PLC Application as an Automatic Transfer Switch for on-grid PV System; Case Study Jakabaring Solar Power Plant Palembang

by Achmad Kurniawan

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PLC Application as an Automatic Transfer Switch for on-grid PV System; Case Study Jakabaring Solar Power Plant Palembang

Achmad Kurniawan[1], Ahmad Taqwa[1] and Yohandri Bow[1]

[1]Applied Master Renewable Energy Study Program, Politeknik Negeri Sriwijaya, Jl. Srijaya Negara, Palembang, Indonesia, 30139 E-mail: a_kurniawan123@yahoo.com

Abstract. Programmable Logic Control (PLC) is an industrial computer specially designed to control the manufacturing process, such as robotics, assembly line, power plant, etc. PLC control program analyzes the input signal to decide the output state according to what has been pre-programmed by the user. This paper discussed the application of PLC as an ATS for on-grid PV system at PLTS Jakabaring which is the biggest PV power plant in Palembang. Therefore, it is interesting to discuss the application of PLC as an ATS in controlling which electric power source used to power Jakabaring Sports City to ensure there is no power outage during Asian Games 2018. The data is taken from July 24-27, 2018 before the event, however, the loads needed to power are more-less the same. The application of PLC as an ATS at PLTS Jakabaring is to automate the switching proses of exporting and importing electrical energy. The energy production data is also compared with the weather forecast to show the effect of sunny days on energy production. Data results show the application of PLC as an ATS for PV system; the ATS hold an essential role for the system due to the system independence of solar irradiance.

1. Introduction

Programmable Logic Control (PLC) is an industrial computer specially designed to control the manufacturing process, such as robotics, assembly line, power plant, etc. PLC control program analyzes the input signal to decide the output state according to what has been pre-programmed by the user. The programming language that is often used in PLCs is Relay Ladder Logic (RLL) [1]. PLC is widely used in industry, and one of the applications is as an ATS (automatic transfer switch). ATS switches connections between several electrical power sources automatically [2–4]. It moves one power source to another power source alternately according to program commands. ATS is the development of COS (Change Over System). The difference between ATS and COS lies in the working system. ATS is controlled or operated automatically without using human power, while COS is controlled manually.

Several types of ATS are distinguished according to the required power capacity or based on Phases and Flow through the panel within the same working principle. The basic of ATS design is to use mathematical logic reasoning with a series of tools such as relays, timers, contactors, and MCB, like switches or breakers. The utilization of ATS panels is distinguished by the electrical power required/consumed. The higher the consumption of electrical energy, the higher the component specifications, especially the breaker and contactor and the size of the cable to be used [5].

ATS is used to control the transfer of power from the main source (utility power) to the backup source (generator) using a machine controller and relay switches that are placed in one electrical panel [2–4]. ATS systems are excellent domestic application and are cheaper and easier to install than conventional switches [6]. The main thing in Automatic Transfer Switch is to produce power with a low-cost relay. ATS disconnects utility and generator through circuit breakers that provide fast protection and provides a form of electrical interlock. This is a crucial feature when seeking compliance standards. ATS does not have to be able to continuously feed the power back from the generator to the utility. Therefore it also functions to prevents unnecessary backfeeding [2].

Photovoltaic (PV) is a semiconductor device that can change irradiance from the sun into electricity [7–12]. If the solar cell receives a beam of light, the output terminals produce DC current; therefore it is sometimes called DC power plants [7,8,13–18]. On-grid PV systems have the advantage of utilizing the power delivered more effectively. However, the technical requirements of the power system network side and PV system side must be synchronized to ensure PV security and utility network reliability [19]. Clarifying technical requirements for grid-interconnection and how to solve the problems arose by the connection is a significant issue for on-grid PV system [8-9].

This paper discussed the application of PLC as an ATS for on-grid PV system. The data is taken and analyzed from a PV System in Jakabaring Palembang, Indonesia that is intended to power Jakabaring sports city, where the Asian Games 2018 is held. PLTS Jakabaring (Jakabaring Solar Power Plant) is the biggest PV power plant in Palembang. Therefore it is interesting to discuss the application of PLC as an ATS in controlling which electric power source used to power Jakabaring Sports City to ensure there is no power outage during Asian Games 2018. The data were taken before the event; however, the loads needed to power are more-less the same.

2. SCADA and PLC Design and Layout

Figure 1 shows Jakabaring Solar Power Plant which consist of 5,248 PV panels installed in 2.5-hectare area, 2 x 250 kW inverter and 2,280 KVA transformator synchronized to medium voltage distribution 20 kV belong to State Electricity Company through New Jakabaring Substation. Jakabaring Sports City has an abundance of solar irradiance due to its position, and there is no shading nearby.

