it was necessary to work with a wider range of public and private actors and strengthen the interaction between the two entities toward a sustainable energy access. One factor that has an influence the likelihood to achieve the common objective was selecting the right collaboration partner.

EnDev strategy was to align the agenda of sustainable energy access with the government 's development priorities both in national and provincial level. Thus, in partner selection process, especially for a pilot project such as RUMI and ENACTING, EnDev firstly identified the interest of the corresponding public organisations. The initial information collection was very often done through other GIZ projects that previously worked in the targeted pilot site, other organisations that had worked with EnDev or GIZ, or even through personal connection. After collecting the required information, EnDev also gathered information directly from the potential partners by conducting initial meeting to assess the degree to which both parties have common goals and objectives.

Meanwhile, in collaborating with private sectors and non-governmental organisations (NGOs), EnDev adopted a slightly different process. Collaboration with the former, two approaches were adopted on the basis of the project's need. First approach was by contracting a private sector to perform several tasks in accordance to the project's requirements. Second approach was by signing a cooperation agreement with the private sectors. Under the second approach, the private sector agreed to contribute to EnDev's project by providing expertise, consultancy, and even products. Collaboration with NGOs was often done through a contracting to do defined tasks. EnDev realised that the local know-how i.e., social, cultural, and linguistic, was important in the project implementation. Hence, the contracted NGOs were usually a local NGO with respect to the location of the projects and most importantly had a good reputation and track records in the subject.

People

EnDev has previously implemented various activities and projects in the field of rural electrification in Indonesia. This section will focus on emphasising two projects: (1) RUMI and (2) ENACTING as these two pilot projects are the most ideal example in describing the importance of public and private collaboration.

Figure 28 Public Collaboration Process

RUMI had two main activities, i.e., strengthening institutional setup of rural PV mini grid program and developing a locally available technical service provider for repair and maintenance. The pilot was implemented in Nusa Tenggara Barat Province which formed a close cooperation between EnDev and Provincial Mining and Energy Office NTB. Key person in Regional Mining and Energy Office NTB also shared similar vision regarding rural electrification program in their province, promoting renewables and focusing on developing local capacity – these visions were varied in each province. The next step is to collect additional information in the targeted province with respect to the challenge and opportunities for pilot project, the task was performed by TRANSFORM. The preparation for collaboration was usually

finalised by signing a memorandum of understanding (MoU) to indicate the commitment. Moreover, for TSP activities, due to the reprioritisation of provincial budget for earthquake recovery, the trial work that had been planned under RUMI period was prolonged to the ENACTING period.

ENACTING took additional approach by creating more public-private involvement on top of collaboration with the regional government offices in Sulawesi Selatan and East Nusa Tenggara. Instead of hiring a local organisation, EnDev decided to hire local independent consultant that had vast network with the local government to speed up the implementation process. Six consultants were hired, three of each worked in Sulawesi Selatan and Nusa Tenggara Timur (NTT) respectively. Two additional business trainers were hired to specifically support the development of small business in pilot sites.

Additionally, ENACTING comprised activities to showcase the promising role of technological innovation to solve challenges in rural areas. The ENACTING arrangement that worked on various measures was intended to convince local government and relevant stakeholders about the promising result of renewable energy for their development agenda. Involvement of various organisations from diverse background was the main strategy, such as: a digital start-up company for the implementation of Smart Payment System, manufacturing of Remote Monitoring System was implemented with a university, battery and electric boat manufacturers for RE Boat, and groups of international and local companies supported solar powered ice maker as well as an international research institute. Collaborating with start-up, universities, and private companies was required to nurture more organisations and create network that could focus on working in the sustainable energy access topic.

External factors

The most notable and unavoidable external factors that affected a pilot project was experienced by Technical Service Provider activity when an Earthquake hit NTB by 2018. Previously, Regional Mining and Energy Office planned to try TSP approach by allocating their budget for maintenance of mini grids. However, the initiative was suspended due to severe impacts of the earthquake which means Regional Mining and Energy Office NTB put other activities as the priorities, e.g., full revitalisation of mini grid.

Recommendations

1. **International practices have indicated that strengthening interaction and cooperation between public and private sector will offer several benefits to the overall program.** A recent approach through public and private partnership has emerged. For example, World Bank demonstrates the benefit of enabling a PPP approach in Bangladesh. Under the PPP approach, to quote directly, "*... a government enterprise in charge of sustainable energy investments to form PPPs for rural electrification of low-income households. Solar panel and other sustainable energy technology dealers became PPP operators for installation and long-term maintenance of the equipment while the government focused on quality assurance, convening partnership with GPOBA and other donors as well as coordination of electrical grid planning, making sure that the PPP operators do not work in the place where the grid is expected soon.*" EnDev has also encouraged the participation of private sector in PV mini grid development through RUMI and ENACTING. Based on the international practices and EnDev experience, we encourage the public sector to consider a Public-Private Partnership in developing a PV mini grid project.

2. **Based on EnDev experiences in PV mini grid, to obtain an effective a public-private partnership scheme, the PPP shall come as early as the project planning before the PV mini grid installation.** In RUMI project, for instance, EnDev tried to implement a Technical Service Provider for PV mini grid in West Nusa Tenggara province. This was deemed necessary but only considered after problems occurring in PV mini grid. In other words, The PPP came in the later stage of the project. Another example of PPP project from EnDev was smart payment system which also implemented in the post-installation period of PV mini grid.

3. **This PPP shall go beyond merely contracting a private company to install the PV mini grid system.** Universal affordable, clean, and modern energy access for all communities is part of the sustainable development goals. This implies that the authorities all over the world oblige to deliver energy, including electricity, by any means. PV mini grid is the most recent trend to provide universal access to electricity but it comes with challenges. For examples, financial capability of the government as the initiator of the program, quality of installation, weak village management team were among the challenges that we found in Indonesia's PV mini grid. These challenges can be alleviated if the system is being jointly implemented by public and private sector and the cooperation goes beyond a working contract from the public to the private.

4. **The PPP approach shall also accommodate the private sector to pursue their economic goal to be profitable**. This, however, shall be done under an innovative business approach model because performing a business as usual model would be challenging in the case of PV mini grid in rural areas. For example, a joint cooperation between private sector and local cooperative or village owned enterprise can be encouraged by the public sector. In the mentioned scheme, direct financial funding from the state or provincial budget shall be optimized with the expectation that private sector can invest directly to local community through cooperative or village owned enterprise.

5. Lastly, **the PPP shall also focus on distributing roles and responsibilities among the involved stakeholders** as indicated by RUMI, ENACTING, and Solar Ice Maker Project. The most comprehensive example was the development of Solar Ice Maker project where each stakeholder commit to their role and responsible for specified tasks. These tasks are complementing with each other. The distribution of roles and responsibilities are better off to be signed in a formal and written agreement to ensure commitment from all involved stakeholders.

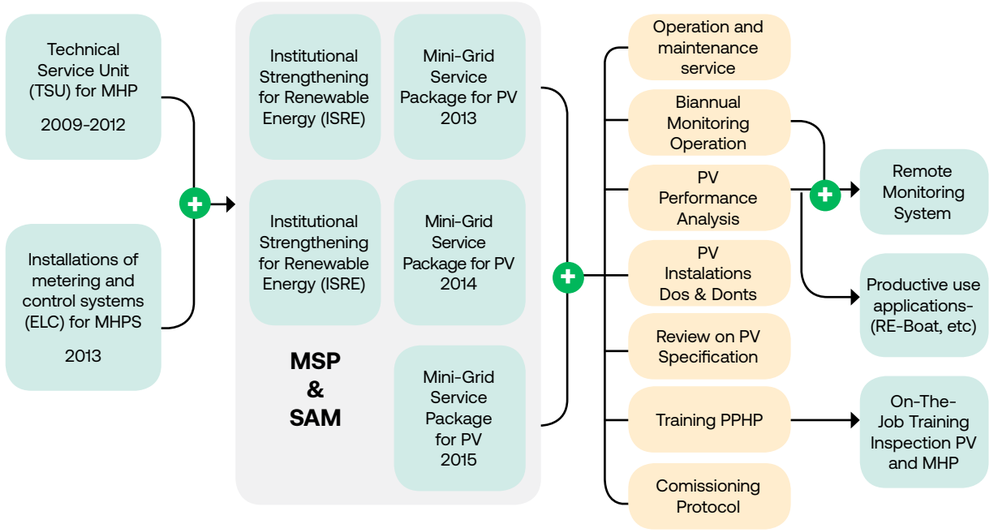
5 Quality Assurance

This chapter highlights how quality assurance had been at the core of EnDev activities in assisting the Government of Indonesia toward sustainable renewable energy infrastructures. Indonesia as an emerging market for renewable energy needs quality assurance to prevent unsafe, underperforming and failure-prone products and installations from ruining perceptions of the technology and harming the market of renewable energy. To accelerate development and deployment of renewable energy, quality infrastructure (QI) is essential. QI is defined as an institutional network, both public and private, and the legal framework that (a) regulates, formulates, edits, and implement standards; (b) provides evidences of its fulfilment such as relevant mixture of measurements, accreditation, tests, certification and inspections (IRENA,2015).

Performance verification of microhydro power

EnDev implemented various measures to ensure quality installations are in place, despite challenges on high costs to conduct laboratory tests and certification, poorly trained practitioners/technicians, insufficient infrastructure to enforce that the standards are being followed. EnDev initiatives on quality assurance were incremental with fully understanding of market situations, especially for micro-hydro power and PV mini grids. The supports were ranging from proposal screening until commissioning of MHP systems, as well as technical review up to installation guideline for PV mini grids. These activities had resulted in positive development although many aspects on quality infrastructure are still needed to be worked on by various institutions both in public and private entities.

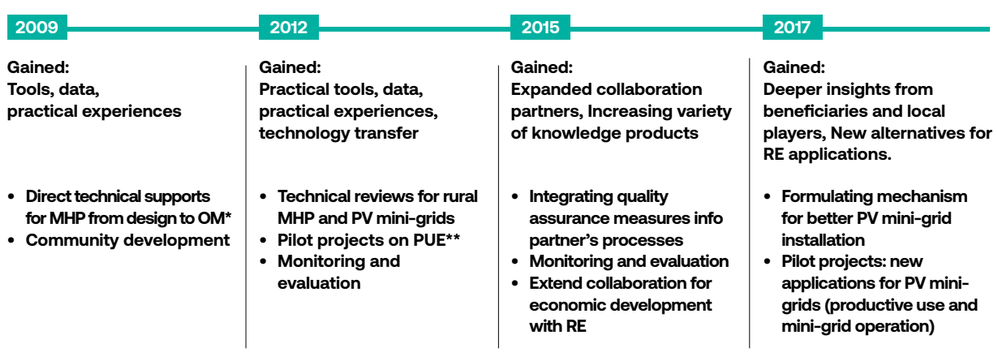
Figure 29 Relation between EnDev activities in Quality Assurance



Process and Timeline

Built up by the experiences in developing micro-hydro power turbine manufacturers and technicians, Energising Development (EnDev) technical assistance was continued to support “Program Nasional Pemberdayaan Masyarakat” (National Programme for Community Development) or usually abbreviated as PNPM. The programme had an arm to develop renewable energy and environment in the community where EnDev contributed by providing technical support unit (TSU) to the community from handling procurement up to post commissioning services from 2009 to 2012. These supports were available in several provinces as being defined by the PNPM, especially in Sulawesi and Sumatera where TSU established regional offices.

Figure 30 Timeline Quality Assurance



Learning from the successful approach of MHP in various remote locations in Indonesia which incorporated high participation from village community, DJ EBTKE rolled out programme to install, in average, 100 PV-battery mini grids annually which spread all over Indonesia since 2011. The locations were proposed by provincial government and selected by DJ EBTKE through various criteria. Therefore, after installation, the systems will be handed over to provincial government who are responsible to manage the mini grid systems. Meanwhile, mandates for DJ EBTKE was to provide specifications for tendering process, procured the systems, up until commissioning of the PV mini grid sites.

Considering the remoteness of the PV mini grid sites, the system should be installed properly which could prevent them from failures caused by insufficient installation quality. PV mini grid programme was a brave leap by the government who previously used solar home system (pico-PV) to provide first access to electricity. As shown in Figure Timeline Quality Assurance , the quality assurance measures had to take a long road before it was materialised into a useful knowledge and added value into the overall processes and sector.

In the period of 2009 to 2012, EnDev focused to assist implementation of MHP covering technical and community development for approximately 130 sites under PNPM program. Local presence was vital in this stage of support that could ease consultation and supervisory activities. In the PNPM setup, village community should be able to manage the process from procurement until operation stage despite their limited engineering background. TSU assured that the micro-hydro technologies installed in the villages were properly designed, constructed, installed, and commissioned based on standard engineering practices.

Figure 31 Activities in MSP

Aligning with DJEBTKE’s rural electrification strategy and with high awareness of the possible risks, EnDev continued to do technical reviews and on-site trainings for MHP and PV mini grids systems during 2013 to 2015 which was called a mini grid service package (MSP). The MSP consisted of technical review, on-site trainings, as well as monitoring and evaluation for the installed mini grids. The technical review examined rural mini grid installations by looking at three aspects, namely component compliance, performance verification, and workmanship quality. MSP method applied to ISRE and SAM for MHP, and MSP for PV mini grids. The support aimed to safeguard the rapid installations with approximately 100 PV mini grid systems per year and MHP systems by various initiatives from Rural PNPM, DJ EBTKE and KUKM.

Only then after mobilising technical expertise to various remote places, EnDev could gain wealth of knowledge about the technical conditions and cross-cutting issues surrounding the technology installed. Therefore, EnDev could analyse data and held fact-based discussions with key stakeholders, namely EPC companies, local governments, relevant ministries, and other key players in the sectors. Moreover, various solutions to solve the quality assurance issues in the isolated mini grids systems could be generated from the process, namely remote monitoring system, troubleshooting assistances, community facilitators, guidelines on PV installations, and others. The following paragraphs will describe these quality assurance measures.

Technical assistances in quality assurance aimed to deliver independent technical advices in the energy access initiatives, from feasibility study, design, until monitoring and evaluation. It aimed to bring constructive feedbacks for relevant decision makers and improve the renewable energy sector and rural electrification programs in all level of governance.

Independency in reviewing process is important to ensure any feedbacks provided from this initiative will be openly received by key relevant stakeholders.

Table 5 The differences between technical assistances

	Technical Service Unit (TSU)	Mini grid Service Package (MSP)		
		ISRE	Support Activity for MHP (SAM)	MSP for PV mini grids
Technology	MHP	MHP	MHP	PV mini grid
Assistance in Planning	Yes	No	No	No
Community preparation	Yes	No	No	No
Supervising Construction	Yes	No	No	No
Test-run and commissioning	Yes	No	No	No
Technical Review	Yes	Yes	Yes	Yes
Training of Trainers	Yes	Yes	No	No
Training for management team	Yes	Yes	Yes	Yes
Training for operators	Yes	Yes	Yes	Yes
Operational monitoring	Yes	Yes	Yes	Yes
Technical report to key partners	Yes	Yes	Yes	Yes
Dedicated detail technical report to contractors	No	No	Yes	Yes
Focus group discussion with contractors	No	No	No	Yes
Data collection	Yes	Yes	Yes	Yes

Technical Service Unit (TSU)

TSU was built as a technical advisory structure for Green PNPM programme. During the courses of 2009 to 2012, TSU had screened more than 500 proposals from villages in Sumatera and Sulawesi. TSU followed through the process from feasibility study to the tendering process conducted by the village team, up until commissioning MHP. TSU structure had two regional offices in Makassar and Padang, while coordination was mostly conducted in Jakarta office. This structure had created a nurturing ecosystem

for MHP which enabled close technical assistance and high accessibility for local partners to collaborate and learn in many aspects of MHP development.

TSU created a database with simple codes that uniquely attached to each MHP site proposed by the villagers, known as site code. Each MHP site had series of primary and secondary data that were required to go through the process in TSU, the details about mechanism in data will be explained in Chapter Knowledge and Data Management. Site code and database had played a vital role in the project management as well as monitoring and evaluation of MHPs, especially those who had been supported by EnDev, from TSU until most recent initiatives.

