The Implementation of the Automatic Dispatching System (ADS) to Support the Smart Grid Pilot Project for Distribution Grid Improvement in Sumba Island

Dimas Bangun Fiddiansyah
Digital Management Division
PT PLN Head Office
Jakarta, Indonesia
dimas.bangun@pln.co.id

Hanny Benchmark
USAID – ICED II Team
Jakarta, Indonesia
hanny.berchmans@iced.or.id

***Abstract*— The Government of Indonesia has set the target to promote renewable energy development to diversify generation resources and reduce GHG emissions. However, with more than hundred isolated grids in Indonesia, there is a critical issue that hampered providing the reliable of electrification in remote island, as the consequence of the high number of diesel fuel consumption due to its high operational and maintenance cost. In addition, dispatch combination between diesel generator (DG), and PV has triggered to unreliable supply since there is no load control center as well as the insufficient communication channel available. Hence, PLN as the major power utility in the country has initiated the pilot project of smart grid in Sumba Island as its effort to increase power quality and grid reliability, as well as to raise the Variable Renewable Energy (VRE) penetration in the generation mix, in order to reduce oil fuel consumption while at the same time raising energy sales market.**

As the increasing technology of VRE has been improving, PLN should take advantage of the latest technology available to improve its generation performance. Therefore, one strategy that can be implemented is by applying the Automatic Dispatching System (ADS), which aimed to manage the various power supply characteristics capable of meeting the fluctuation of their load demands. On the other hand, ADS will be the flexible solution as the demand response in this distribution grid. Currently, the island condition has 2 grids, Eastern & Western Sumba system, in which both grids are mostly supplied by Diesel Generations (DG) based. Meanwhile, Centre and Southern part are not yet electrified. Among DG based in the eastern grid, it has been operating a 1 MW Solar PV (SPV) which represents 15% penetration. Thus, to increase the VRE penetration, this system intends to host an additional 1 to 2 MWp of PV. While the rising trend of PV in the eastern grid, West grid doesn't have no PV installed. Hence, most DG previously has operated in Load Following setup with manual dispatching.

Based on the load profile in East Sumba, stated that the peak-load 6.8 MW, and during a week's cycle, the daytime load has fluctuated between at 3.7 MW to 4.8 MW. Thus, the power plant configuration consisted of 9 MW DG and 1 MWp PV. Having ADS installed over the East grid DG, it would be capable of interconnecting between east grid and west grid. By integrating them in the ADS system for automatic and sequential dispatching of the generators according to grid load behavior, it would not only guarantee the power quality and grid stability, but also will support the load reduction from the Solar PV. Hence, this allows PLN to minimize fuel consumption, and develop the first operational Smart Grid system.

Keywords — Automatic Dispatching System, Diesel Generations, Variable Renewable Energy, Power quality, Smart Grid system

I. Introduction

Implementing variable renewable energy (VRE) such as PV energy into Indonesian State Electricity Company's (PLN) power grid has been their main challenges in the past two decades. Hence, one innovative solution is by applying the Automatic Dispatch System (ADS) which is integrated in the power generations. Creating the innovation, PLN would increase the reliability and power quality to the customers by improving the unstable condition in the system. Last year, PLN supported by USAID ICED II project initiated a commissioning project test to run the installed ADS in Sumba grid within the period of 2019 -2020. The ADS was installed at the 20 kV distribution lines in eastern grid of Sumba Island since it is interconnected to the 1 MWp installed capacity of solar PV.

Fig.1 Sumba distribution grid and its planning expansion

Meanwhile, solar PV and the diesel plant are developed at Kambajawa Distribution Station. During the test, the ADS has performed proven and were able to control the grid frequency at stable rate by managing the operation of Kambajawa diesel power plant to meet the variability of power load/demand as well as the variability of 1 MWp solar PV power plant output. Thus, PLN will continue to observe the situation, especially during critical hours (peak hours or high ramping rate hours) to ensure whether the controllers and the generation power system balance power supply and power load if a nearby 1 MWp solar PV power plant supplies electricity intermittently due to weather condition. The success of ADS installation, testing and operation boosted PLN's understanding and confidence to replicate the innovation to increase VRE integration and penetration in other distribution grids.

