WHOLE ISLAND TRANSITION ROADMAP

Final Report Summary | November 2022

This report has been commissioned by South Asia Research Hub, Foreign, Commonwealth and Development Office (FCDO), Government of UK. However, the views expressed herein do not necessarily reflect the UK Government's official policies.

SCENARIOS

Based on the results of island suitability assessment according to the proposed selection criteria and weightages, Buton Island in Southeast Sulawesi Province, Indonesia was selected for development of the roadmap.

- The scenarios used for this roadmap are as follows:

Scenario	Energy Mix
RUPTL 2021-2030 Scenario (Base Case)	• 30 MW of Hybrid Energy Power Plant (PLTH); • 9.8 MW of Biomass Energy Power Plant (PLTBm); • 15 MW of Wind Energy Power Plant (PLTB); and,
100% Renewables Scenario	• 45 MW of Solar PV with BESS (PLTS); • 9.8 MW of Biomass Energy Power Plant (PLTBm); • 15 MW of Wind Energy Power Plant (PLTB) ; and, • 9.432 MW of Mini-hydro Energy Power Plant (PLTMh), in addition to the existing 0.8 MW Rongi mini-hydro and 1.5 MW Wining mini-hydro power plants, hence the total capacity of PLTMh is approximately 11.732 MW.

Implementer	RUPTL Scenario	100% Renewables
PLN	**1** • PLN delivers PLT EBT Base ○ PLT EBT Base consists of the combination of solar PV and diesel generators • IPPs deliver PLTBm and PLTB	**2** IPPs deliver all new plants and replace existing generation fleet with RE
IPP		

EXECUTIVE SUMMARY
FINANCIAL ANALYSIS

- Project IRR of each of the technology considered are as follows.

Data source / Project developer	Units	TDIPS		Actual project data	
		PLN	IPP	IPP (low)	IPP (high)
Solar PV	%	12.58%	9.48%	11.45%	17.86%
Solar PV + battery	%	0.28%	(2.71%)	(2.19%)	2.69%
Wind	%	10.31%	6.98%	11.82%	1.72%
Small hydro	%	36.26%	36.63%	47.33%	34.17%
Biomass	%	N/A	N/A	N/A	N/A

- Only solar PV and small hydro plants under IPP mode that only solar PV and small hydro plants under IPP mode that able to satisfy the hurdle rate of 14%. The hurdle rate was determined based on our discussion with a power developer. In the case of small hydro projects, it should also be taken into account that project viability is highly site specific. The absence of sufficient biomass feedstock on Buton Island makes the option of a biomass plant unviable, even though it is the only technology that can provide reliable supply without providing grid level storage.
- The option of solar PV + battery storage addresses the intermittency problem. However, with current cost of storage and the policy environment around tariffs for renewable energy, hybrid deployments are not commercially viable. The higher cost of solar PV + battery deployments should be considered in light of the ancillary services it provides to the grid like primary and secondary reserve for frequency regulation and supply security, in addition to energy production.
- Meaningful power sector reforms to enhance governance frameworks, and industry and market structures are required to lower the risk perception and return expectation of private sector investors across the board. Well-developed and structured renewable energy projects on Buton Island as part of a decarbonisation pathway of the island's electricity supply may attract interest from developers.

EXECUTIVE SUMMARY
TECHNICAL ANALYSIS

- To achieve renewable energy transition, it is important to ensure that the integration of new renewable energy-base power plants into the existing grid does not interrupt service or interfere with a stable operation of the grid following the grid code requirements. During the grid simulation through the various scenarios, it was found that the grid conditions are sufficient to handle any potential shortcircuit faults.
- From the technical analysis and grid modeling using the DIgSILENT PowerFactory, the following observations were made:

1. During load flow simulation through RUPTL scenario and 100% renewable scenario, both scenario still comply with grid code standards, however for 100% scenario tapping on transformer substation primary side is needed to maintain the voltage system criteria. Some concerns during the load flow analysis are mainly due to overloaded network lines in some grid sections The original impact study indicated that there is minimal impact in prospective fault levels with the solar farm connected.
2. To maintain the grid stability, installation of a 30 MW of hybrid PV-Diesel plants capacity should be scattered in a few locations, as near as possible to the existing diesel or other baseload power plants to avoid grid voltage drop.
3. During load flow simulation during daytime and evening peak load, the voltage values in normal conditions fall within the set ranges (±10% for 150 kV system and +5% -10% for 20 kV system), which imply it has complied with the grid code standard.
4. Based on the current analysis, one of the required upgrades is to add additional lines that are identified to be overloaded into two parallel lines to reduce the drop voltage, at Baruta and Tolandona, by adding approximately 20 km (10 km + 10 km) double cable for 20 kV line. It is also advised for the breaker connected to Ereke sub-system to be opened i.e. changed into an isolated system which operates independently, to minimize the drop voltage risk.

EXECUTIVE SUMMARY
GHG EMISSION ANALYSIS

- This analysis calculated an estimate of GHG emissions as generated from the existing and planned power plants in Buton Island based on the received data sourced from RUPTL 2021-2030 and data received from PLN offices in Baubau and PLN South East West Sulawesi Region for comparison as there was discrepancy found in relation to the existing power plants installed capacity.
- From the calculations, the following observations were made:

Estimated GHG emissions from	Unit	Estimated GHG Emission based on Data Source	
		RUPTL 2021-2030	PLN Offices
Existing power plants	Million tCO_2	2.85	2.81
Planned power plants	Million tCO_2	2.97	2.97
Total	**Million tCO_2**	**5.83**	**5.79**
Total estimated cost of GHG emissions	**Billion IDR**	**4,355.33**	**4,323.86**
	Million €	**275.42**	**273.43**

The calculations of estimated avoided cost due to the emission of power assumes cost of carbon of IDR 747,172 per ton of CO2 (€ 47.25 per ton of CO2 based on IETA GHG Market Sentiment Survey 2021 Report); emission factor based on technology as per the 2019 IPCC Guideline and the Fifth Assessment Report; and technical lifetime and capacity factor of each technology based on the Indonesian Power Sector Catalogue for Generation and Storage of Electricity 2021.

EXECUTIVE SUMMARY

- The barriers for 100% renewable energy transition in Buton may include the transparency of the procurement process and the relatively small project sizes resulting in difficulties of financing the project commercially. Gradual and measurable actions toward transitioning to 100% renewable energy should be implemented to ensure there are no interruptions of service to the current and near-future electricity consumers. Below are some strategic actions that can be considered as a transition strategy to get Buton Island to 100% renewable:
  - **1st phase**: Utilize the identified potential for hydro in Buton and Muna Islands;
  - **2nd phase**: Add grid-connected solar PV and wind power plants in a hybrid configuration with existing and new fossil fuel generators to significantly decrease emissions by at least 25%. Relocation for existing diesel power plants may be required to move them closer to the solar power plants if the solar plants are unable to be located close enough. Wind contribution might be insignificant considering that there are very few wind resources in Buton Island;
  - **3rd phase**: Substitute coal power plants with biomass;
  - **4th phase**: Gradually substitute diesel on hybrid PV-diesel/ wind-diesel power plants with BESS; and
  - **5th phase**: Gradually phase out gas (considering gas infrastructures investment).

- The driving force of the renewable energy mix in Buton specifically is not the LCOE but the **availability of resources**. From the LCOE calculation, that hydropower plants offer the most effective cost; however, the challenge is the dependency of this type of technology onthe site-specific potential of the energy resource. Solar PV may become a better option as solar technology and BESS costs continue to decline due to growing demand and the advancement of technology and materials.

THANK YOU