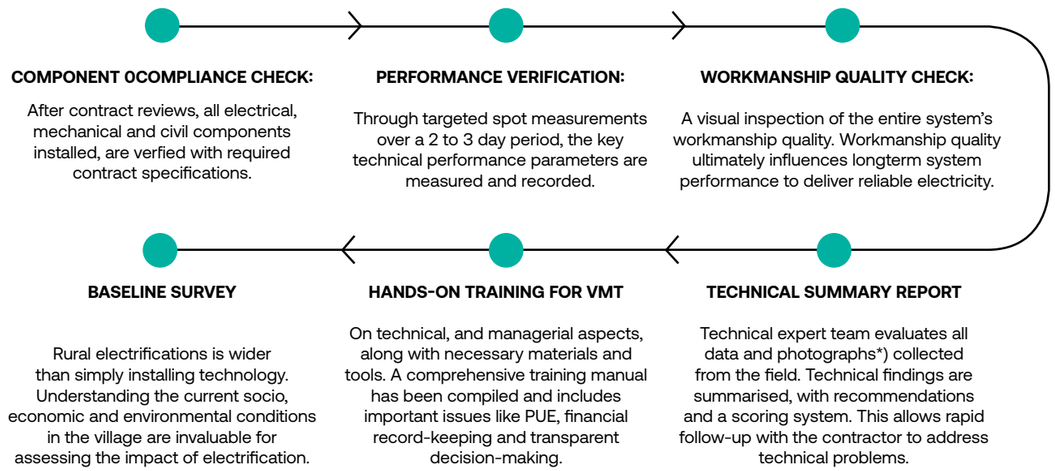
At the end of TSU, more than 130 MHPs had been built with close supervision. Moreover, local turbine manufacturers and contractors in Sulawesi and Sumatera were already well connected and confident to serve the area with any technical inquiries. They are also affiliated to reputable MHP manufacturers in Bandung. Based on study from World Bank Group in 2012, MHP systems which had received assistances from TSU had better quality in technical performance, had less technical problems, and the management teams were more skilful in monitoring and manage daily operation of their MHP, such as in handling revenue and expenses.

Mini grid Service Package (MSP)

The MSP aimed to sustain rural electrification infrastructures that highly affected by both technical and socio-economic aspects of the mini grids. To fulfil the purpose, the MSP bundled series of activities targeting the root causes of the struggling mini grids in rural Indonesia namely reliable technical support and practical skills to manage the systems. MSP consisted of:

- Technical review to provide systematic and objective evaluations of mini grid installations which must stand up to the scrutiny of any contractor feeling unjustly appraise;
- On-site VMT training on both technical and managerial skills to build necessary operational skills in the community;
- Concise feedback to DJ EBTKE about the quality of the installed mini grids and must be handled in the strictest confidentiality;
- Socio-economic surveys to collect relevant data in order to promote more productive electricity use and monitoring.

Detail of the activities are mentioned in the figure below.



In the MSP process, documentation was an essential part that allowed recording of information and provided a record of pertinent facts, findings and observations for future examination. Data and photo documentation were collected by field surveyors, while reviews, evaluations, and reporting were performed by a reviewer team in Jakarta. This arrangement needed to emphasise in the correctness and reliability of the collected data and photos from the site. Therefore, EnDev prepared all the tools for data collection and measurement, initial data about the sites, and trained the field staffs before departed to the targeted sites. Guideline to conduct MSP had been published as a guideline book, titled **Inspection Guide for PV Mini grid (2015)**. The data collected should directly be reported to the reviewer team due to the tight timeline for MSP.

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The MSP proved to be an exceptionally robust, cost effective and time efficient instrument with potential to be used in broader applications both in national and international communities. In planning and formulating activities for the MSP, several considerations arouse which comprised of:

- Field inspections should be performed by technicians who were familiar with electricity installations in rural area. The preference was based on the notion that they are (a) familiar with working under difficult conditions, (b) culturally aware when communicating with the communities, and (c) better understanding of rural context.
- The MSP team had to be small thus they had higher flexibility to reroute or rescheduling in order to anticipate long distance and area with low accessibility.
- A standard technical review form should be quantitative with verifiable evidences and strict inspection regime, must be devised to avoid variations and accidental bias. This discipline must be applied because a re-visit to any mini grid site was not possible and to avoid any conflict with contractors based on unjust criticism.
- The technical review must equally consider all technical and construction aspects of mini grid installation, from electrical to civil construction, with emphasis in safety aspects.

Field staffs also conducted trainings for operator on the basic operation of the mini grids and management team on how to administer the electricity service. For this task, EnDev prepared all the training materials, information posters to be put on the site as a reminder, as well as training of trainers for the field staffs.

1. Institutional Strengthening for Renewable Energy (ISRE)

Catering requests from other PNPM programme, TSU prolonged its services through ISRE for additional six months, from February to August 2014, and reviewed more than 80 MHPs in Sulawesi. ISRE was built upon objectives to (1) transfer TSU knowledge and mechanism within RURAL PNPM organisation; (2) strengthening knowledge and skills of PNPM facilitators about MHP development; (3) providing technical advices to improve MHP quality; and (4) trained the village management team to independently manage, operate and maintain the MHP. ISRE activities consisted of trainings of trainer (TOT), group training for VMT, and MSP.

There were two training of trainers (TOT) for facilitators and six trainings for village management team (VMT). The trainings were held in town of each district and combined with field practices in the MHP sites. Institutionalising quality assurance mechanism required active participation of relevant stakeholders. EnDev facilitated the collaboration by reaching out to the local and national key stakeholders, jointly defined their roles based on their experience and familiar topics and provide the activities for them to contribute. The training should follow andragogy method that involves more games and active learning method to uncover knowledge from the participants.

Table 6 ISRE Activities

TECHNICAL SUPPORT	
Technical review procedure	Output: • Site code provided • Inspection report (Technical review report)
CAPACITY DEVELOPMENT	
Facilitator training Participants: Rural PNPM Technical facilitators and facilitators for community empowerment	
5-day training on technical aspects of MHP, including introduction to MHP Operation, site assestment, DED and BoQ calculation, MHP maintenance, mechanical and electrical commisioning procedure.	Output/outcome: • Technical facilitator training conducted. • Facilitators are able to assess new sites and perform commisioning. • Facilitators able to conduct VMT training in their respective villages/sub-districts.
VMT Training Participants: VMT Members	
4-day training programmes on MHP operation and maintenance, administration, tariff setting, village regulation, and PUE.	Output/outcome • VMT training conducted • VMT is able to manage, operate, and maintain MHP facility independently
SUSTAINABLILITY MONITORING	
KPH survey and SMS-Gateaway (BReIDGE) for monitoring and feed-back	Output/outcome • Monitoring information materials distributed • BReIDGE record

Table 6 Training materials for ISRE

	TRAINING MATERIALS	TOT TRAINING	VMT TRAINING
A. INTRODUCTION			
1	Introduction to MHP principles and sustainable utilization	✓	✓
2	Introduction to VMT	✓	✓
3	Environmental management for MHP sustainability	✓	✓
4	PUE and business development	✓	✓
5	Sustainability monitoring: KPI survey and BReIDGE	✓	✓
B. TECHNICAL ASPECTS			
1	Technical workshop	✓	✓
2	Site survey/site verification	✓	
3	DED and BoQ development	✓	
4	Stakeout	✓	
5	Commissioning	✓	
6	MHP Maintenance	✓	
C. ADMINISTRATION AND MANAGEMENT ASPECTS			
1	Introduction to VMT	✓	✓
2	Tariff setting	✓	✓
3	Financial management	✓	✓
4	Administrative and management aspects	✓	✓
5	Legal aspects of VMT and cooperative establishment	✓	
FIELD TRIP		✓	

ISRE assessed the MHP sites that were built by the villagers with assistances from community facilitators under Rural PNPM scheme. Compare to MHP sites under TSU supports, the quality of MHP from Rural PNPM needed more improvement. One of the causes was that community facilitators were not equipped with proper survey equipment and poor technical documentation from feasibility study, construction until commissioning, such as no specification label on the installed equipment, etc. Unavailability of these data led to inability to measure performance of the system and compare the quality of installation with other MHP facilities.

Checking on civil contruction
Weir, intake, channel and forebay

Checking on mechanical elements:
Penstock, turbine, and mechanical transmission

Checking on electrical elements:
Generator, control panel, ballast load, transmission, and installation

Figure 32 Technical review processes for MHP in ISRE and SAM activities

2. Support Activity for MHP (SAM)

In 2013, Ministry of Cooperatives and Small Medium Enterprise (KUKM) had funded several cooperatives to develop 10 micro-hydro power (MHP) systems, as well as DJ EBTKE who had built 11 MHP systems but with different mechanism. Interestingly, KUKM programme provided direct grants to build MHP to the selected cooperatives. The setup aimed to ensure legal basis and effective management of its operation to deliver electricity service. Moreover, electricity was used to power existing economic activities by the cooperative's members. In the meantime, MHP from DJ EBTKE were set to be operated by appointed management team who was formed prior to installation of the MHP.

The differences in the programme setup affected type of supports for the MHP. For DJ EBTKE, EnDev performed the support which consisted of activities in MSP. Meanwhile, additional assistances were performed for KUKM since the MHPs were managed by cooperatives. Therefore, on top of MSP activities, trainings for rural entrepreneurs and cooperative members were held to leverage their skills and knowledge to start and expand their small businesses which was known as business capacity development (BCD) training. Each BCD training held in three-days and covered topics ranging from business identification, marketing, human resources, investment and access to loan, bookkeeping and planning for business. Details about the BCD training will be explained further in the chapter about catalysing economic development.

Due to the high variation of MHP designs, the technical review had to be performed by experienced MHP technicians. In the case of SAM, there were three teams performing MHP reviews thus the results should be attuned between teams in order to have more standardised and comparable scoring of the MHP.

Based on the technical review, there were components which were frequently founded to have subpar quality in the installation or having wide range of quality of works. Resume of the findings are explained in the table below:

Table 7 Common findings from Support Actvity for MHP (SAM)

No	Component	Findings
1	**Civil construction**	Civil construction has the biggest portion of work in MHP thus requires meticulous planning and diligence to comply with the design. In general, the reviewed MHP had sufficient workmanship quality, mostly penstock and powerhouse which had lesser quality among other components.
2	**Mechanical and electrical**	Most of the MHPs were using crossflow turbines and propeller with good fabrication and safe installation. All the MHPs had synchronous brushless generator, electronic load controller (ELC) and hour-meter. Nonetheless, common shortcoming was unavailability of kilowatt-hour meter in each of MHP system to support performance monitoring and evaluation. Moreover, internal wiring of the MHP had the poorest quality among other components.
3	**Distribution network**	Wooden poles were common to be found in rural electrification, nevertheless, it requires frequent maintenance and regular replacement.
4	**Household connections**	The use of conduit and proper grounding should be required and checked properly to increase safety in the installation.

In MHP systems, the generated power is a function of head and flow. There are various aspects to consider during assessment of MHP performance, namely:

- Season and weather; whether less water flow is caused by less rainfall in certain months
- Topographic difficulties; rocky topography may force changes in the construction of civil works, such as weir and channel. The changes could affect height of the head and directly results in the amount of generated power.
- Man-made factor of poor workmanship in the systems, such as poor concrete works causes leakage and sedimentation that affects amount of power being generated.

There was an inevitable difference between conducting MSP for PV mini grid, and for MHP. Design and specifications of PV mini grid was standardised with minimum design complexities in civil works. In the meantime, design of MHP system consisted of civil and electro-mechanical engineering that directly affect the system's performance. Moreover, civil works design in MHP were customised for each site adapting to the surrounding landscape. Thereby a standardised form to compare the three aspects in MHPs with scoring could still be improved with additional analysis mechanism. The results from SAM and ISRE could need more detailed assessment especially when most of the initial design documents were absent. The following paragraphs will describe in detail about each of activity with MSP.

3. MSP for PV Mini grid

The MSP for PV mini grid was performed continuously in three consecutive years from 2013 to 2015 by EnDev. It had covered more than 300 systems in 28 provinces. The result had also been presented and submitted to the participating PV mini grid contractors for them to improve their quality of works. Started with 11 participating PV contractors, through the review process and improved tender mechanism, the number had been reduced into five participating companies who were committed to deliver quality installations. Workmanship quality among the participating contractors and locations were vary although the specification had been standardised. Coping with remote locations, the installations were performed jointly by the participating companies and local subcontractors. This combination enabled rapid deployment of PV mini grid.

The PV mini grid systems were built by DJ EBTKE whilst accommodating the inquiries from various government institutions, such as KKP, National Body for Border Management (BNPP) and provincial governments. The PV mini grid program by DJ EBTKE was started with one-size-fits-all system of 15 kWp systems despite the various numbers of connections in each village. It resulted in various cases of both overcapacity and overload. During the field visit, the reviewer team also validate initial data provided by DJ EBTKE, especially about the location details. Often there were 20% of initial GPS coordinates data which were inaccurate and needed to be revised.

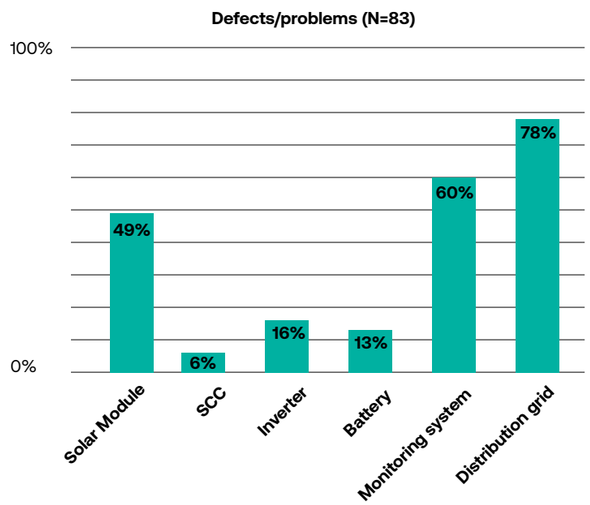


Figure 33 Technical component defects or problems (MSP 2015)

In the MSP for PV mini grid, technical measurements and data collection were conducted using standardised form as a tool to collect the right data for further analysis. Each on-site technical review required one and half day to measure the required parameters, comprising measurement during peak-load time at night, and battery status in the morning. Therefore, estimated battery condition and load profile could be captured. Moreover, the collected data then reviewed along with photo documentations to understand the data better and conduct scoring for the three aspects. After the reviews and intense discussions, EnDev submitted **Technical Survey Summary** to DJ EBTKE for each of the PV mini grid which was also forwarded to the relevant contractors. All documents were confidential. Details on the technical inspections comprises of data collection forms, scoring, and guideline to use the tools can be found in the **Inspections Guideline for PV Mini grid**.

The technical review in MSP were conducted between four to six months after installations, therefore it was common to find some dysfunctional components during technical review. Based on technical review in 2015, most common issues were in (a) distribution grid followed by (b) monitoring system and (c) solar module.

Distribution grid transmits electricity from powerhouse to the connecting households thus safety should be prioritised to avoid injury or fatalities. Main problems in the distribution grid were poor cable interconnection, cable hanging too low and reachable by hand, cable distribution resting on metal surface or sharp edges, and cable blocking road access.

Remote monitoring system (RMS) is essential for facilities installed in isolated locations to monitor its performance and data logger for further analysis. Based on the technical review, the installed RMS usually fell into these categories, namely:

- Active and functioning: RMS was actively monitoring and storing real time data
- Active but not recorded: RMS was monitoring real time operation but unable to store the data into external storage (MMC or SD Card)
- Inactive: RMS was not active and did not record any data. Most of the RMS in PV mini grid systems were in this state.
- Most common issues in the solar module were shading, exposed cable in the PV terminal box, hotspots, snail tracks, and low quality monocrystalline.

