Site Visit Report

To accommodate the development of this study, the project has conducted site visits to solar farms in Indonesia twice, to get some insights from the operational of the solar farms. The first site visit was conducted on 28 March – 1 April 2022, where representatives from ASEAN Centre for Energy (ACE) and Directorate General of Electricity visited Likupang Solar PV Plant in North Sulawesi. For the second visit, representatives from ACE and Directorate General of Electricity, as well as ASEAN-China Cooperation Fund (ACCF) management team visited four solar projects in East Nusa Tenggara from 1 – 5 August 2022.

1. Site visit to Likupang Solar PV Plant

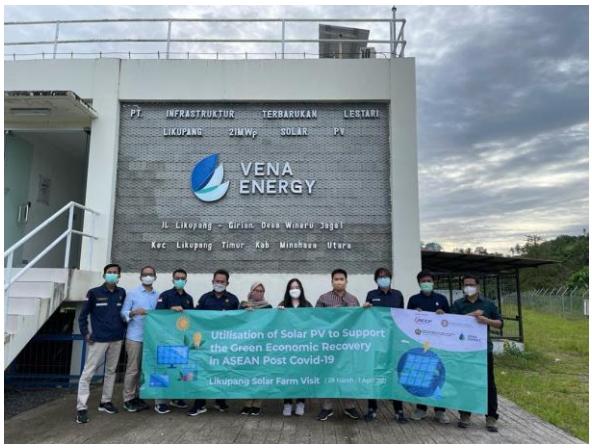
Likupang Solar PV Plant, or also called Minut I Solar Project, is located in Wineru village, Likupang Timur district, Minahasa Utara regency, North Sulawesi, Indonesia. Developed by Vena Energy, the project has achieved full commercial operation since September 2019, after one year of construction by Consortium of NARI Group Corporation and PT Pembangunan Perumahan (Persero) Tbk. Considering the high solar potential in North Sulawesi with more than 2,000 kWh/m2 of Global Horizontal Irradiance (GHI), Vena Energy acquires 29.2284 ha of land to build 64,730 PV modules.

The Likupang Solar PV Plant is deemed to be the largest solar PV plant in Indonesia to date. With 21 MWp of installed capacity, the plant is able to produce renewable electricity of 33,400MWh per annum, providing clean electricity to 20,138 Indonesian households from 05:30 to 17:30. Although the plant is only used for power generation, it has reduced approximately 28,071 tonnes of greenhouse gas emissions, supporting the green recovery in Indonesia.

Location is very influential on the efficiency of the PV modules. If it is located in a mining environment, for example, it becomes dusty and reduces electricity production. Likupang Solar PV Plant is located in a rural area surrounded by many trees, therefore having good effectiveness. Every month, the staff and operator carry out one cleaning cycle of the PV modules. Delay in cleaning the PV modules can cause a loss of 3.6% per week. In addition to dirt and dust, source of losses also comes from temperature. To minimise the temperature losses, there is quarterly and yearly evaluation to monitor the temperature.

The construction of Likupang Solar PV Plant involved more than 200 local workers, thus contributing to economic development of the local community. Vena Energy also continues to contribute to the rural communities through several Corporate Social Responsibility (CSR) Programs as follows:

- Provide donations for the community, such as in public events and provision of school needs for elementary students.
- Provide free health clinic and Covid-19 preventive actions.
- Help the community to preserve tourist sites.
- Cooperate with universities to provide internship opportunities and conduct training on renewable energy.
- Provide entrepreneurship training and support women group in home industry.



2. Site visit to East Nusa Tenggara (West Manggarai Regency)

The Komodo National Park (TNK) is a popular tourism spot in the East Nusa Tenggara, Indonesia. Famous for its Komodo dragon, beautiful reefs, and scenic beaches, people across the globe come to enjoy island hopping archipelago adventures. Located in coastal areas, people living in the smaller island has no access to electricity. Some in dire needs for electricity must provide their own diesel engine electricity generator. Furthermore, several regencies in East Nusa Tenggara even experience extreme drought and are facing scarcity in fresh water supply. The supply of diesel fuel and clean water for living in the island was relying on the bigger Flores Island.