II. ADS Configuration

Automated dispatching control system (ADS) is a control system tool which has function to monitor the system of the load flow in power network from various power generation types whether conventional and variable renewable energy, thus it capable to enter the electricity and energy market, as well as to accommodate the energy mixed.

ADS have been widely implemented in any system voltage level system whether in medium voltages and high voltages. Meanwhile, the important role in the configuration of ADS, as the main direction of control system development, was the formation and implementation of SCADA, which collaborate information about the processes and centralize control. Thus, ADS is a type of automated process control which capable to control any type of power generation roles in the grid.

The operation mode and the automated dispatch would not only guarantee the power quality and grid stability, but also it will support the induced load reduction from the Solar PV and other VRE that would be installed in the future. By allowing PLN to capitalize on the fuel usage savings and the cost spin-down effect of the incorporation of continuously lower cost VRE generation, which subsequently would lower PLN's operational cost as well as increase corporate profits.

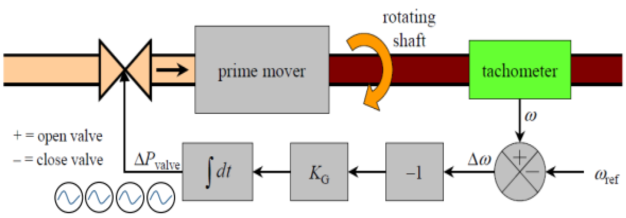

Fig.2 Control Basic Design of ADS System

Equation of ADS control design represent by formula

$$\frac{2H}{\omega_0} \cdot \frac{df}{dt} = P_m - P_e$$

Current ADS reflects Multiple Generator status (on/off, synchronized or disconnect) and Multiple generator dispatch. Hence, ADS send power instruction, not just control signal. Thus, it reads the status of the grid and the generations in real-time instantaneously, and automatically instructs the diesel generations to dispatch certain actual power to stabilize the frequency, while at the same time, it maintain generations in operation within its optimal power settings.

In general, ADS has automatically decided which generations have to be switched on, synchronized, loaded or stopped. Consequently, this solution can handle any type of power generation technology, as well as can be applied to any grid in any size.

III. Distribution Grid Operation

Currently, Sumba Island has two main grids, eastern and western grid which the majority supply based on diesel fuel generation. On the other hand, either southern or northern part is not yet electrified. Based on the RUPTL (PLN's Power supply business model), in Sumba, will be developed new diesel and gas power generation, as well as new high voltage power grids to expand the installed capacity in the island. The share of power generation composition recently dominated by private rental vendors, but PLN will gradually replace the rental with PLN generations. East grid has PV generation with the installed capacity 1 MWp, which now represent 15 % of the capacity. In addition, eastern grid intend to have additional 2 MWp while west has no PV generations. Meanwhile, most of the diesel generations are operating in load following mode with manual dispatching.

Load profile in Sumba has typical load profile characteristic which has low load in the daytime and increasing load demand in the evening. The peak-load 6.8 MW, and during, the daytime load, has parallel operation with the maximum PV generation week's cycle, which fluctuates between 3,7 MW – 4,8 MW.