PV Installation Guidebook: Do’s and Don’ts

PV mini grids implementation was relatively new for DJ EBTKE compared to MHP. Based on the results of PV Mini grid Service Package (MSP) program, the PV mini grid systems built by DJ EBTKE have shown considerable improvement from year to year. During this time, both DJ EBTKE as the owner of the systems, and GIZ have gained valuable information in the performance and the workmanship quality of all inspected sites. Most of the systems, in recent batches, are within the installation standard and few are still required to be improved. Therefore, the MSP method and accumulated wealth of practical knowledge and documentations of the MHP and PV mini grid installation should be disseminated to relevant stakeholders and wider audiences.

Maintaining a good installation and keep the quality at high standard is one of the key factors to make the PV mini grid system to be technically sustainable. The owner of the system should maintain the quality of the installation since the beginning of the project through a good planning, proper design and selection of the components, as well as acceptable installation according to best practices. Lessons learned from the three consecutive years of inspection were used to formulate a practical guideline to briefly assessing quality of the PV mini grid installation, titled “***PV Installation: Do’s and Don’ts”.*** It aims to achieve a standardise installation quality among the sites and continue with the on-going improvement, as well as conducted dissemination of the lesson learned to the relevant local stakeholders which consist of government, contractors, inspectors, service technicians, and local operators. This is also to avoid the practitioners in repeating similar mistakes and use the good examples in the future installation. Apart from the installation guideline, some recommendation during the planning until the maintenance of the system are also written to provide a broader picture in maintaining the quality of a PV mini grid. Details about the guidebook ***“PV Installation: Do’s and Don’ts”*** will be explained further in the Chapter Knowledge and Data Management.

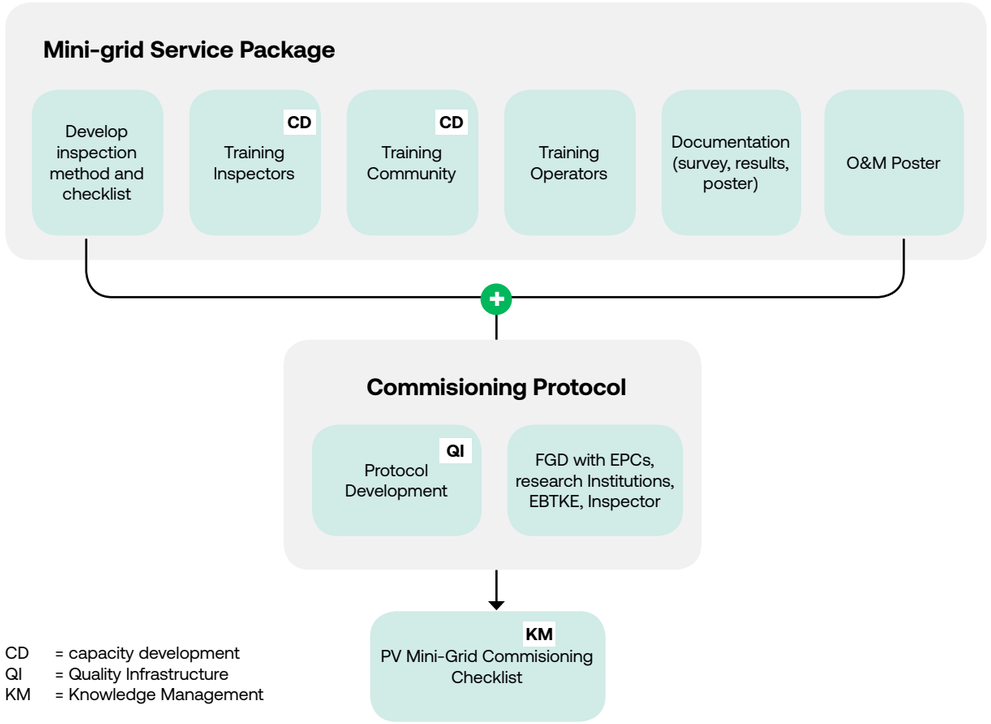
PV Mini grid Commissioning Protocol

A comprehensive commissioning process is believed to be the last effort to ensure the quality of installed components and workmanship of a system. It is one of the key processes in the entire development PV mini grid system. Commissioning aims to ensure that the system as well as the components are properly installed, well-functioning and capable to produce an output according to the specification, expected performance, and meet the safety standard.

There was no standard commissioning protocol available both nationally and internationally to ensure the quality of PV mini grid installations. Each technical inspection agency or contractor uses their own commissioning protocol which is very varied from the content up to quality of the assessment. One of the consequences was wide range of the installation quality and the system performance from each site. as seen from the results of mini grid service package (MSP) program. To enable standard electricity

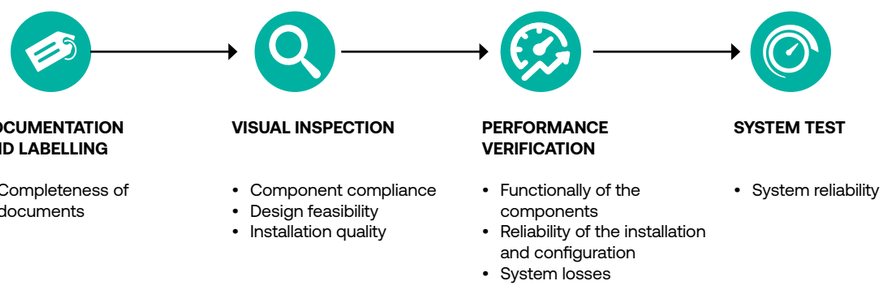
service, a commissioning protocol checklist for PV mini grid was drafted. The results of the commissioning report can also be used as an objective reference during site acceptance test and assets hand over. It can give transparent and fair assessment of the system's condition to avoid any misinformation among the relevant parties.

Figure 34 Commissioning protocol idea development



The commissioning process is estimated to be carried out within one week including the visual inspection and performance verification of each component and overall system. The overall system test must be carried out within minimum of three (3) days to see the battery cycle in normal operating conditions. The data will be recorded by a data logger and system performance during this commissioning period will be analysed. Below figure illustrates the steps and activities for PV mini grid commissioning. The duration of implementation can vary depending on the weather conditions during commissioning activities.

Figure 35 Steps and activities in PV mini grid commissioning



On top of the proper commissioning and system test acceptance, documentation of the results should also be attached to the report for further assessment and evaluation. The information contained in the commissioning report are as follow:

- Project information which covers asset owner, completion date of construction and test date
- Information and specifications of PV mini grid system
- Visual inspection observations that are completed with photos as supporting documents and verification report of design suitability
- The results of measurement and test carried out in the commissioning process are completed with photographic evidence
- Summary of commissioning results with additional comments or corrective actions if correction is needed
- Identification of special care needs or periodic actions

Improving Monitoring System

Not less than 20 MWp of PV mini grid systems had been installed in more than 600 rural areas in Indonesia. By looking at the massive number of PV mini grid systems installed by the government all over the country, it is expected that as of today the government have at least some figure on the amount of energy generation that had been utilised by the end beneficiaries. However, none of the systems are monitored, due to several reasons such as: (1) inadequate installation quality, (2) incorrect selection of monitoring system, (3) damaged components, (4) unavailability of mobile network, (5) unsettled mechanism for remote monitoring system within the organisation. In consequence, only installed capacity is known, neglecting the operational status of the system despite the urgency to conduct preventive or corrective maintenance by utilising the operational data. DJ EBTKE preference to use in-house server instead of cloud-based monitoring system from the manufacturers required proper IT infrastructure to enable in-house remote monitoring system. The process took considerable amount of time. More details will be explained in the Chapter Knowledge and Data Management.

1. Monitoring by Phone

In the meantime, EnDev had conducted regular monitoring and evaluation on the sites that was reachable by phone through biannual monitoring activity since 2014 to 2016. From the technical perspective, at least operational status of the system and number of kWh consumed were obtained which then could be reported to DJ EBTKE and forwarded to provincial government. Result of this activity is available on ***"Report on the Operational Status of Rural Micro-Hydro Power and Photovoltaic Mini grids in Indonesia".*** The regular phone check with limited parameters and interview data was found ineffective to mitigate risks of technical failures. The gathered data was not able to be quantified and compared among systems. More detail technical parameters and reliable monitoring are urgently required to enable better preventive maintenance instead of massive roll-out of repair initiative.

2. Offline Data Logger and Performance Analysis

Parallel with the regular monitoring, technical reviewers were collecting data from the existing data logger in PV mini grids during the MSP. Raw data was obtained from the local data storage in the monitoring system installed on site and later being processed and analysed. They manually transferred the data from the machines using SD card and stored in their laptops. The attempts were successfully conducted in less than 100 systems out of 305 inspected sites. Nonetheless, due to improper settings of the relevant components and various types of the installed monitoring systems, the data collected come in various forms. Approximately only data from less than 30 sites could be processed further. Utilising the best available data, a more detail performance evaluation was conducted in 2016 for two sites, located in Central Java and Maluku. The sites were

chosen based on comprehensiveness of data available, as well as different community type and topography. Similar approaches will require extra efforts as well as additional budget, especially when the owner had to perform a phone call to every site and get a detail technical data from the PV mini grid systems.

EnDev had to develop a method to evaluate performance of isolated PV mini grid which was not readily available yet during that time of study. Detail of the method and results are available in a technical report titled ***"Measuring System Performance of Isolated Photovoltaic Mini grid in Rural Indonesia".*** Through various monitoring measures in EnDev, automated remote monitoring system is preferable to provide more real-time and robust performance evaluation of the installed PV mini grid systems. Therefore, DJ EBTKE and/or any relevant government institutions that are responsible to oversee the electrification program and renewable energy development shall agree on the mechanism to manage data and monitoring activities among. Hence an integrated remote monitoring system can be deployed and use effectively for decision making.

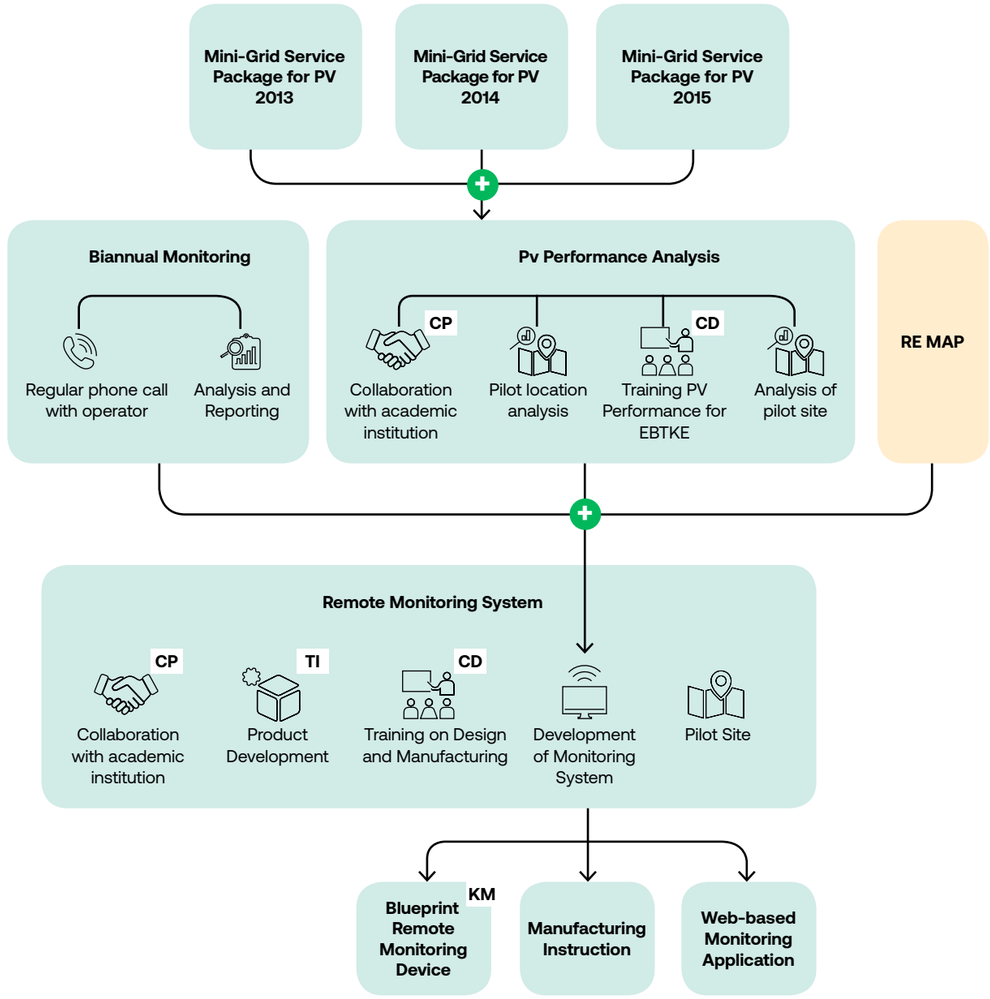
Through various monitoring measures in EnDev, automated remote monitoring system is preferable to provide more real-time and robust performance evaluation of the installed PV mini grid systems.

Measuring electrical parameters in combiner box for a PV mini grid in Riau

3. Universal Remote Monitoring System

Highly aware of the needs for better monitoring system, EnDev developed a universal monitoring system concept and prototypes to be installed in the existing PV mini grids. The development comprised of hardware and software which are explained further in the Chapter of Technology Innovation. Completing the support to function the RMS, EnDev supported the communication using internet of things services for the first year period which will be taken care by DJ EBTKE as the host.

Figure 36 Innovation journey of universal monitoring system (REMOS)



People

Quality assurance involves multiple aspects, namely capacity development, engineering technology, metrology and standardisation, industry value chain, as well as market and business models. These aspects require various skills and competences. Through years of evolving supports, EnDev identified roles that were able to give significant contributions in the process. These roles collaborated to achieve the common goal and targets, for example in TSU, the team comprised of diverse team members. It consisted of international and Indonesian engineers, local technicians, and multi-disciplinaries advisors who focused on community development and policy advise. The multidisciplinary approach was essential to build a well-rounded analysis and judgements throughout the process.

The multidisciplinary strategy was continued throughout the following quality assurance measures.

Table 8 Steps and activities in PV mini grid commissioning

Activities	Roles	Skills and competence	TSU	MSP			RMS	Guide book
				ISRE	SAM	MSP PV		
Technical support -Designing phase	System Designer	• Engineering: civil, mechanical, electrical	Yes					
Technical support -Construction phase	Supervisory for technical design and construction	• For MHP - Engineering: civil, mechanical • For PV – Engineering: Electrical	Yes					
Technical support -Post installation	Technical surveyors		Yes	Yes	Yes	Yes	Yes	
Technical review – Operation phase	Technical analysis		Yes	Yes	Yes	Yes		
Facilitating multi-stakeholders	• Facilitating discussions and coordination among stakeholders • Influencing key persons in the community	• Communication • Social studies, • Experienced or trained in community facilitation	Yes			Yes	Yes	Yes
Formulating book content (guidebook, manual book)	• Designing framework • Formulating main content • Writing	• Formal writing skills • For MHP - Engineering: civil, mechanical • For PV – Engineering: electrical • Graphic designer (illustrations, book design and layout)	Yes		Yes	Yes		Yes

Team for ISRE consisted of five people which comprised one coordinator, one assistant coordinator, and three field technicians. ISRE delivered eight trainings involving 17 multi-disciplinary trainers as mentioned in the table below.