Initially, the power grid was done sporadically by the joint venture from the community with a diesel generator. Then in 2019, a private energy EPC started the construction of solar power plant and hired operators from local people (trained 2 people in each site). After a year of operation, the power plants were handed to the PLN (Indonesia's electric utility) and managed by them. The initial electric meter was more expensive during the private grid, however after managed by the PLN, the lower kVA meter is subsidised. Installation in Messah island and Papagarang island was done by PT. Indo Electric Instruments and Seraya Besar island was done by PT. Surya Energi Indotama.

The solar power plant installations and systems are typical in these three islands. The polycrystalline PV cell was equipped with lead-carbon battery system, AC/DC inverter, power switch, and electricity grid. Figure 1 shows the typical power plant off-grid system in these islands, where connection to other grid is planned for future development. Charging the battery is prioritised, as the operators are assigned to switch off the connection to the island grid if the battery reached below 20%. The batteries are assembled in series at Papagarang and Messah, and in parallel at Seraya Besar. The capacity of each module is 330-340 Wp and battery capacity is 1,000 Ah each cell.

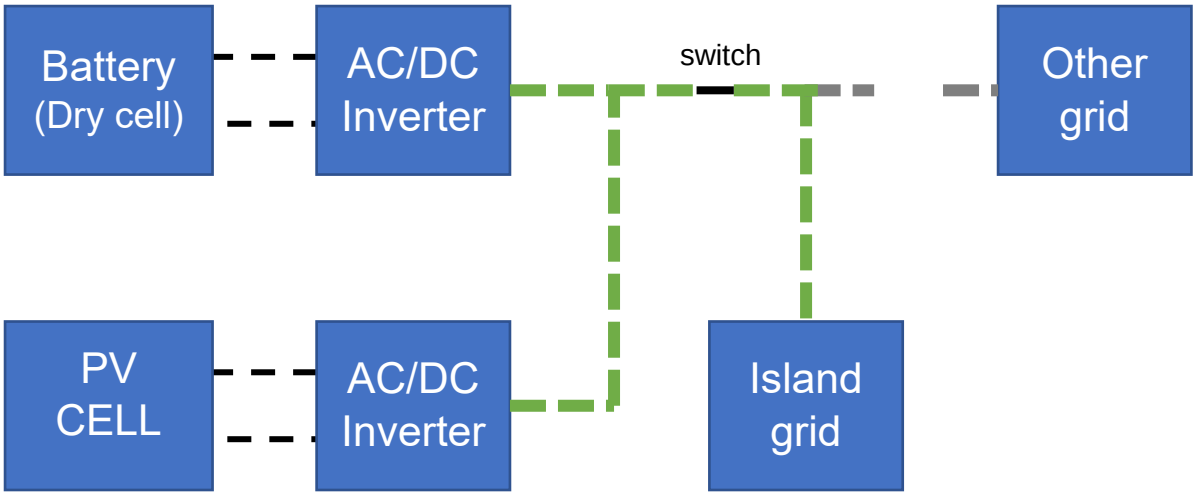


Figure 1 Typical Solar Power Plant System

Solar irradiation is not a challenge as the solar plants are located in a nice tropical coastal area and can achieve peak capacity at noon. Cloud or shades only become common occurrence in rainy season from November to February. Cleaning, however, is a major challenge as the manpower and clean water supply is limited. In Messah island especially, the PV cells are placed densely near a cliff which make it harder to clean. This is noted to cause up to 20% of efficiency drop by the local operator. The PV cells usually cleaned twice a month, except in Seraya Besar island where water is easier to get. The island could become very dry and hot, but efficiency loss due to excessive heat is unnoticed by the local operator.