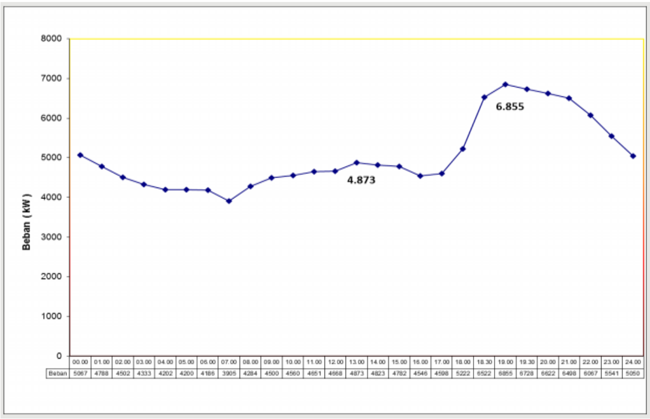

Fig.3 Typical daily load profile in Sumba Island

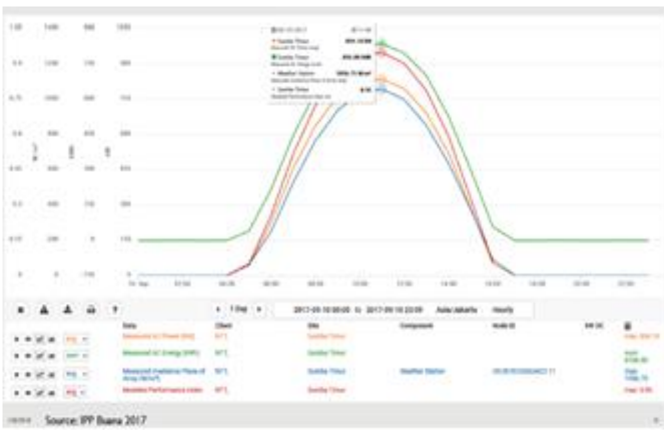

Fig.4 PV output 1 MWp in East Sumba Grid

No	Diesel Units	Owner	Total Installed Capacity (kW)	Rated Power (kW)	Remarks
1	S W D	PLN	336	220	
2	YANMAR	PLN	270	220	
3	DEUTZ	PLN	260	200	
4	DEUTZ	PLN	260	180	
5	S W D	PLN	336	220	
6	S W D	PLN	336	220	
7	CATERPILLAR	PLN	728	650	ADS Retrofit
8	MTU	PLN	700	650	
9	MAN	PLN	500	400	
10	CUMMINS (new unit)	PLN	500	500	ADS Ready.
11	CUMMINS (new unit)	PLN	1000	1,000	ADS Ready.
	Total PLN Unit		**4,715**	**4,460**	
12	MTU	Rental	500	400	
13	MAN	Rental	500	330	
14	MTU	Rental	500	400	
15	DOOSAN	Rental	500	410	
16	DOOSAN	Rental	500	410	
17	DOOSAN	Rental	500	410	
18	DOOSAN	Rental	500	410	
19	DOOSAN	Rental	500	410	
	Total Rental Unit		**4,500**	**3,590**	
	Total Diesel Capacity		**9,215**	**8,050**	Status on Dec 2017, when th engine arrived.
20	Solar PV	IPP	1000	880	COD on early 2017
	Peak Load (Oct 2017)			6,855	
	Reserve Margin during the Night peak-load			1,195	Status on Dec 2017, when th engine arrived.

Table 1. Power Generation Composisition in Sumba

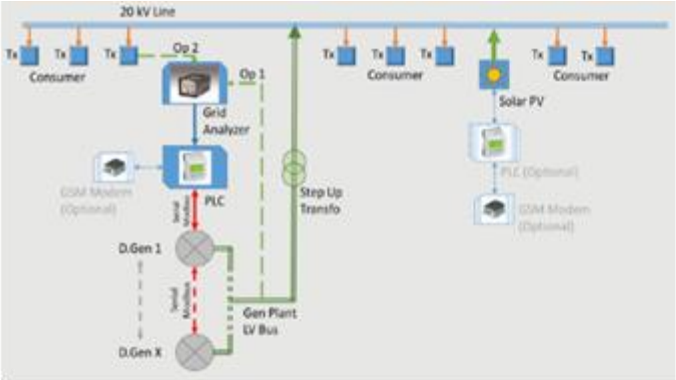

Fig.5 Conceptual Layout of Proposed System Components

East Sumba Solar PV 1 MWp has equipped the inverter with capacity 880 kWac using smart string inverter and feature of PV Module quality.