			Introduction	Technical Aspects	Administration & Management	Package							
						1	2	3	4	5	6	7	8
1	Arman Abu, ST	ISRE Team	*		*								
2	Ir. Muhindar	ISRE Team			*								
3	Irr. Ferdinandus BT	ISRE Team	*	*									
4	Munawir, ST	ISRE Team		*									
5	Alamsyah,ST, MT	ISRE Team	*		*								
6	Marthen Rambung	Government Official			*								
7	Jufri Manga, ST	Rural PNPM			*								
8	M Iqbal ST	Rural PNPM		*									
9	Yesaya Famay	Local NGO	*										
10	Yusuf Sampe Alik	Local Cooperative			*								
11	Amil Sudir Ambara	Rural PNPM		*									
12	Syahrum ST	Green PNPM	*		*								
13	Haltin Singkang, ST	Rural PNPM			*								
14	Muklis	Local NGO	*										
15	Supriadi Yusuf	Rural PNPM	*										
16	Rahmiaty A. Tamma	Rural PNPM			*								
17	Farida Hamra, SP	Rural PNPM	*		*								
18	Abd. Rahman, SE	Rural PNPM			*								

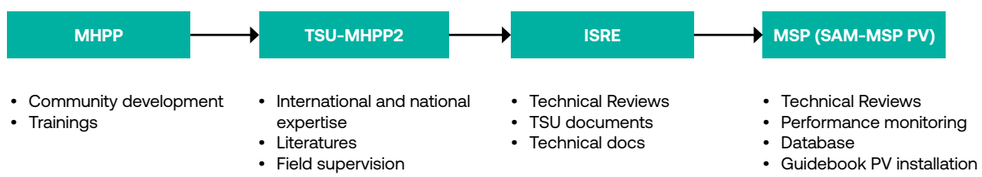
Workmanship quality reflects the contractor reliability; compliance to technical design as well as adherence to best practices and safety requirement. This issue has partially been discussed in the previous sections for each component.

Formulation of Guidebooks

The guidebooks for quality assurance were formulated through an in-depth process that involves key partners namely DJ EBTKE as regulator and owners of the PV mini grids, technical committee for national standards (SNI) of renewable energy, contractors (EPC), practitioners, and technical inspection agencies. The involvement of various key partners aimed to gain inputs and practical feedback about the guidebooks and protocol. It was formalised in the form of focus group discussion, which was conducted in two sessions:

- Preliminary meeting with DJ EBTKE and the technical committee for national standard in April 2018
- Public hearing with DJ EBTKE, technical committee, contractors, technical inspection agencies, PV mini grid practitioners in May 2018. Inputs and suggestions from experts and practitioners had enriched the commissioning protocol to be more realistic and practical without reducing the quality of the assessment.

Figure 37 Adaptive and evolving measures for quality assurance in



Resource

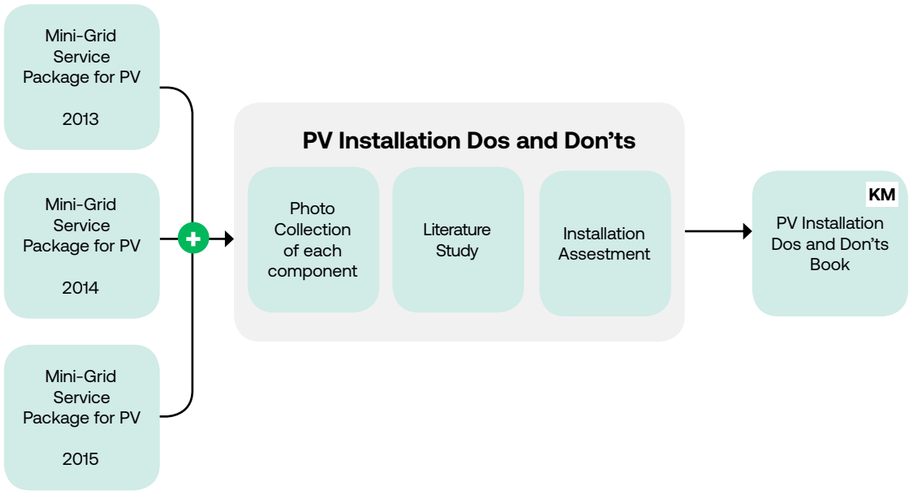
Quality assurance requires practical tools and clear guideline for the relevant parties and stakeholders to conduct the activities hence EnDev prepared accordingly.

Lessons were gained deriving from the data and information which were gathered during various visits to more than 600 mini grid facilities, both for MHP and PV systems. All learnings were captured and documented in various form of technical summary report and thousands of photos capturing different components from all the visited sites. Photos from each component were selected to represents all cases that might be found during the installation of PV mini grids. These lessons and documentation had become the major source for many publications and books about mini grids.

The **PV Installation: Do's and Don'ts** book aims to improve the installation quality hence its contents used reference from:

- International and national standards such as IEC (International Electrotechnical Commission), SNI (*Standar Nasional Indonesia*), and national utility standard, in this case, SPLN (*Standar* PLN);
- User manual from specific components in the PV mini grids were used as references to enrich the content and make the book more practical and relevant;
- Various literatures on electrical and renewable energy which are listed in the book.

Figure 38 Resources for PV Installation Dos and Don'ts



The developed commissioning protocol contains recommendation on measurement method, data collection form, and evaluation procedure of each component and the entire system. The commissioning protocol was drafted based on the following resources:

- ESDM Ministerial Decree No. 10 concerning Procedures for Electricity Accreditation and Certification
- IEC 62446 "Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection"
- Best practices in the commissioning process by different PV mini grids contractors nationally and internationally
- Commissioning guidelines from components' manufacturer
- Inspection guide for PVVP which was developed and used for inspecting more than 300 sites of PV minigrid

External factors

TSU – MHPP2

- Sustainability of quality technology installed in the rural communities is highly influenced by social cohesion and cooperation within the community. This finding was discovered during a EnDev study that compared operational condition and its driving factors from technical, social, economy, and environmental aspects. The study examined around 30 MHPs in West and South Sulawesi as described in more detail on "EnDev 2 Indonesia: Impact on Sustainability – A Comparative Study" . Although the MHP sites that were supported by EnDev exceled in technical performance, but disrupted operation often occurred caused by poor management practices and unsupportive environment such as regulation, access to finance, and natural disaster.

- The technical support unit (TSU) structure was formed to support technical inquiries in the National Programme for Community Development (PNPM). The other aspects that were also significantly affecting the quality and operation were handled by different structure in PNPM. Hence, the results of the quality assurance activities from EnDev was highly dependent on the performance from other structure in the joint programme.

Mini grid Service Package for MHP and PV

System design up to asset handover were tackled by DJ EBTKE. EnDev support came in at the end of the project to review the installation of MHP and PV mini grid followed by conducting systematic evaluation as a feedback for the contractors. In the meantime, installation quality and system performance of the mini grid systems were mainly a product of proper system design, qualified construction works and adequate supervision. Thereby results of MSP activities which were indicated by high score of installation and workmanship quality can only be seen after more than two cycle of MSP supports and close assistance to DJ EBTKE to improve their processes. In EnDev case, it took three consecutive years to achieve improvement in the installation quality and system performance. Adoption of the MSP processes into the partner organisation also highly affected by the readiness of the organisation to incorporate a detail process of technical assessment. The activity might pull significant resources such as time, travel arrangement, and budget compare to the current process. These factors are seen to be major hurdles for the adoption process

.

PV Installation: Do's and Don'ts

Fast technology improvement and different technologies available in the market has caused iterative revision during the writing process. Although lead acid batteries are still being used in the off-grid system due to its robustness, newer technology such as Lithium-Ion and even newly developed Zinc-Air battery for stationary application have been implemented in hundreds of sites in Indonesia. Therefore, to keep the book up to date with the new installations, the book also includes the new technologies, brands, and, models used in the PV mini grid built from 2015 to 2017.

Commissioning Protocol

An idea of having a guideline on the detailed procedure, measurement techniques, and evaluation criteria was proposed during the development. The document should describe the referred regulation, component of the commissioning, pre-commissioning preparation, required tools, and lastly the method to verify the functionality of a component or system. The protocol was tested in either a new PV mini grid installation or revitalisation of a PV mini grid.

Recommendation

Rural electrification in Indonesia had been addressed by various ministries which the four of them had been directly assisted by EnDev. Through the technical assistances, EnDev found that there are several areas of improvement for quality assurance, as being listed below:

1. **Implement systematic and detail technical review process which comprises of proper tools to collect data and evidences**, trained technical surveyors, competent technical reviewers, and structure of the contract shall accommodate verification of workmanship quality that comply with the required standards, if not satisfactory, significant amount of payment should be withheld until fixes are made and verified.

2. **Consider longer term of service agreements.** The maintenance services can be performed by the contractor or a third party who will be responsible for repairs that exceed the capabilities of the management team. Engaging operation and maintenance services from a third party will ensure that any technical issues after commissioning are taken care of by competent entities as well as creating jobs for the local economy.

3. **Responsibility of the village management team** can be related to commercial (collecting payments) and custodial (basic cleaning) works, while a technical entity from third party service provider should be contracted separately either by national or provincial government.

4. **Proper and systematic site selection**. Local governments were responsible to conduct site selection, thus they need to be guided on relevant information to be analysed, such as free from risks of flooding or shading from the surrounding topography, and clear from any ownership issue. It is recommended to do pre-feasibility checks which includes:

    - Community engagement before commencing construction works to raise the awareness and give unified information about the PV mini grid and its operational setup

    - Require each local/provincial government to submit a feasible five-years operation and maintenance plan as part of the document submission for approval. Prior to approval for the following years, the local government will be reviewed for adherence to this five-years O&M plan. The plan can also mention their collaboration plan within its organisation or beyond to leverage the use of mini grids for local economic development.

5. **Efficient hand-over process from DJ EBTKE or any project owners to the mini grids management team and/or designed owner of the system.** The designed mini grid owners shall be identified from the planning phase and engaged in the regional development plan to secure operation and maintenance budget and other relevant activities to leverage the use of electricity from the mini grids.

6. Optimising mini grids specifications that refer to and includes national and (where practical) international standards in future tender. Details on the improvements of tender are mentioned in the **Review on Design and Specification of PV Mini grid Systems (2016) Report.**

7. **Capacity building of the relevant stakeholders which comprises of national institutions/ministries, local government, village communities, contractors and suppliers**. Open bid system that was used to procure the mini grids. Therefore, it is crucial to design effective tender document ensuring the systems are the right fit. Initial measures should be taken in the design phase such as a reliable site investigation survey for each proposed site and suitable development of design specification for the system consists of sizing to meet load demand and specific requirements.

8. **Improve knowledge management system**, such as reliable remote monitoring system that enables relevant decision makers to oversee the performance of the installed mini grids. Therefore, any maintenance and repairs can be addressed effectively. Several attempts to repair the PV mini grids were ineffective due to unavailability of reliable data and standardised method to compare performance of the mini grids.

Focus group discussion regarding renewable energy in small and outer island.

6 Knowledge and Data Management

This chapter explains about activities in managing data and accumulated knowledge in EnDev from years of support in the development of sustainable energy access in Indonesia. It had generated findings and practical knowledge that would be beneficial for further development by the government and other relevant stakeholders. Hence, EnDev had been maintaining initiatives in data and disseminating knowledge through various mediums to reach both specific and wider audience for the knowledge products.

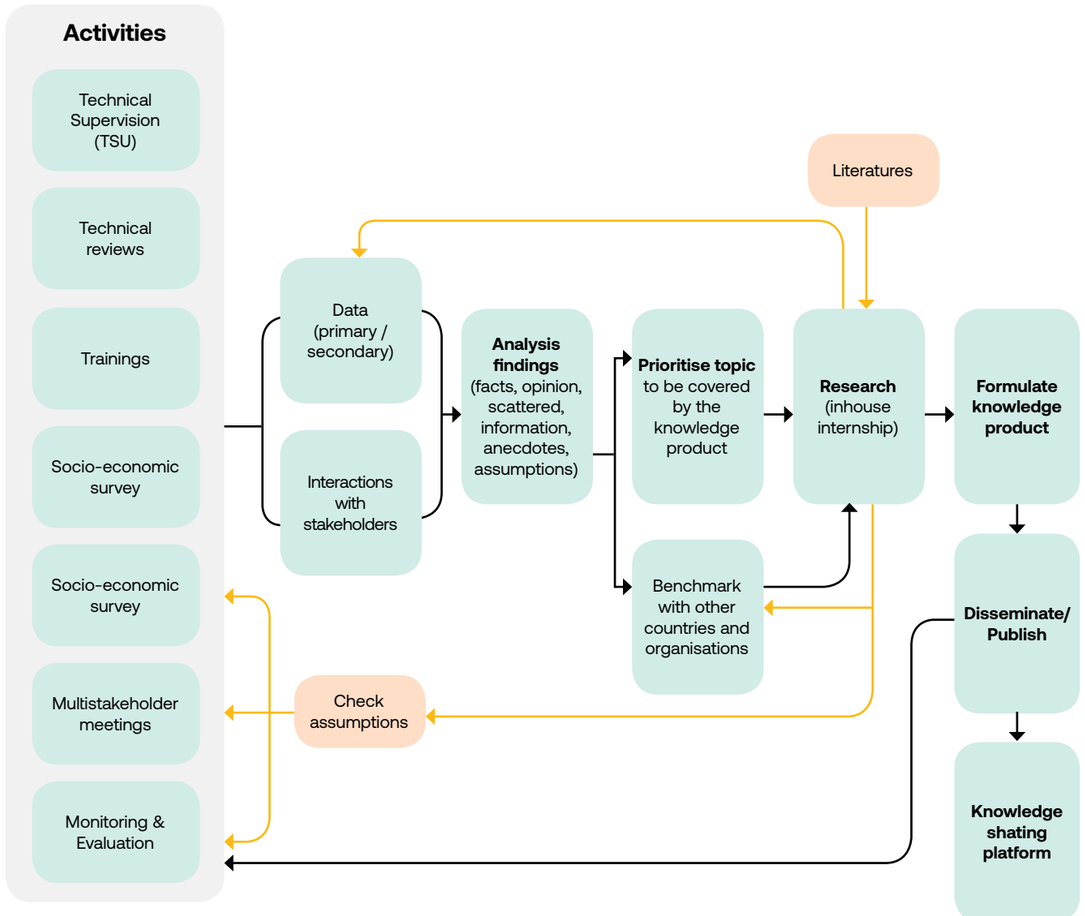
Vocational students attended PV mini grid training in Mataram, West Nusa Tenggara

Since the beginning of the project, EnDev had been diligently keeping track of the mini grid sites and the relevant data about them which consisted of technical and socio-economic data. Since the support to MHP projects, the data was collected in detail and analysed to enhance the knowledge about sustainable energy access in rural area, both for MHP and PV mini grids.

EnDev developed knowledge products based on the findings and analyses from the data and interactions in the project activities. As seen in the diagram below, the facts and interactions from the stakeholders had been the major source of idea to release any knowledge products, especially from the technical assistance, surveys, as well as monitoring and evaluation activities. Those three activities had been the prominent source of data to be analysed further. Based on the facts and opinions from the beneficiaries and stakeholders, especially those who were directly affected by the mini grids, EnDev analysed topics which were lack of practical knowledge. In this stage, benchmarking to other organisations was crucial to consider whether to build new product or adopt the existing knowledge by the other organisations as well as to find niche in the upcoming product.

Processes in managing data and knowledge for the EnDev project were summarised in the diagram below.

Figure 39 Managing knowledge



From the prioritising topic, EnDev released the need to conduct internal research to understand the issue better. Hence, EnDev would open opportunities for graduate students to conduct their research aligned with the internal research agenda. This arrangement was effective to maintain objectivity in the studies, also academically proven with the supervision from capable academician in the university. Most graduate students were coming from universities in Germany and Netherland who were informed about EnDev activities in energy access community. Researches that were conducted together with students had significantly contributed to the learning process in EnDev supports to the Indonesian Government. Internal research was also conducted by the advisors with the support from undergraduate students who were mostly studied in Indonesia. Unlike the graduate students, internship for undergraduate students needed more intensive direction from the advisors. Interestingly, most of the undergraduate students who were interns in EnDev continued to work in the renewable energy or energy access topic It indicated that the internship had positive and effective influence to spread and retain the knowledge of sustainable energy access in the Indonesian institutions.

Formulation of the knowledge products was mostly conducted by advisors in EnDev, and intensive consultation with practitioners in the sector. Depending on how complex and the depth of knowledge to be included in the product, the formulation took months to prepare and write. Series of consultation meetings with the group of experts and practitioners should also be conducted to maintain the quality and relevance of the content.