Figure 1. Birds eye view of Jakabaring Solar Power Plant Palembang.

PLC as an ATS in this study is to switch electric power source from Jakabaring Solar Power Plant to PLN (State Electricity Company). If interference occurs or the generated power is not enough to supply Jakabaring Sports City, the ATS will automatically switch to PLN. The main supply of PLN

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and the main supply of PLTS will work in an interlock, meaning that if the main source is on then, the reserved supply cannot supply the load. ATS is typically multi-pole switches. Thus, an automatic transfer switch used with a three phase, four wire system will always include three poles for switching the three phase conductors of the load between the three phase conductors of the regular power source and the three phase conductors of the emergency power source. The fourth, neutral conductor of the load is often permanently connected to the neutral conductors of the normal and emergency sources [20, 22].

Figure 2 shows the layout design of PLC as an ATS in Jakabaring Solar Power Plant. The PC that is used serves to remotely monitor which must be connected to the internet network and has been synchronized with the PLC using a LAN (Ethernet) cable. Remote monitoring is used as a device that can be controlled by sending control information and receiving information status from equipment connected to the network [10, 20]. PC in figure 1 is the SCADA (Supervisory Control and Data Acquisition) as a control system interface for PLC. The operator interfaces enable monitoring the process commands such as set point changes. However, the networked modules that connect to the field sensors and actuators are performed by a controller.

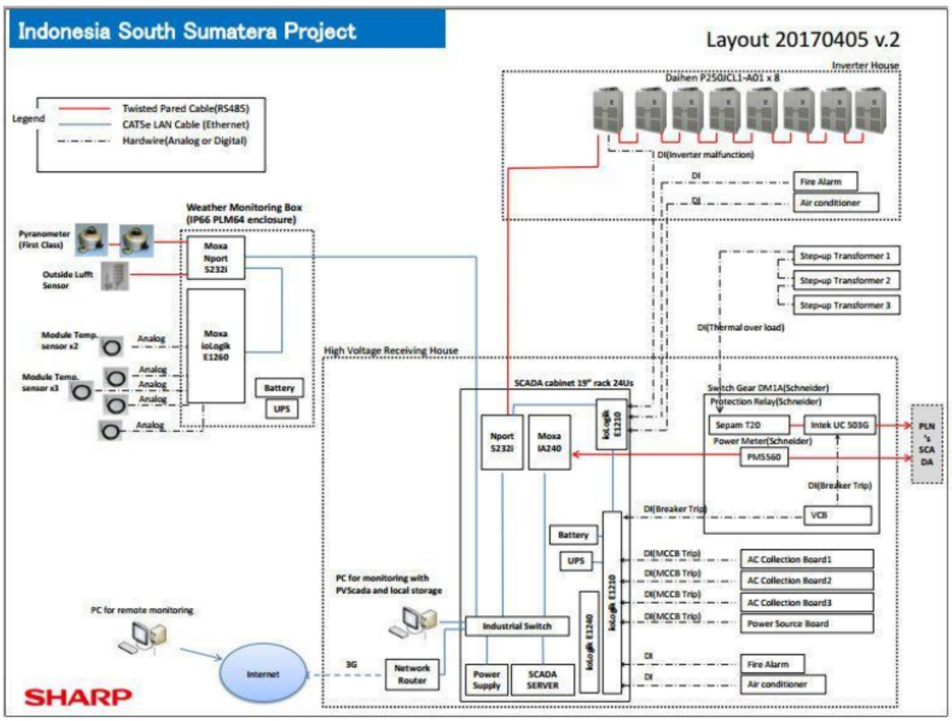

Figure 2. Layout design PLC at Jakabaring Solar Power Plant Palembang

SCADA connects to remote I/O to collect the data from Inverter and current PV from the combiner box and also included is the alarm of surge detection in the box. It is the interface to 5 Remote I/O equipment system which supports 32 Analog inputs and 32 Digital inputs and performs as a Data logging and control system to collect all data from Inverter, Meter, Temperature Sensor, WIND sensor and pyranometer and the current of Solar combiner box.

The controller sends all data to the server via GPRS modem and stores all of the data into memory. In case the network GPRS is down, the controller will store the backup data and will send the backup data to the server whenever the network is recovered. The user can use an internet browser to monitor all the meters and status of the equipment which include Historical, Real-time data, Graph, and alarm logging. The client software can connect to the web browser to log in to the system and see the SCADA real-time status, Alarm, Event, Power consumption, Communication efficiency, Inverter status, Electricity production, DC and AC voltage, and current logging and Trend graph, etc.