IV. Sumba Grid Recommended Improvement

There are several methods that can be applied to improve Grid quality in Sumba system : implement ADS over East grid gensets, interconnect both grids (east and west grid) through high voltages lines, implement ADS over west grid power generation once upgraded, and develop the first operational smart grid power management.

Basic dispatching control system which is the first stage of smart grid concept has two approaches to be implemented; (1) Operate the diesel generations in load response mode, with minimum operation set point of 30% and maximum set point of 80%, (2) Integrate them in the ADS/AGC system for automatic and sequential dispatching of the generators according to grid load behavior.

The picture 4 above described conceptual layout of system. Depending on model, grid analyzer can read the grid from the LV bus (option 1) or from a consumer type step down transformer on the main HV outcomer (option 2). Thus, the PLC can be replaced by a full size computer or a laptop computer, while GSM modems or more complex telecoms can be implemented for remote management and/or integrate with an active solar SCADA. Meanwhile, there are basic requirements to be implemented for preliminary phase in smart grid, which consists of;

1. All flexible generators to be operated exclusively in “full range load following ”mode, with minimum operation setting defined at 30% or lower and maximum operation setting defined at 80%
2. All flexible generators to have ECU’s, electronic governors and ModBus and, optionally, TCP/IP protocols. Removal or redefinition of the now obsolete grid KPI of SFC; to be substituted by the actual international standard of liters per kWh delivered
3. Definition of new procurement requirements, aligned with the Smart Grid transition strategy.
4. Assignment of financial value to the modern grid KPI’s, which now will be monitored and adjusted in the decision tree, like frequency stability, voltage stability, technical loses, power stability, customer confidence in service, organic demand growth per customer, operational environmental footprint, CO2 & NOX reduction, operation financial margin, cost reduction, technical loss reduction, collection efficiency, operation loss reduction, cash flow improvement, renew growth, profit growth, flexibility index and many others.

Implementation Phase for Diesel Reduction strategy and smart grid Introduction in Sumba Island was the upcoming flexibility solution for distribution grid improvement in Sumba Island since high grid losses and fuel consumption dominated the operational system, which disrupt the power quality and reliability of electricity sources to the customers.

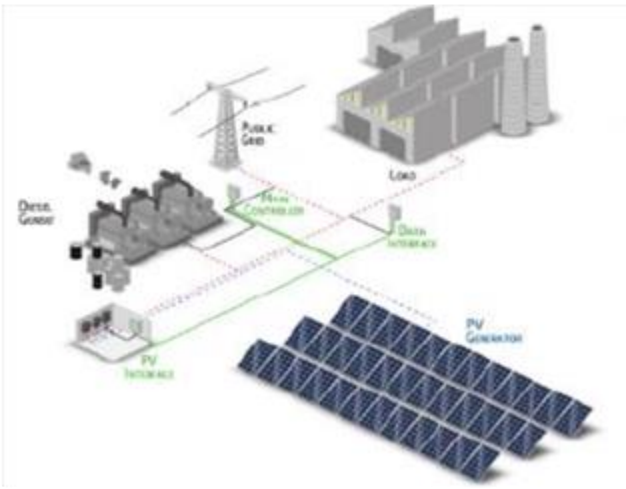

Fig.6 Pilot project outline for Diesel Reduction and PV integration

The development for smart grid can be executed by implementing the following systematic method as mentioned:

1. Grid analysis, by doing the simulation study and modeling of the power system in existing Sumba grid that combined with the proposed generations, would be obtained the load flow analysis and the other electric output parameters.
2. Sizing and design of diesel buffering engine/engines, would be required to estimate the appropriate diesel capacity that are feasible to integrate with VRE. Hence, diesel sizing also compulsory to determine the ramping rate in the system
3. All diesel should be equipped with ECU/Modbus controls, and operated in stepped dispatching procedure
4. Sizing Solar PV up to 60% of diesel, one way to implement the high level penetration by integrating the PV share which is higher than diesel generation. This can be combined by applying the Automatic dispatch system (ADS), as the hybrid controller unit that has function to control the flexible operation mode between PV and diesel. Subsequently, the ADS will match the synchronization between generation sources and the load demand.
5. Data acquisition units in all grid key nodes, data acquisition as the controlling and monitoring unit can be applied to assist the communication and remote surveillance to ensure the smooth operation in the system.

V. OUTPUT RESULTS

The main issue in the distribution grid before ADS installation was the difficulty to maintain frequency stability in East Grid when the intermittency condition occurred as the result of fluctuation of output operation from the PV due to the PV soothing and solar irradiance changing.

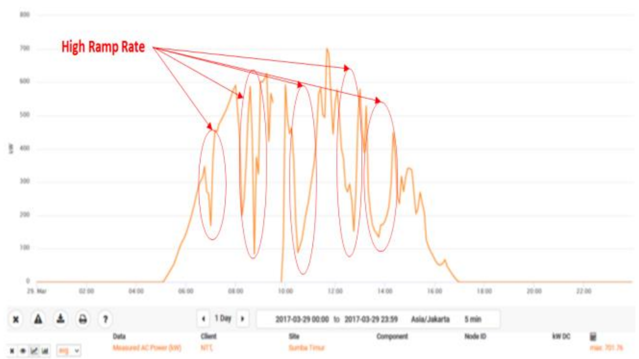

Fig.7 Typical electricity production of the Solar PV 1 MWp in East Sumba during cloud events.

The High Ramping Rate triggered to the sudden changing of power frequency, which can impact the power quality and stability in distribution grids.

There are preexisting condition before ADS integrated in the system, such as manual dispatching and wider range of grid frequency operation, constant power spillage by overpowering the grid, high thermal losses and high power leaking to neutral, high instability of the grid during operation hours of PV, and Black out/feeder disconnection due to under frequency.

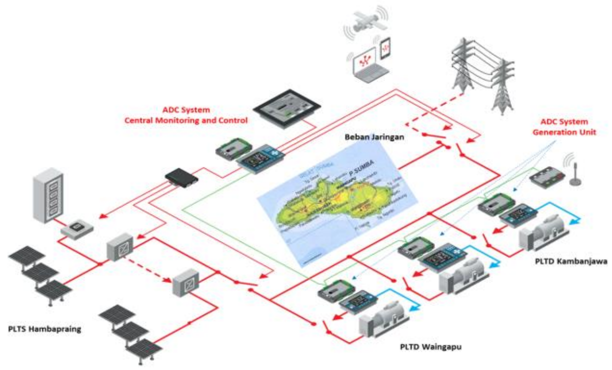

Fig. 8 The proposed of ADS configuration system

ADS system is able to control the complex mini grid operation that consist of PV and diesel generation, which is possible to integrate between many renewable energy sources with diesel generation by maintaining stable power quality with high efficiency and security level.