The knowledge products were disseminated through EnDev activities and online platforms. EnDev used websites[3] such as DJEBTKE website and open knowledge platform, Energypedia, to publish the knowledge products. Nonetheless, the main dissemination strategy was through EnDev activities such as trainings and workshops with stakeholders. The activities could reach both national and provincial stakeholders as more assistances were directed to be implemented in the provincial level. Moreover, researches and internship had engaged academicians to direct their researches to the topic of sustainable energy access and widen the network of experts, especially between Indonesia, Germany, and the Netherlands. The expanded network had helped to more efficient and effective dissemination of the knowledge and information.

Formalising Data Initiatives in DJEBTKE

An important weakness in the development of rural mini grid were monitoring and evaluation both in the construction and operation of the mini grids. The situation was mostly happened due to the extreme geographical challenges and unavailability of mechanism to gather data from the mini grid locations. On the other side, EnDev in global scale used rigorous indicators to measure its impact in each country where it delivered supports. The arrangement drove the data initiative in the project and convinced the partners to be involved.

Process

Data Handling and Remote Monitoring System

The data initiative started since the beginning of the project and had been evolved following the complexity of the activities and the partners involved. Diversity of partners required reliable data and information about the rural mini grids or sustainable energy access to be used as a reference to align their objective and activities from their perspectives. Hence, EnDev had been consistently maintain the rural mini grid data based on its activities that provided high exposure to the technicalities and socio-economic aspects of rural mini grids. Started with a modest database of MHP and socio-economic survey, EnDev routinely updated the rural mini grid data from both PV mini grid and MHP in spreadsheet format. The format was favoured because of its simplicity to share and be used by the partners. For public information, ENDEV established an online mapping of the rural mini grids from DJ EBTKE called REMap. REMap

[3] Website DJEBTKE http://ebtke.esdm.go.id/e-library

stands for Renewable Energy Map where public can have basic data about the installed mini grids both MHP and PV such as location, brief description of system and pictures. All data that was gathered by EnDev activities are owned by DJ EBTKE, hence any request to use the data for research and other purposes from other organisation would be directed to DJ EBTKE for approval.

In recent years, KESDM had growing interest to integrate data within the ministry and coordinated by the Centre for Data and Information (PUSDATIN) KESDM. Hence, each directorate general had to structure and manage their data and information within their organisation. EnDev supported the initiative by formulating mechanism for the respective directorates to gather data and submit it regularly within the DJ EBTKE structure. The mechanism had been officially published and being implemented by DJ EBTKE.

Monitoring the project performance in delivering support to the implementing partner and the beneficiaries had been important for EnDev operation in Indonesia. Most of the supports from EnDev in Indonesia were conducted during commissioning, or after the installation was finished by the contractors. Exception was applied to MHP supports for PNPM in 2009-2012, which EnDev had involved since the proposal stage and supervise the construction. Through experiences in those field, EnDev had found that the rural mini grid projects in Indonesia were mostly weak in the monitoring mechanism although it was essential to sustain the electricity supply for the beneficiaries. Hence, EnDev had performed various measures to find the most feasible monitoring mechanism to be adopted by the partners. It ranges from regular visits to the mini grid sites, installing digital meters for MHP, SMS gateway for operator to report their situation and ask questions, mobile apps called Energi Desa as a knowledge sharing platform among practitioners, biannual monitoring by interviewing the operators about their mini grid condition, and the latest was the universal remote monitoring system which was designed to open to be used by various inverter types and manufacturers. The pilot for universal RMS (REMOS) was directed to be implemented in the government funded PV mini grids.

Monitoring the project performance in delivering support to the implementing partner and the beneficiaries had been important for EnDev operation in Indonesia. Most of the supports from EnDev in Indonesia were conducted during commissioning, or after the installation was finished by the contractors.

Despite that all the installed PV mini grids in Indonesia were already embedded by remote monitoring system, but the data were not yet stored in a central database and ready to be analysed. Data from each of the monitoring device was stored in the memory card on site, and in various databases owned by the manufacturers. Significant numbers of them were struggling with the availability of mobile network to send the data. The afore mentioned issues had hampered the initiative to analyse performance of the PV mini grids and monitor their performance. In order to facilitate the monitoring of PV mini grid performance, EnDev initiated the idea of developing a simple and universal remote monitoring system for PV mini grid system. The universal RMS does not only acquire raw data and send the data to server, but it is also equipped with data processing and analysis algorithms that is programmed in the web server and later be visualized in the web platform. For this purpose, the development of universal RMS was not only limited to the hardware, but also a web platform or dashboard that is operated by the system owner.

The concept of universal RMS was started in August 2018 and followed with the development of both hardware and software, testing, manufacturing, and lastly the implementation. In general, the following activities were conducted during the development of the system.

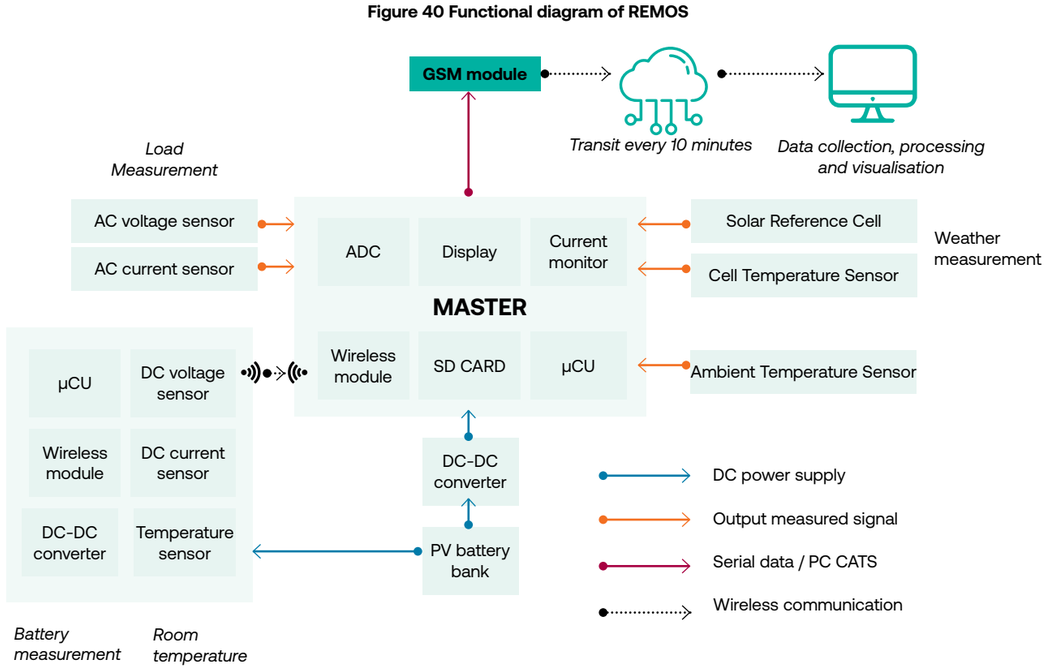
- 2. Development of hardware prototype including the design, manufacturing, and testing.
- Development of software or web platform with the involvement of software engineer. The implementation includes the algorithm or methodology to analyse the performance of PV mini grid developed during the PV performance analysis activity in the past.
- Implementation of the software in the government's server
- Finalisation of blueprint design including the hardware manufacturing instruction and software
- Manufacturing of 25 units of the universal RMS by having cooperation with academic institution.
- Capacity development in PV mini grid, manufacturing, and installation of REMOS
- Installation of REMOS in up to 25 pilot sites

Like a typical product development activity, the initial process consumed most of the development time, such as finalising concept, design implementation, and iterative trial and errors processes. The development of the universal RMS hardware was done inside EnDev. At the later stage, the knowledge and know-how were transferred to partner institutions and made it available for public.

First REMOS prototype: (1) Master unit (left) and (2) Slave unit (right)

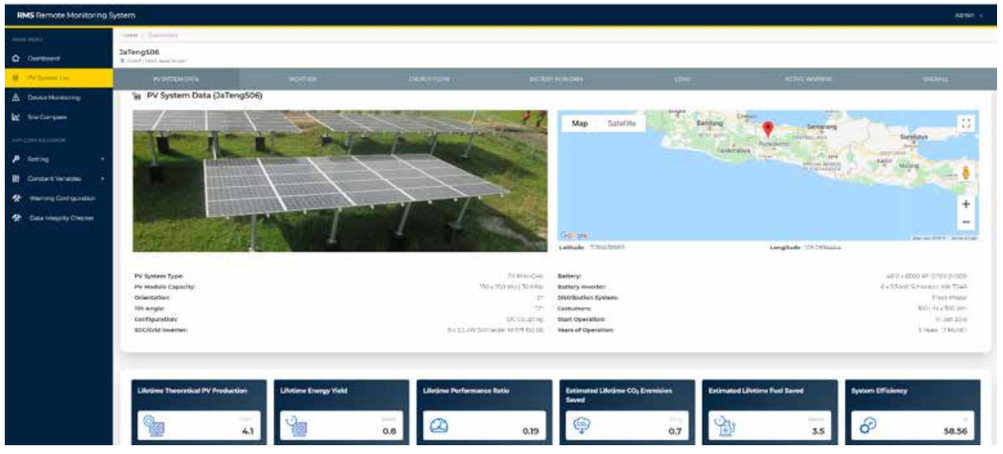
The universal REMOS hardware consists of a master and a slave or possibly multiple slaves depending on the number of battery bank. One slave is used for one battery bank. The slave will send the data acquired from the battery bank to the master that is located close to the AC panel distribution. The Master will collect the data from available battery banks and acquire the data from the weather sensor as well as the output AC parameters. Once all the data are collected, calculated data will be visualized locally and the raw are sent using GSM/GPRS to the FTP server and ready to be processed. The prototype and functional diagram of the monitoring system are illustrated in the following figures.

Figure 40 Functional diagram of REMOS



In parallel, the web platform was also developed based on the performance analysis methodology and calculation formulas which were previously researched by EnDev. Several consultation meetings between the software developer, EnDev, and DJ EBTKE were conducted to ensure the required functionalities and incorporating the demand from the PV system owner. Since August 2019, the web platform had been installed and tested in the DJ EBTKE's server.

Figure 41 Visualisation of REMOS web platform



Universal REMOS will be installed in at least 25 PV mini grid system all over Indonesia. The selection is based on the following criteria: (1) PV Mini grid that operates properly, (2) at least has 2G network coverage, (3) consist of the systems with lead acid or lithium ion battery technology, (4) include samples from varioussystem capacity, (5) samples from various provinces.

People

Data from the surveys and technical inspections were handled by using spreadsheet for calculation and analysis due to its simplicity and easiness to share. EnDev also used several software for online survey to help with storage, simple statistics for data presentation, and disseminating knowledge. Although many survey tools were available for the tasks, but the readiness of the partner to adopt the solution shall be put into main consideration. Standard data management shall be put into work in the organisation such as the data flow, roles and responsibilities about data management in the organisation, and which data to be stored and analysed. Absence of the data management procedures will halt the implementation of any information management technology.

Cooperation was made between EnDev and University of Malang to transfer the knowledge of the remote monitoring system, especially to replicate the system where it took place in State University of Malang (UNM). Although the design was open for public, it was expected that UNM could proactively replicate or even improve the system when the demand increases and commercialized the product. Under the cooperation, EnDev provided the materials to manufacture the first 30 units and sequence of trainings from the basics of PV systems, remote monitoring system concept and design, hands-on training in manufacturing universal RMS in the lab, calibration of the system, and installation of universal RMS in the real PV mini grid sites. In the meantime, the University of Malang was responsible to deliver 30 units of functioning universal RMS under close supervision of EnDev.

Engineering students of Malang State University were assembling remote monitoring system (left) and installer verifying the correct data on the human machine interface of REMOS hardware on site (right)

The training was conducted in two weeks period consisting three days in-class seminar, two days on-the-job training in the laboratory, and three days site visit. There were in total of 10 students and three lecturers were joining the training to get the insight of the design, understand the PV mini grid system installation, and gain practical experience in the field.

Resources

Development of the product was started from scratch and already through a relatively long process of development starting from concepting, design, procurement, assembly, and testing. Not only the hardware, software was also required to create the PCB design of the system and to program the microcontroller. An open source software was chosen to ease the further development of the system in the future. EnDev was also invested on a mini testing bench to assemble and test the prototype. Measurement tools to calibrate the sensors and additional assembly tools such as clamp meter, irradiance sensor, temperature sensor, soldering irons, and a small-scale PV mini grid system were purchased to support the development.

As mentioned in the functional diagram above, some components such as microcontroller as the brain of the hardware unit, hall-effect voltage and current, and temperature sensors are used to measure the physical parameters in the PV mini grid systems. Apart from that, a GPRS communication module and SIM card is embedded in the master unit to send data to the server. An SD card is also required to support the data transmission in case of missing network connection. To show the instantaneous data from the PV systems to the operators on site, an LCD display is equipped in the master unit. This will provide valuable information to the operator to possibly perform preventive maintenance when abnormal condition is shown.

A total of 35 master units and 85 slave units are being produced by University of Malang. Procurement was done locally although few components were still sourced from abroad especially the sensors and electronic components.

External factors

Good decisions are backed by meaningful information and reliable data. Data and solid monitoring and evaluation process can support for better measures in achieving sustainable energy access. However, the ideals were not yet achieved due to unequal access to information technology. Many areas where PV mini grid and MHP existed do not have access to mobile network, hence data initiatives were halted since the data cannot be sent to the network. Moreover, setting of monitoring devices were not uniform which make data from each system was recorded differently and added complexity in analysing it.

It is important for an organisation to have a proper data handling if they want to create better solutions in their product and services. Often data in the ministries was challenging to collect and extracted for further analyses. Although there were many software and applications were created inside and outside KESDM, but often use uncoordinated data and overlapped. Currently PUSDATIN handles all data initiatives in the ministry and also manage the existing application in the ministry.

Other than the prototyping process, procurement process was the most time-consuming development phase as it required relatively long internal administrative process as well as lengthy production time. Some components were also required to be imported that add an additional time in the tax and custom authority. As the procurement had to be done in a component basis, not less than 100 unique items were listed in the bill of material and had to be purchased from several vendors. It was difficult to find a vendor that could provide all the listed items. In consequence, the procurement had to be done separately by different vendors.

The mobile internet connection is essential for the data transmission. It requires at least 2G connection to send approximately 10 kb raw data successfully in every 10 minutes. However, since the PV mini grid sites are resided in remote areas, there is big possibility that the mobile internet connection is not available around the powerhouse.

Ownership of the monitoring system is crucial to sustainably monitor all the sites. For the pilot phase, GIZ-supported energy programme support one-year subscription for all pilot sites and later be continued by the owner of the system. The contract with the mobile network provider with widest coverage was first initiated by EnDev for 25 sites. DJ EBTKE as the owner of the PV systems and server was involved in the discussion for taking over the subscription when the contract between GIZ-supported energy programme and the provider ends.

Lessons learned

Establishing a reliable system for data and information about renewable energy installations, especially for rural mini grids, need more than just a software development process. It requires improvement in the organisational design which enable seamless data flow between functions. The roles, responsibilities, and mechanism for data management had to be defined clearly and agreed among in the organisation since the beginning hence will maintain actual data and information are updated. Moreover, the level of data transparency and accessibility will take significant portion in the discussion with the partners and the relevant stakeholders.

As EnDev had been supporting DJ EBTKE since its formation, the support in establishing better data had also adapted to the changes in the organisation. Started from data initiative in each sub directorate, recently the orchestration of data in DJ EBTKE have been handled by PUSDATIN (the data centre) and supported by various organisations. Hence data initiatives have been flourishing and hopefully will be more accessible for the practitioners and relevant stakeholders. EnDev had been keeping track of rural mini grids installed and codified them for effective monitoring. As the data expanded, EnDev supported with visualisation of data through REMap Indonesia, and in recent years, DJ EBTKE had established mechanism for data management in their organisation.

Smart payment system was created to be operated in the remote villages, thus problem with connectivity is anticipated by Low Range (LoRa) network. Moreover, pre-survey should be conducted prior the installation to ensure that the network connection inside and around the powerhouse is available. The first system was installed in the PV mini grid site in Sabangko Island, South Sulawesi. However, it was found the mobile signal around the powerhouse was not stable enough to support the data transmission to the FTP server. As a result, data was only stored locally and forwarded when the signal is back. This created a delay in sending the live data and was not the best result. In this case, a uni-Directional cellular antenna with higher gain is required to achieve better signal.