Weather monitoring is used to monitor the weather around the solar panel. The purpose of using this sensor to observe the daily weather since PV system production depends on the amount of irradiance that is received by the panels. Weather monitoring consists of various components, namely:

- Pyranometer is a sensor used to measure solar irradiance on a PV panel surface and solar radiation in flux density W/m2.
- Outside Lufft Sensor, is a sensor used to measure temperature, humidity, air pressure, wind speed and direction, solar direction, brightness, and global radiation dusk. This sensor is connected through the RS485 interface serial.
- Temperature module consists of a series of temperature sensors.

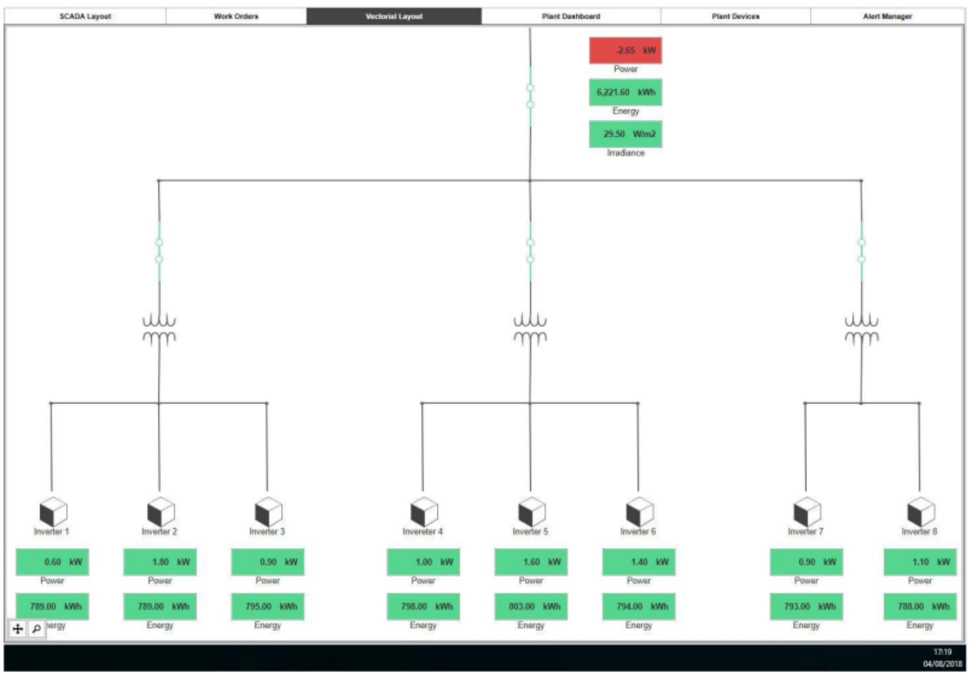

Figure 3. Layout PLC switch for an on-grid position at Jakabaring Solar Power Plant Palembang

Figure 3 shows the layout of PLC switch for on-grid position at Jakabaring Solar Power Pant Palembang. 8 inverters is connected to 3 transformators. Inverters are used to change the DC voltage produced by PV panels to AC voltage to power the loads, Jakabaring Sports City. The step-down transformators are used to step down the energy to be distributed by medium voltage distribution 20 kV through Jakabaring Substation.

3. Result and Discussion

The main disadvantage of a PV power plant is that it depends on the supply of solar irradiance over the PV panels; therefore the weather condition affects the production. Due to this condition, the PLC role is significant to ensure that all the loads are powered continuously without power outage not even a dim.

PLC and power production data at Jakabaring Solar Power Plant was taken from July 24-27, 2018 for 4 days, to show how much energy produced (energy active and reactive) by Jakabaring Solar Power Plant. The data shows the PLC activities as an ATS to export and import energy according to power generated and needed to supply the loads. Exported energy is the energy supply by Jakabaring Solar Power Plant to the loads around Jakabaring Sports City, and imported energy is the energy supply by PLN when Jakabaring Solar Power Plant cannot produce enough power due to cloudy days or during the night.

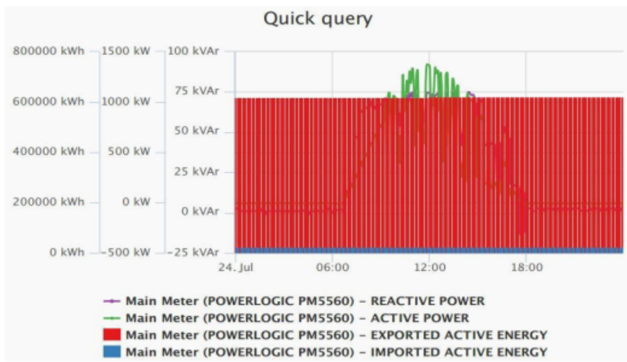

Figure 4. PV panels energy produced by Jakabaring Solar Power Plant on July 24, 2018.