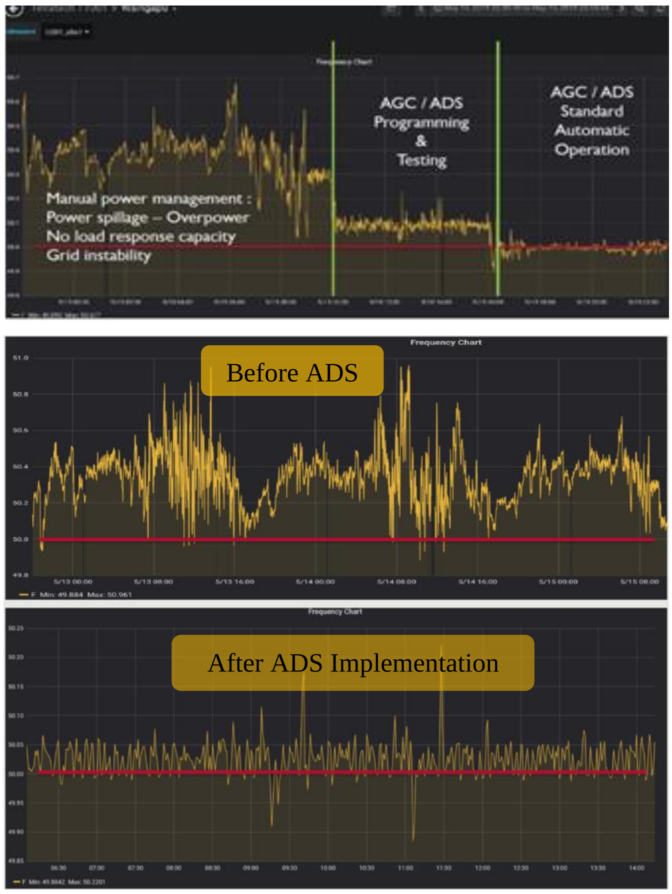

Fig.9 Typical electricity production of the Solar PV 1 MWp

From the graph displayed in figure 9 above described that ADS has primary roles to maintain the frequency stability in its nominal ranges by adjusting mechanical power in the power generations. Yet, ADS utilization offers flexible operation since main devices (power generations cover PV, diesel, micro hydro, and so forth) can be modified as needed, as well as modifying its control algorithms in a good manner. Subsequently, the outcome emerges after ADS Installation which referring to the data diagram obtained that frequency system fluctuation is better adjusted within the nominal required range compared with the previous condition. This proved that ADS is capable to minimize the losses in the distribution grids in its certain value standards, as well as maintain the system frequency in its required nominal range.

VI. Solutions

1. The ADS implementation is possible to raise smart grid's operational performance, in order to provide reliability and quality power to their consumers, while minimizing the operation cost, which can be achieved by embracing the ADS installation as the first step to improve the power quality, as well as to minimize losses in the distribution grid.

2. The development urgency of ADS in Sumba considers high generation cost, flexibility of system operation, and the potency of power factor correction. On other hand, ADS has proven capable of maintaining frequency stability in the system that contains intermittent power generation.

3. Gaining insights of ADS as the support system, this deployment in the system offers benefit to maintain the stability of level voltages and power within its optimal settings, and prevent the grid operations from abnormalities, such as over frequency, phase imbalance and frequency hunting.

4. ADS implementation and grid monitoring system can be considered as the main part in integrating variable renewable energy into power network, not only to compensate the fluctuations characteristics of VRE, but also to maintain grid stability in the system network.

Acknowledgment

The author would like to express the gratitude to the joint working team between PLN and USAID ICED team who have great effort to develop and configure ADS implementation project in Sumba Island. Within the period 2018-2019, this obtained full support by the grant project from US Government. Thus, this smart grid project would be typical of pilot project in the future in deploying reliability and sustainability of renewable energy in the power network since this can be potential solution to shift dieselization program into clean energy environment.

References

[1] L. Grigoriev. A. Kostogryzov, A. Tupysev: ” Automated dispatch control; problems and details of modeling,. 7th IFAC Conference on Manufacturing Modelling, Management, and Control International Federation of Automatic Control, June, 2013, Russia, pp. 2-3

[2] USAID - ICED II Team: 'The Summary of Grid Improvement in Kupang and Sumba ', May 2018, pp. 1–21

[3] USAID - ICED II Team: “Development of Automatic Dispatch Controller System and Grid Monitoring for East Sumba Grid ', May 2019, pp. 1–46

[4] B. Justin, H. Adams, and Kaiser Jim, “Power Generation Automatic Dispatch System for Energy Trading, pp.7, April 2015. Users Conferences 2015”