Remote monitoring system for PV mini grids was in shortage of reliable and meaningful data. Monitoring devices which were already installed in PV mini grid systems were not programmed uniformly to feed data to the database in DJ EBTKE. Hence, the anticipated data could not be automatically used and consumed more time to be processed. Moreover, each manufacturer had their own database that use different parameters and calculation method. Universal Remote Monitoring System was sought to answer this challenge and make better alternative for the performance measurement.

The purpose of developing universal RMS was not to showcase a new technology, the initiative aims to proof a universal monitoring concept for both hardware and software instead.

Installation of universal remote monitoring system was planned to be conducted in 25 PV mini grids which met the qualifications. DJ EBTKE was being prepared to adopt the universal RMS for the existing PV mini grid installation as well as the future one. The purpose of developing universal RMS was not to showcase a new technology, the initiative aims to proof a universal monitoring concept for both hardware and software instead. The selection of measurement points, data processing algorithms, and data visualization are essential in the entire remote monitoring system concept. Developing such new hardware that fulfils the data requirement of the software will not give any differences compare to the currently developed hardware. Hence, the specification of monitoring system can basically be embedded in the tender specification and standardised for all systems.

Knowledge Products

EnDev supports were closer to the implementation of rural mini grids hence it had gained numerous practical knowledge on sustainable energy access topic, especially for renewable mini grids situated in rural areas. The knowledge had to be translated into a shareable format and disseminated to the targeted community of practices such as from regulators, practitioners, academicians, and technicians. Hence, the shareable format of EnDev accumulated knowledge was called knowledge products. The products came with various forms, from guidebooks, posters, and course materials. Despite numerous guidebooks had been published under the cooperation, the list below will describe the products which had received numerous appreciations from stakeholders and categorised based on the technology.

Process

1. Micro-Hydro Power

There are several main knowledge products about micro-hydro power that had gained high public interests, namely:

A. Best Practice Guideline Off-grid MHP for Rural Electrification

The guideline explains about various measures and steps to establish a communal micro hydropower system in rural setup. The writing of the book had involved various MHP experts and practitioners in Indonesia, such as IBEKA and turbine manufacturers. The book was built upon local experiences and practical methods that suited the Indonesian context. Although the book is largely explained about Indonesian experience, but many countries have expressed that the cases and methods in the book is highly relevant for their country. Hence, the English version of the book is made available for practitioners and stakeholders in other countries for them to learn and adopt.

B. MHP Scout Guide

EnDev is a global project that has been working in 24 countries. The network has enabled a fluid exchange between countries to share knowledge and experiences. The MHP Scout Guide was firstly written in Ethiopia which then translated into Indonesian language. The workbook is rich with illustrations about technical aspects of MHP and easy to understand for beginners.

C. Multimedia DVD for MHP

The Multimedia DVD comprised of many course materials, videos, and photos about MHP which had already categorised in various topics. Most of the content were gathered from various trainings both technical and managerial aspects of communal MHP held by Technical Support Unit (MHP-TSU) since 2009. The DVD format was chosen due to its high capacity and easy to be distributed.

2. Photovoltaic

A. PV Mini Grid Installation: Dos and Don'ts Book

Started in the end of 2016, EnDev initiated the development of handbook that could explain about good installations of PV mini grid and examples of installations that had to be avoided in rural areas in Indonesia. The book intends to develop the capacity of the relevant stakeholders in the process of design, installation, system verification, and operation and maintenance of the system. It was designed to provide examples of the common issues that were frequently found in the main and auxiliary components of PV mini grid system ranging from PV modules to household connection.

The writing process includes the screening of various installation examples from roughly 300 PV mini grid sites. Each selected photo was categorised into good or bad examples which then enriched with further description and explained reasoning of the category. Theoretical background and recommended specification were included in the book to expand the knowledge of the reader.

During the writing process, the guideline went through the review and editing processes from both technical and non-technical aspects. The review was done collaboratively with partner or system owner, in this case was DJ EBTKE.

The book consists of 14 chapters that represents the main and auxiliary components of the PV mini grid systems from PV module to household connection with no less than 600 supporting photos. Since the target readers are not only the developer and contractor, each chapter also includes the following topics to reach broader target readers such as academicians, technicians, local operator, or even anyone who is willing to learn about PV mini grid system. The topics are:

1. Basic principles of PV mini grid systems and its components
2. General design and installation principles
3. Tips to avoid mistakes in installation
4. Measuring techniques
5. Simple maintenance and troubleshooting guide for local operator and technicians

The book was introduced to public on August 31st ,2018 in "The 7th Indonesia EBTKE ConnEx 2018". The event was the annual conference and exhibition event of DJ EBTKE where practitioners and regulators met up and shared knowledge in the sector. The launching was held together with the Testing and Commissioning of PV Mini grid workshop that was mainly attended by inspectors and practitioners that later will be projected to be the user of the book. During the event, the Director of Various Energy from DJ EBTKE expressed that the variation of installation quality and condition of PV mini grid systems in Indonesia were the results of many factors including technical and non-technical aspects. From the technical point of view, improvement on the quality of the infrastructure can be done by having a good installation which comply to the best practices and available standards, comprehensive commissioning process, and proper operation and maintenance was in place.

Figure 42 PV mini grids Do's and Don'ts idea development process

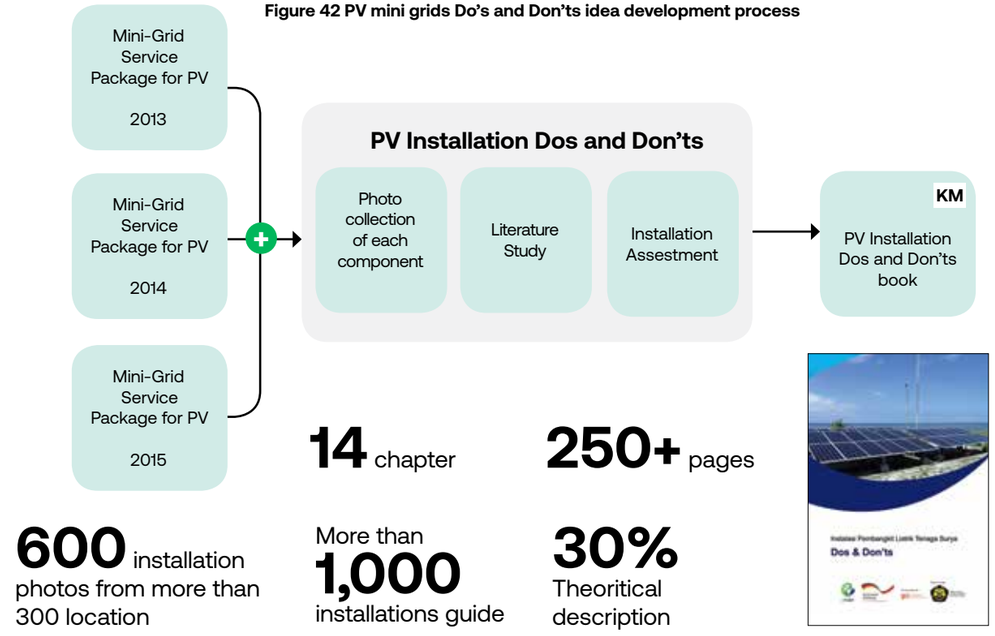
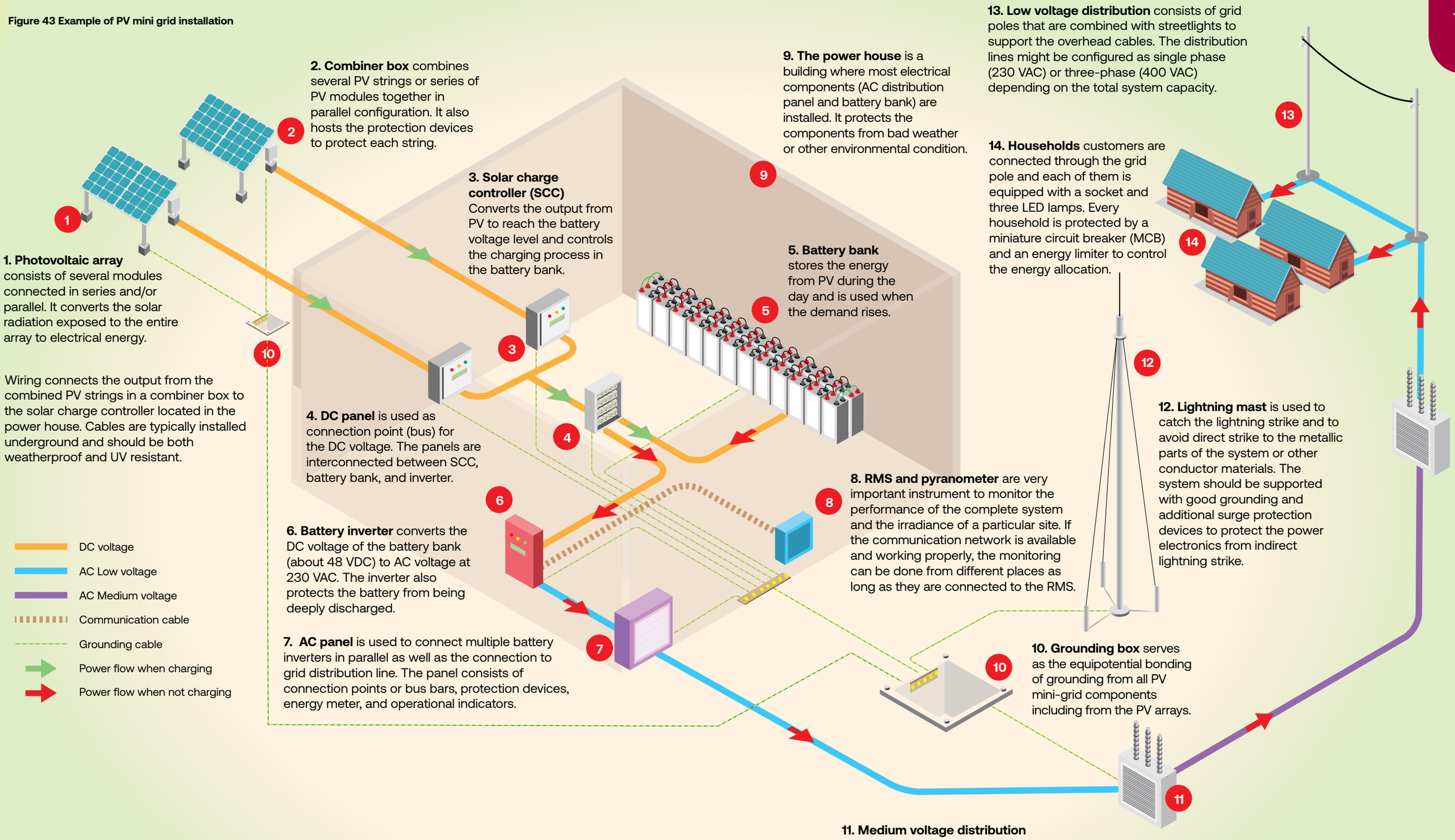


Figure 43 Example of PV mini grid installation



1. Photovoltaic array consists of several modules connected in series and/or parallel. It converts the solar radiation exposed to the entire array to electrical energy.

Wiring connects the output from the combined PV strings in a combiner box to the solar charge controller located in the power house. Cables are typically installed underground and should be both weatherproof and UV resistant.

2. Combiner box combines several PV strings or series of PV modules together in parallel configuration. It also hosts the protection devices to protect each string.

3. Solar charge controller (SCC) Converts the output from PV to reach the battery voltage level and controls the charging process in the battery bank.

4. DC panel is used as connection point (bus) for the DC voltage. The panels are interconnected between SCC, battery bank, and inverter.

5. Battery bank stores the energy from PV during the day and is used when the demand rises.

6. Battery inverter converts the DC voltage of the battery bank (about 48 VDC) to AC voltage at 230 VAC. The inverter also protects the battery from being deeply discharged.

7. AC panel is used to connect multiple battery inverters in parallel as well as the connection to grid distribution line. The panel consists of connection points or bus bars, protection devices, energy meter, and operational indicators.

8. RMS and pyranometer are very important instrument to monitor the performance of the complete system and the irradiance of a particular site. If the communication network is available and working properly, the monitoring can be done from different places as long as they are connected to the RMS.

9. The power house is a building where most electrical components (AC distribution panel and battery bank) are installed. It protects the components from bad weather or other environmental condition.

10. Grounding box serves as the equipotential bonding of grounding from all PV mini-grid components including from the PV arrays.

11. Medium voltage distribution is an alternative solution to reduce distribution losses including voltage drop. It consists of step-up and step-down power transformers to convert the voltage from low to medium, vice versa. MV distribution is necessary when the distance from PV system to the load or customers' connection is more than 1 to 3 km, depending on the size of the cable and the demand. Low voltage distribution consists of grid poles that are combined with streetlights to support the overhead cables. The distribution lines might be configured as single phase (230 VAC) or three-phase (400 VAC) depending on the total system capacity.

12. Lightning mast is used to catch the lightning strike and to avoid direct strike to the metallic parts of the system or other conductor materials. The system should be supported with good grounding and additional surge protection devices to protect the power electronics from indirect lightning strike.

13. Low voltage distribution consists of grid poles that are combined with streetlights to support the overhead cables. The distribution lines might be configured as single phase (230 VAC) or three-phase (400 VAC) depending on the total system capacity.

14. Households customers are connected through the grid pole and each of them is equipped with a socket and three LED lamps. Every household is protected by a miniature circuit breaker (MCB) and an energy limiter to control the energy allocation.

Figure 31 Example of PV mini grid installation

3. Inspection Guideline for MHP and PV mini grid

Successful implementation of MHP was attributed to excellent technical supports that were available during the planning, implementation, and post-installation. This included a clear inspection guideline to assess the quality of the MHP, i.e., quality of components, quality of installations, and performance of MHP. Drawing from MHP experiences, EnDev adopted similar approach for PV mini grid projects which required major redesigning of the inspection or review process.

By 2013, EnDev launched a Mini grid Service Package (MSP) project that consisted of six main activities which have been explained in the Chapter of Quality Assurance. To conduct the technical review or inspection of the mini grid installations, EnDev developed the method and checklists of PV mini grid technical aspects. Although the inspection guideline had been used since 2013, revisions were continuously conducted on every inspection cycle to improvise until its finalisation as a product and launched it to public in 2015. The finalisation was made after using the guideline for 300 PV mini grids, intensive analysis, and reporting to DJ EBTKE for feedbacks to their contractors. After three years piloting on how to conduct quality assurance through MSP initiative, the MSP had to be fully adopted by the local partners for their upcoming PV mini grid projects. Hence, the support from EnDev had shifted to technical training for the internal reviewers (PPHP) within the DJ EBTKE organisation. The training used inspection guideline as the main course material and would be better if it could be officially adopted for the technical review process within DJ EBTKE.

Figure 44 inspection guideline process flow

In general, the use of inspection guideline was illustrated in Figure 33 and more detailed about the method in the chapter about quality assurance. The guideline includes planning the site visit and preparing measurement tools, checklist to review technical aspects of PV mini grid, and socio-economic survey. The guideline also serves as a proxy to measure the quality of PV mini grid based on component compliance, performance verification, and workmanship quality. A score was formulated in order to track achievement and standard for comparison among PV mini grids. In addition, the guideline includes socio-economic survey to capture the apparent social issues that relates and/or may contribute to the sustainability of PV mini grid.