The people in these islands are mostly fishermen which use canoe and diesel boat. The presence of these solar power plants does not only provide light, but it can revive the economy and give access to information. People in the archipelago started buying rice cooker (shifted from biomass), washing machine, refrigerator, and ice machine to support their seafood industries. Some are also able to attend online learning to achieve university degree during the pandemic.

a. Papagarang Island

   Papagarang island is one of the islands located in the Komodo National Park area, in West Manggarai Regency, East Nusa Tenggara, Indonesia. To be able to drink, people in Papagarang island have to buy clean water with a relatively high price from the mainland, Labuan Bajo, which is located 21.8km away. The very rare rainfall also makes them very dependent on the delivery of clean water from Labuan Bajo. On average, families in Papagarang island spent up to USD 600 per year for clean water, while having standard income of only USD 3,000 per year. Moreover, the lack of electricity infrastructure in the island hinders daily activities, such as for lighting, cooking, refrigeration, as well as to provide clean water.

i. Clean Drinking Water Project

Supported by the Korea International Cooperation Agency (KOICA), a social enterprise called Komodo Water conducted water feasibility studies in several locations in West Manggarai Regency. This includes social mapping, market research, hydrogeology survey, and geophysics survey. Aiming to improve the community's access to clean water without harming the environment, Komodo Water uses Osmosun®Brackish Water Desalination, powered by 5.6 kWp solar panels.

The aquifer has saltwater intrusion causing the well to become brackish with Total Dissolved Solids (TDS) of 2,000 ppm. Using reverse osmosis technology, Komodo Water produce clean water directly from the brackish water without using filtration. The produced water is safe to drink with TDS of around 250 ppm.

ii. Solar PV Plant in Papagarang Island

The solar power plant here generates 380 kWp for 392 houses. Even though built by the same EPC with PLTS Messah, access to the station is challenging, it is located up in the hill with unpaved road. The electricity was provided for 24 hours in the first year, but now it is only available between dawn to midnight. There are plans to increase the battery capacity from the current 500 kAh. Further expansion of solar power plant utilisation could be beneficial to support clean water and ice production.

b. Solar PV Plant in Seraya Besar Island

The power plant in this island was officially named PLTS Seraya Marannu. Compared to the other islands with PLTS project, Seraya Besar island has its own clean water spring and even has a small hard wood plantation. Though the PV cell can generate 190 kWp to provide for 130 houses, it is located rather poorly in the foothill with counter slope, causing delayed electricity production due to shadow from other cells. Usually, the electricity will be cut off during midnight until dawn. However, at lowest point, it only starts charging the battery at around 10 am and starts distributing electricity to the grid around noon until midnight. The battery here has 240 kAh capacity and supported by 30 inverters due to its parallel electrical network. One thing that should be improved is the access to the island as the only existing dock very obsolete. The bridge is very fragile and dangerous even for the locals.

c. Solar PV Plant in Messah Island

Messah island is the most populated island in comparison to the other two. The island has grown in popularity since the G20 Sherpa Meeting on 12 July 2022. The solar plant facilities here are the most maintained and well run. When it was built, it provided 24 hours of electricity with 590 kAh battery capacity. However, due to increasing demand, after a year of operation the electricity was cut off during midnight to dawn. Therefore, new battery arrays were added in the beginning of August 2022 to provide 24 hours service again.

It provides 530 kWp of electricity to almost 500 houses, but the number of households exceeds this number as more than one household live in the same house. The hill where the solar PV plant is mounted was originally a small forest. Deemed sacred by the local community, there is one tree left in the hill and can be spotted in the middle of the solar PV arrays. The construction of the solar power plant was done in respect to local belief for local needs by the local people.

Solar PV has proven to bring benefits to the community. Starting from electricity to support livelihoods into supporting business and personal growth. These installations have proven how solar power plant could easily placed on remote locations with minimum technical support.

Although Indonesia has huge solar potential, only 0.2% land is used for solar PV. This is caused by the lack of regulations to support renewable energy companies, thus hindering solar PV development in Indonesia. The existing regulations are made for RE technologies in general and not specific to solar PV. For instance, there is no regulation related to waste of PV modules, how to dispose or recycle the PV modules. Due to the absence of a clear framework, it costs up to millions of Rupiah to dispose PV modules. This is of course makes investors reluctant to develop solar PV because of the high costs needed.