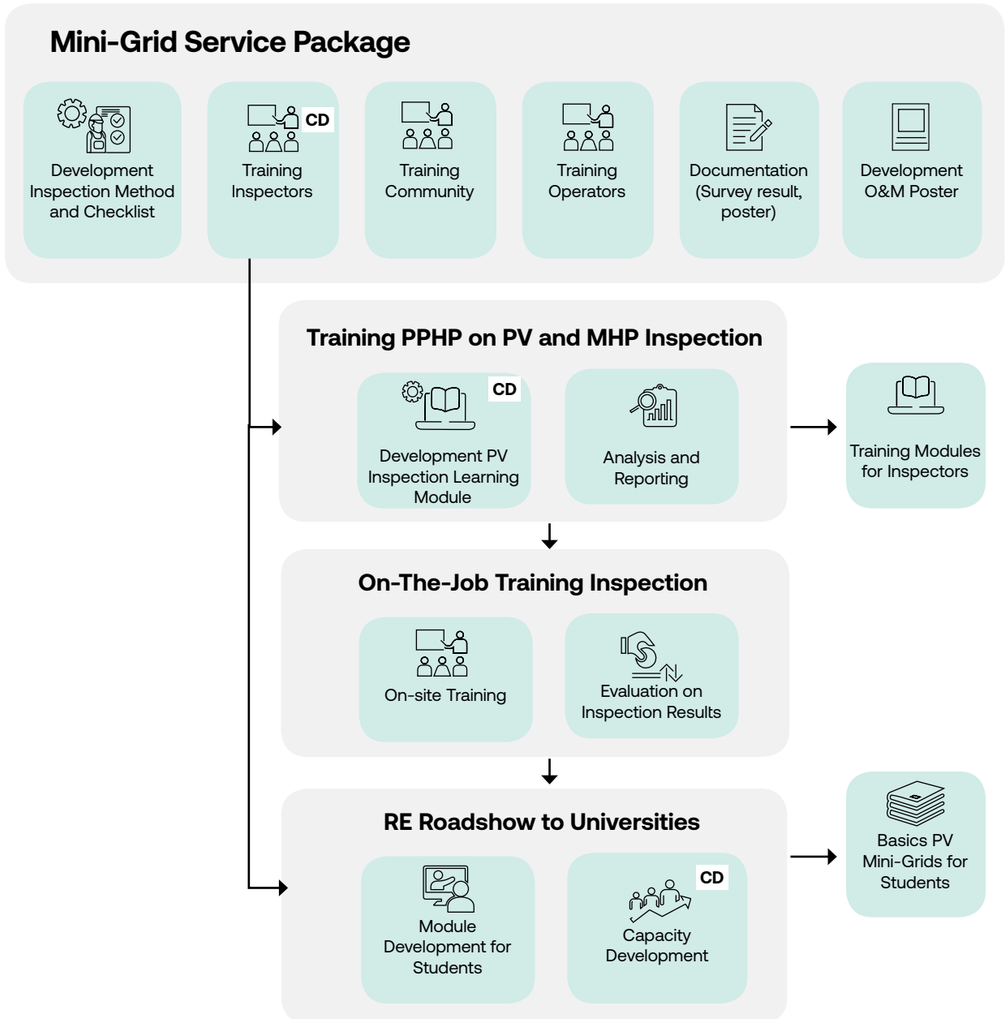
4. Disseminating Strategy

EnDev disseminated the knowledge through various forms such as trainings both held by EnDev or partners, mobile application ‘Energi Desa’, articles in various knowledge platform such as Alliance for Rural Electrification (ARE) and IRENA, posters about managerial aspects of mini grid, gender equality and troubleshooting of the system, as well as presentations in various occasions from rural areas, in national up to international stages. Knowledge in multimedia format, especially video, had also been uploaded to the official YouTube channel of GIZ Indonesia.

The mobile application ‘Energi Desa’ was built on the idea to decentralise knowledge of renewable energy, especially MHP and PV mini grid, to the operators of rural mini grids who were isolated from information. Energi Desa adopted the idea of crowdsourcing by targeting academicians and practitioners to be the contributors and rural mini grid operators as the target audience. Hence, Energi Desa enabled connectivity between SMS and the mobile application, thus the operators can interact with the practitioners and experts in Energi Desa by sending their questions and receiving the replies through SMS. Data package was not accessible by them therefore SMS was the optimal option.

At the final period of EnDev supports in Indonesia, an international mini grid workshop was held in Makassar that was attended by representatives from African and Asian countries, and a public talk show and exhibition to showcase and disseminate the knowledge and collaboration between stakeholders in Indonesia. The exchanges in the workshop had been fruitful and unfolded many lessons from the countries involved.

Figure 45 Dissemination of knowledge on quality assurance



CD = capacity development

Researches

Deeper and thorough analysis about sustainable energy access and mini grids in the project were formulated by internal researches, both from advisors and graduate students who conducted their thesis in the EnDev project. Most of these students were coming from universities in Germany and the Netherlands and supported by their academic supervisors and research group. The exchange between practitioners in EnDev and academicians had enhanced the analysis and expanded the horizon about the global efforts in sustainable energy access. The thesis topics ranged from assessing the sustainability aspects of the project to analysing technical performance of PV mini grids.

People

Practitioners in PV mini grid and different segment of readers have reviewed and contributed technically and linguistically to the content of the knowledge products. The involvement aimed to improve the readability and check the relevancy of content for different users. The language used in the guidebooks follows the target readers. Most of them were published in two language versions to reach larger audiences. Knowledge products of EnDev had been disseminated to various stakeholders including government officials, utility grid staff, academicians, trainers, contractors, inspectors, and other practitioners. The products were disseminated on several occasions that were related to capacity development of renewable energy and sustainable energy access themes. Most of the guidebooks can be downloaded from the DJ EBTKE electronic library on their official website (https://ebtke.esdm.go.id) and an open source platform about energy (https://energypedia.info).

The inspection guideline was developed and improved under MSP initiative in EnDev. Hence, in the context of formulating the guideline, test and validation of the guideline were performed by EnDev while outsourced teams to conduct project management of technical reviews. The tasks included managing resource and assignments of the technical reviewers. The teams went to over 300 PV mini grid sites all over Indonesia between 2013-2015. The team comprises of one (1) experienced technician and one (1) assistant. The team conducted two-days visits for each PV mini grid site with technical inspection and trainings as the main activity. In addition, the socio-economic survey was used to capture an insight about the socio-economic situation on the visited site. The team was also obliged to conduct technical training on operation and maintenance to the management team and operator during the visit. The team was ordered to take pictures based on the suggestion lists provided in the book and follow the recommended photography techniques. The pictures would be the most valuable data for analysis conducted by the reviewers. Any sloppy pictures would cost the team to revisit the PV mini grid site again. The latter case was highly avoided due to the remoteness of the locations and cost efficiency.

Resources

In EnDev, creating a knowledge product will consumes time in the process of figuring out the topic and how to deliver it through which form of publication, whether a guideline, theoretical book, posters, or any other forms. The proposed topics were validated by considering our partners development priorities and relevance into current interests of the potential readers. Consideration also to position our knowledge products among other existing publications and which topic with few organisations working on it.

The advantages from EnDev massive technical supports for MHP and PV mini grids were the rich data and experiences on practical implementation in both the technology. The direct access to the users provided deeper and practical insights about how mini grids interact with the surrounding communities. The advantages had position knowledge products from EnDev as practical and niche in the sector. As an example, the inspection guideline was deliberately formulated to provide practical checklists about PV mini grid condition for the technical reviewer, and system so that they would be able to briefly assess whether their PV installation was done properly or need improvements.

Most of the knowledge products from EnDev were created by separate initiatives under knowledge management tasks. Nevertheless, some of the products were formulated as a tool to anchor supports to the partners, for example the inspection guideline, PV installation Do's and Don'ts, troubleshooting posters for MHP and PV, etc. Inspection guideline was created as a tool for mini grid service package (MSP) initiative hence most of its resources were coming from the MSP activities.

External Factors

Most of knowledge products were made based on findings from activities in EnDev which often bounded by activities initiated by DJ EBTKE as the main partners and from cooperation with several other ministries and organisations. However, rural electrification program in Indonesia was performed by many ministries and organisations thus there was a probability that the knowledge products from EnDev had not yet covered learning from their initiatives and they were not yet exposed to the knowledge products from EnDev.

Hence often advices and recommendations in the knowledge products were not yet implemented until EnDev resumed in 2019. Nonetheless, the situation highlights the importance of documenting the initiatives and insights from the activities thus the lessons and experiences can be accessed by wider audiences.

Improvements in the implementation of rural electrification was triggered by various factors such as managerial priorities, readiness to accept new ideas and implement, regulation, etc. Hence often advices and recommendations in the knowledge products were not yet implemented until EnDev resumed in 2019. Nonetheless, the situation highlights the importance of documenting the initiatives and insights from the activities thus the lessons and experiences can be accessed by wider audiences.

Take the PV Installation Do's and Don'ts guidebook as an example, the book was written as an effort to improve the quality of PV mini grid installation in Indonesia. However, until the MSP activities resumed

after three-years of support, a standard mechanism and tools about conducting technical review for PV mini grid was not yet an obligation from the system owner, in this case government through DJ EBTKE. Nonetheless, the guidebook is still available to use for any system owner, such as a private company, to assess their project and ask the EPC companies to follow the examples or practices from the book.

Publications from EnDev had to be made available for public. Thereby the copies of the book were disseminated through events, meetings, and online library in the partner's websites. At the end of EnDev project in Indonesia, the rights to modify and reproduce the knowledge products are owned by DJ EBTKE. In the meantime, the demand for the guidebooks remains high especially for the hard copies in which the readers can write and take notes. Demand were mostly come from practitioners and academicians. To disseminate the knowledge further and reach more readers, collaboration with publishers can help the government reproduce and handle the distribution of the book.

Lessons learned

Through many processes of creating knowledge products for renewable energy mini grids, there are some aspects that can be considered for further knowledge products and sharing sessions in the sector both for national and international community, such as:

1. **Organised documentation of planning, processes, monitoring, and evaluation from all the activities related to sustainable energy access are very much needed.** It includes uniform code for the mini grid facilities which can be categorised by their source of budget. Hence a database which is accessible to relevant organisations can be developed to ease monitoring and evaluation process as being mandated by the ministerial decree.

2. **Product knowledge with practical insights and advices are the most needed by the practitioners and relevant stakeholders.** Although the number of renewable energy projects in Indonesia are increasing, but it is still not enough to catch up to their potential. The rising number of practitioners also affect the spread of quality installations and systems built by them. Hence, practical guidance with relevant context where the systems are installed are very much needed by the sector to enable more quality installations in renewable energy mini grids.

3. **Stories from the field with distinct experiences and approaches for various target communities.** Renewable energy is still considered as new technology in Indonesia and use by limited communities both in urban and rural areas. Most of the people is connected to the national grid or using diesel as their electricity source. The foreign feeling is also apparent among the decision makers, and potential customers, especially to visualise the experience of using renewable energy for their properties and calculating the potential benefit and risks from using it. Many people decide to use MHP after being influenced by their neighbouring village, relatives, or seeing the system on site as shown by experiences in many parts of Indonesia. The stories can influence people when they share the same context and aspiration with the technology.

   EnDev had held many benchmarking and sharing sessions among practitioners and users where many encouragement and collaborations had been resulted from the event. The most recent uplifting results was when the VMT from Rote Island (NTT) and Pangkajene Kepulauan (South Sulawesi) learnt by visiting the award-winning PV mini grid in Muara Enggelam (East Kalimantan) village, which was followed up by sharing through a popular mobile chat platform. The experiential learning and stories told by the peers were very engaging and motivating for them although they had to travelled for more than two days from their village. The stories from various sites with their unique circumstances also captivated international audiences, especially Indonesia. There are still few publications from Indonesia about renewable energy mini grids, although it holds enormous potential for more applications.

4. **Conversational method to disseminate the knowledge where people can ask questions and share their experiences.** Experiences in rural mini grids, moreover with renewable energy, are limited. In Indonesia, the rural mini grids are built for isolated villages where national grid are not existed. Therefore, the systems are not accessible for other people who are outside of the communities to learn from them. This situation creates bubble among the practitioners and hampered the sector to advance from the existing practices.

   Conversational sharing with open question and answers allow the participants to have a fair share of them to tell their stories and findings from their initiatives in rural mini grids with renewable energy. Internationally, publications of experiences and lessons about rural mini grids are still dominated by the implementation in countries from Africa, and parts of South Asia which are more continental landscape. Archipelagic countries, like Indonesia, can learn from them but also contribute on the experiences in implementing rural mini grids in their circumstances, such as from the geographical, social, and economical challenges for fishers and coastal communities. During various workshops held by EnDev where various practitioners from different areas both national and international participants involved, the discussions had been effective to unfold lessons from the implementation and highlighted based on the different circumstances.

5. **Include actual data and relevant visual media.** Availability of reliable and actual data about renewable energy installations, especially about rural mini grids, are still not widely accessible. Hence, knowledge products which provide data, like REMap Indonesia, and series of photos from the sites are more likely to get more attention from the readers as it provides visualisation of data and information. Moreover, evaluation of performance from the installed systems is also highly anticipated, especially to analyse many aspects in mini grids, such as load profile, performance ratio, and reliability of the systems during their operation.

"One of the most informative PV mini grid book that is very practical but also supported with theories and design practices."

-Training of trainers participant"

Explaining about PV mini grid system to training participants.

The afore mentioned aspects for knowledge products can be delivered through online and offline channels depending on the objective and target audiences. During EnDev projects, dissemination strategy had ranged from visit to mini grid sites to popular social media feature, such as Instagram stories. The latter was chosen since the publication had aimed to reach the students, and young practitioners.

Take the PV Mini Grid Installation: Do's and Don'ts as an example, dissemination strategy of this guidebook had been conducted through in-class and on-site trainings, as well as webinar and Instagram stories of DJ EBTKE. The webinar was done on the 30th September 2018 organized by ECADIN (Energy Acedemy Indonesia) while the live question and answer sessions in Instagram through official DJ EBTKE account was conducted on the 27th of September 2019 aiming to millennials. At least hundreds of viewers from each session was achieved. The audience was very enthusiast and got the chance to ask lively from basics of PV systems to the design of PV mini grid.

In the end, having a knowledge product that is consisted of countless lessons is important, but making the knowledge product visible to the practitioners is even more important. By spreading the information through several training sessions, webinar, and conference, it is expected to reach more readers will be increased and the main objective to have reliable and sustainable PV mini grid systems for the benefit of the people in the remote areas can be achieved.

Selected knowledge products, mostly technical guidelines, from EnDev Indonesia project have already available in the DJ EBTKE website to be accessed by public. To have , It is advised to have a mechanism that the publications can reached their target audiences, for example, EnDev Indonesia had once conduct a book discussion about PV Installation: Do's and Don'ts in a social media platform. Although the audience was limited but it might only one of many dissemination activities that can be pursued by DJ EBTKE or any relevant organisations. The publications might also be translated into a short course material and delivered through various platforms, both online and offline.

Practical knowledge is on demand as many renewable energy projects developed and the increasing urgency to have more competent local technicians handling PV mini grid and other renewable energy technologies.

Many books and technical guide of PV technology are written in English and not yet accessible for local technicians.

Moreover, most of the experts are concentrated in Java although the demands are mostly coming from the eastern areas and island setup. Redistribution of knowledge is crucial to ensure sustaining renewable energy system. EnDev Indonesia had conducted several methods to disseminate knowledge especially for rural electrification with MHP and PV Mini grid, such as:

- **Practical on-site training**, alongside with classroom sessions to strengthen the concept, had always been an effective method for various topics namely, community development, engineering and technical, and rural business.
- **Peer to peer learning method** is proven to be effective among rural communities. EnDev Indonesia conducted peer to peer learning sessions for technical, managerial and productive use of energy topics. It embraced conversational and experiential learning from the peers who had faced similar challenges and the feeling of connectedness among them.
- **Leverage the use of social media platform** to engage with the practitioners and enthusiasts. It enables lively discussions about the knowledge products as well as the surrounding aspects. EnDev had developed a mobile apps as a discussion platform for renewable energy practitioners and experts. After running it for approximately three years, the service had been in hiatus because there was not yet a local organisation who was ready to run the service. Hence, the existing social media platform is currently the most efficient and effective platform to reach the target audiences.

Recommendation

Data

- EnDev highlights the importance of reliable data and information for better decision making on every level of government administration, from national to the village level. The problem with reliable data had affected the implementation of strategy to achieve 100% electrification ratio and 25% renewable energy in the national energy mix. Despite growing initiatives to develop many software applications in the renewable energy sector, integration of the data and information that are circulated in the organisation, especially within KESDM organisation, shall be prioritised. Currently, the data initiative in the organisation has been led by PUSDATIN. EnDev had contributed in drafting a standard operating procedure for data and information management in DJ EBTKE.
- Through various pilot projects and interaction with local stakeholders, provincial government holds a very important role in sustaining energy access for their people. Hence, the relevant ministries need to leverage their involvement, including access to actual data, and competence to manage the mini grid facilities in their area.
- Indonesia with its thousands of islands have been attractive for the development of decentralised renewable energy. Hence, it has attracted many researches and academicians to study the situation in Indonesia in relation with the progress to achieve SDG 7. Access to data should also be open for researchers aiming to advance the development of renewable energy in Indonesia. EnDev project had been able to conduct handful of researches from the data that was managed by the project and got valuable insights from them to continuously improve our measures. Hence, DJ EBTKE, as the implementing partner, can continue this practice by inviting more relevant organisations, such as research institution and academicians, to conduct studies in the existing systems and improve the current policies and approaches in this topic. Data can be the glue to attract more collaborations to come.

If you cannot measure it, you cannot improve it –
Peter Drucker.

Knowledge management

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Practical knowledge is on demand as many renewable energy projects developed and the increasing urgency to have more competent local technicians handling PV mini grid and other renewable energy technologies. Many books and technical guide of PV technology are written in English and not yet accessible for local technicians. Moreover, most of the experts are concentrated in Java although the demands are mostly coming from the eastern areas and island setup. Redistribution of knowledge is crucial to ensure sustaining renewable energy system. EnDev had conducted several

methods to disseminate knowledge especially for rural electrification with MHP and PV Mini grid, such as:

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- Leverage the use of social media platform to engage with the practitioners and enthusiasts. It enables lively discussions about the knowledge products as well as the surrounding aspects. EnDev had developed a mobile apps as a discussion platform for renewable energy practitioners and experts. After running it for approximately three years, the service had been in hiatus because there was not yet a local organisation who was ready to run the service. Hence, the existing social media platform is currently the most efficient and effective platform to reach the target audiences.

EnDev Indonesia Seen from Our Partners

Mempermudah dalam melakukan inspeksi dan pengawasan pembangkit aneka EBT dalam hal ini plts dan pltmh, karena kita telah dibekali pengetahuan inspeksi yang mendalam sehingga membuat menarik dan senang dalam melakukan setiap inspeksi ke pembangkit2 tersebut.

Ease the works on inspection and monitor various renewable energy system, in this case photovoltaic system and micro-hydro power, because we had been trained about technical inspection. Hence we are enjoying the process of inspecting the renewable energy systems.

– Syed Jarrar, Ministry of Energy and Mineral Resources

Secara pribadi sangat bermanfaat karena selain memberikan training-training utk pembuat Turbin, operator, pemeliharaan, pengelolaan serta usaha produktif (productive use) juga sebagai stimulan bagi kabupaten/desa potensi lainnya utk membangun PLTMH dgn biaya APBD kabupaten bahkan Provinsi.

Very helpful because more than trainings for turbine manufacturers, operator, maintenance, management and productive use of energy, the EnDev support stimulated regencies/villages to develop MHP by using their budget.

-Ibrahim Pakki, South Sulawesi

Kegiatan monitoring yang dilakukan oleh EnDev menginspirasi Yayasan EnerBI untuk melaksanakan program pendampingan pasca instalasi sistem RE di beberapa tempat. Hal ini untuk memastikan bahwa hasil dari implementasi proyek dapat berlangsung secara sustainable dengan memanfaatkan potensi masyarakat lokal.

Monitoring activities that had been conducted by EnDev had inspired EnerBi Foundation to do technical assistance after system installations in various locations. It helped to ensure that the result from the project implementation can benefit the local communities in a sustainable manner

– Ery Wijaya, EnerBi Indonesia

Selama bekerja sama dengan MHPP & EnDev th 2008-2012 pada program PNPM lingkungan khususnya PLTMH berbasis masyarakat kami mendapatkan banyak manfaat berupa pengetahuan teknis perencaman, survey potensi pltmh, teknik operasi & pemeliharaan serta kelembagaan masyarakat. pengetahuan yg kami dapatkan dari MHPP & EnDev kami adopsi dan kami terapkan di program lainnya, yaitu Sumba Iconic Island."

During cooperation with EnDev in 2008 to 2012, in the framework of National Program for Community Development (PNPM Mandiri) especially Community MHP, we had learnt enormous knowledge from design engineering, MHP survey, operational and maintenance as well as community management. We adopted and implemented the lessons from EnDev for Sumba Iconic Island program.

-Warintoko, Entrepreneur

Secara pribadi saya mendapatkan pengalaman serta keilmuan yang lebih luas mengenai implementasi tenaga terbarukan. Bergabung dengan giz, merupakan impian tersendiri bagi saya semenjak kuliah, dan mendapatkan kesempatan kolaborasi dengan GIZ telah memberikan saya inspirasi dan pengalaman tak terlupakan. Hal tersebut menjadi modal saya dalam melanjutkan karir akademik saat ini. Terimakasih, EnDev

I had received many experiences and broader knowledge about renewable energy implementation. Joining GIZ had become my dream since college and got the opportunities to collaborate with GIZ had inspired me and gave unforgettable experiences. This had been my modalities to continue my academic career. Thank you EnDev.

Kita dapat meningkatkan kedisiplinan kerja, dan selalu monitor hasil yang telah dikerjakan. kesinambungan ini jarang dilakukan kontraktor2 yang ada dengan EnDev kita terbantu dalam monitor hasil kerja kedepan.

We can improve our disciplines at work and always monitor our work results. This is rarely being conducted by contractors. EnDev had helped us to monitor our future works.

– PV contractor

Kisah sukses/gagal yang dibagikan oleh setiap lembaga yang terlibat dalam EnDev menjadi referensi bagi kami dalam mendesain solusi listrik yang berkelanjutan di wilayah pedesaan

The successes and failures stories that had been shared by every institution who are involved with EnDev had become a reference for us to design sustainable electricity solution in rural areas

– Yasmine (GMN)

Saya mengenal EnDev pada saya menjadi Direktur Energi Baru dan Terbarukan. terakhir saya sebagai Direktur Pembinaan Program Ketenagalistrikan. Sebagai Direktur Pembinaan Program Ketenagalistrikan saya menjadi Alternate SOE Leader Indonesia untuk Energy Asean Meeting. dalam dua posisi jabatan itu saya mengenal GIZ, dan pernah berkerja sama dalam mereview hasil pembangunan PLTS di daerah pedesaan yang terbelakang, terpencil dan terisolasi pada tahun 2013 - Medio 2015. karena saya ditugasi menjadi Direktur Pembinaan Program Ketenagalistrikan. Dalam kerjasama tahun 2013 -2015, saya sangat terbantu dalam melakukan evaluasi hasil pembangunan dan usaha meningkatkan kwalitas para kontraktor dan pada akhirnya mampu meningkatkan kwalitas hasil pembangunan" – Alihuddin Sitompul

I had known EnDev since I become the Director of New and Renewable Energy. In the period of 2013-2015, I feel very supported by the technical review for PV mini grid in rural areas. Hence the quality of installations was improved.

– Alihuddin Sitompul, former Director of Various Energy DJ EBTKE

Melalui kerjasama dengan EnDev, dapat menambah networking kami selaku perusahaan swasta ke entity di Daerah (baik di pemerintahan, perusahaan lokal, maupun tenaga teknis lokal) Kami juga mendapat beberapa masukan dan informasi mengenai program pengembangan PLTS di daerah

Through cooperation with EnDev, our network as a company are expanded to entities in provincial area, such as public sector, local companies, and technicians. We also received many inputs and information about PV mini grid development in the regional level.

– Annisa Chairani, TMLEnergy

Dengan program ENDEV, masyarakat dibantu dalam melakukan pengelolaan PLTS dan PLTMH secara berkelanjutan, masyarakat dibantu dalam memanfaatkan listrik untuk kegiatan produktif, dan memberikan pelatihan untuk meningkatkan kemampuan teknis operator dalam mengoperasikan dan memelihara PLTS dan PLTMH.

EnDev program had supported the communities to manage their PV mini grid and MHP sustainably, introduce productive use of energy, and trainings to increase technical competence and skills of the operator to operate and maintain the MHP and PV mini grids.

– Maritje Hutapea, Former Director of Various Energy DJ EBTKE

Dengan mengembangkan usaha ekonomi produktif berbasis energi terbarukan, EnDev memberikan sentuhan nyata sebagai bagian dari solusi peningkatan perekonomian masyarakat di daerah yang terabaikan.

By developing productive use of energy with renewable energy, EnDev provided real experience as part of the solution to increase local economic condition of the disadvantage regions

– Ardi Kobit, Community Facilitator.

EnDev banyak membantu dalam mendukung kebijakan dan kegiatan yang secara teknis dan non-teknis belum dapat dilaksanakan secara mandiri karena berbagai hal, utamanya keterbatasan sumber daya manusia.

EnDev had helped supporting policies and activities both in technical and non-technical context which had not be able to be conducted independently due to various reasons, mostly insufficient human resources.

– Ezrom D Tapparan, DJ EBTKE

Bantuan kerja sama diberikan oleh EnDev bisa langsung mencapai sasaran (masyarakat penerima bantuan).

The supports from EnDev can directly reach the target beneficiaries.

– Prowater, NGO in West Sumatra

Memotivasi saya untuk selalu menggerakan kegiatan pada energi baru terbarukan, pada kegiatan tugas akhir mhs Politeknik Negeri Padang jurusan Teknik Mesin meneliti dan membangun Pikohidro dipadesaan bersama masyarakat.

EnDev had motivated me to be the motor for renewable energy activities, especially for the students in State Polytechnique of Padang to research and develop pico-hydro in rural areas with the community.

– Nota Effiandi

Kerjasama kami dengan EnDev menurut kami sangat baik, yaitu bagaimana mengembangan keberlanjutan pengelolaan PLTS Komunal di NTB d, yaitu di 4 Dusun, yaitu Dusun Pegadungan Desa Sambek Elen KLU dan Dusun Arung Santek, Lepa Loang dan Brangkuang Desa Labuhan Haji Kab. Sumbawa. Saat ini telah terbentuk kelembagaan pengelolaan berupa Koperasi di du lokasi tersebut dan telah mendapatkan bahan hukum dan kementrian koperasi dan UKM. Kedua Koperasi ini telah melakukan RAT pertamaya saat ini.

Cooperation with EnDev was good to develop sustainable management of the PV mini grids in four hamlets in NTB. Currently, organisations to manage the PV mini grids had been formalised and operated legally. The cooperatives had conducted their first Year-End Meeting.

– Suyono, TRANSFORM NTB

Kesadaran masyarakat terutama di lokasi binaan meningkat, manajemen lembaga pengelola menjadi lebih baik. Saya memiliki keinginan untuk membentuk kemitraan Pemda dan swasta dalam hal pemeliharaan instalasi energi terbarukan.

There is an increasing awareness from the community, especially in the piloted area, which made better management of the PV mini grid. I had the urge to establish partnership between Provincial Government and private companies to establish installation and maintenance service for renewable energy

– Niken Arumdati, Mining and Energy Office NTB

Bekerja dengan EnDev membuat saya bahagia karena bisa mengedukasi masyarakat tentang pemanfaatan energi serta bisa membantu masyarakat dalam memberdayakan potensi yang mereka miliki

Working with EnDev had made me happy to educate the community about energy utilisation and empower the community with all of their potential – Jeszy Patiri

– Jeszy Patiri

Keterlibatan saya di isu pengelolaan RE oleh masyarakat local yang diawali kerja sama dengan EnDev, menginisasi saya membuat riset etnografi mengenai dampak sosial budaya dan perubahan system kelas yang terjadi di masyarakat. Mengingat banyak sekali proyek RE di desa-desa terpencil di Indonesia, dan tidak semuanya sukses dikelola oleh masyarakat local. Beberapa di antaranya ada yang dikelola swasta dan bekerjasama dengan PLN.

My involvement in the renewable energy management was started in the cooperation with EnDev. It had inspired me to conduct an ethnographic research about the socio-culture impact and the change in class system in the community.

– Hamidah Busyrah, former Community Facilitator

Annex

Table 1 Summary of People Role and Contribution

Technology Innovation Activities	Expertise	Contributions/ Role	Institutions
Technology transfer on MHP	• Engineering: Civil, Electrical, Mechanical.	• Trainers for classroom and practical trainings	
Solar Business System (SBS/Solbis)	• Engineering: electrical	• Product development • Manufacturing • Installation and monitoring	• EnDev – Adyawinsa Solar • Adyawinsa Solar • STT PLN
Solar Powered Ice Maker (SPIMA)	• Engineering: refrigeration, mechanical, electrical • Business management • Project Management • Social studies	• Product development and manufacturing • Business feasibility • Community preparation and impact measurement	• GIZ multi-projects, ILK Dresden, AIREF, ATW Solar • GIZ multi-projects, AIREF • GIZ, specifically EnDev Project
Local Technical Service Provider (TSP)	• Engineering: electrical • Business management • Project Management • Public policy/ Law	• Technical trainers, classroom and practical trainings • Business feasibility study, form partnership • Policy advise to local and national government about the interconnected aspect in the bureaucracy	• EnDev and TML Energy • EnDev , TMLEnergy, local technician • EnDev
Universal Remote Monitoring System (RMS)	• Engineering: electrical, industrial, informatics, telecommunication • Project Management	• Product development (hardware, software) • Manufacturing • Installation	• EnDev • UNM • EPC – RESCO Sumba, Mobile Provider - Telkomsel
Renewable Energy Boat (RE Boat)	• Engineering: electrical, industrial, informatics, naval • Business Management • Social studies	• Product development • Business feasibility study	• EnDev • EnDev
Smart Payment System (SPS)	• Engineering: electrical, industrial, informatics, naval • Business Management • Social Studies	• Product development • Business feasibility study • Community preparation	• EnDev, Startup company - Newlight • EnDev • EnDev – Community facilitators

Table 2 Summary of Resources

Technology Innovation Activities	Resources needed	Provider
Technology transfer on MHP	• Training modules and trainers • Measurement tools (working tools such as flow meters, GPS, measuring tapes, electrical testing equipment such as AVO meter, clamp meter, test pen and other tools.) • MHP sites to visit • Event arrangement • Travel and accommodation (optional)	EnDev
Solar Business System (SBS/Solbis)	• Design • Hardware components	• EnDev – Adyawinsa Solar • Adyawinsa Solar • STT PLN
Solar Powered Ice Maker (SPIMA)	• Detailed Engineering Design (SPIMA and the Power system) • Manufacturing instructions • Hardware components • Manufacturing facilities and team • Initial capital for: - Logistic arrangement - A warehouse facility to install SPIMA - Construction and installation works	• GIZ multi-projects, ILK Dresden, AIREF, ATW Solar • GIZ multi-projects, AIREF, Manufacturers of components • The company to operate SPIMA- BIDCAB
Local Technical Service Provider (TSP)	• Training modules for technicians • Trainers • PV mini grid to visit • Initial capital to start open new service	• EnDev and TML Energy • KESDM
Universal Remote Monitoring System (RMS)	• Detailed design • Electrical tools and measurement • Hardware components • Dedicated locations to develop, test and assemble • Operating PV mini grid to test RMS • SIM Card and mobile data subscription	• EnDev, UNM, • KESDM • Mobile Provider - Telkomsel
Renewable Energy Boat (RE Boat)	• Detailed design • Hardware components • Boat 1 Gross Ton capacity • Operating PV mini grid • RMS	• EnDev, Fishermen, KESDM
Smart Payment System (SPS)	• Detailed design • Hardware components • Facility to manufacture and test • Operating PV mini grid to be installed • Houses to be installed	• EnDev, Startup company - Newlight

Annex