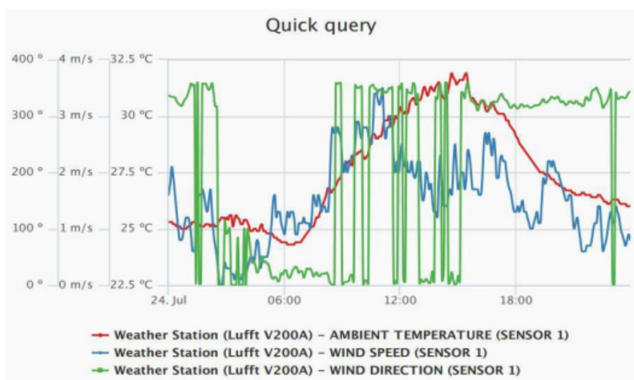

Figure 5. Weather station report at Jakabaring Solar Power Plant on July 24, 2018.

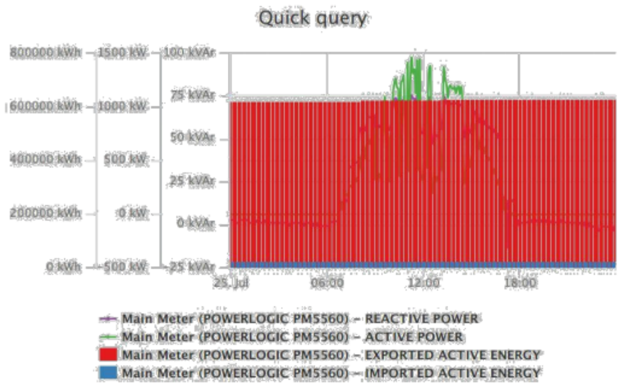

Figure 6. PV panels energy produced by Jakabaring Solar Power Plant on July 25, 2018.

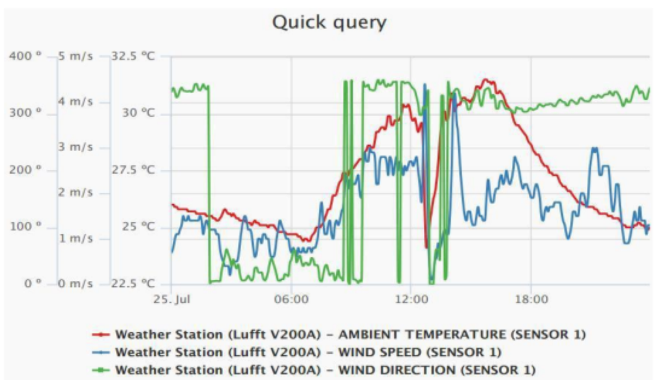

Figure 7. Weather station report at Jakabaring Solar Power Plant July 25, 2018.

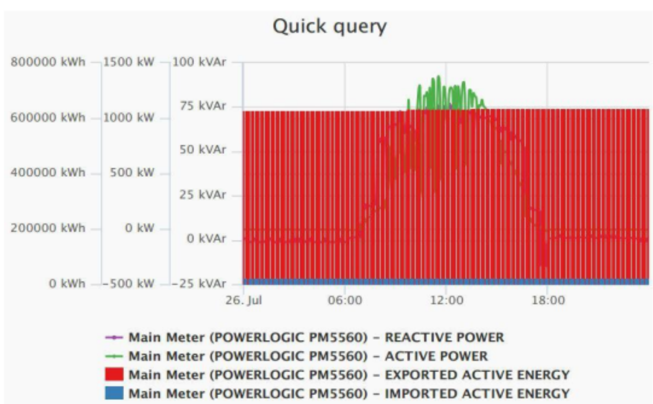

Figure 8. PV panels energy produced by Jakabaring Solar Power Plant on July 26, 2018.

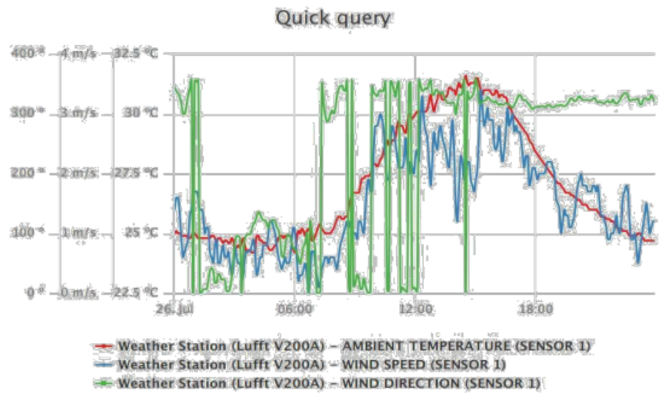

Figure 9. Weather station report at Jakabaring Solar Power Plant on July 26, 2018.

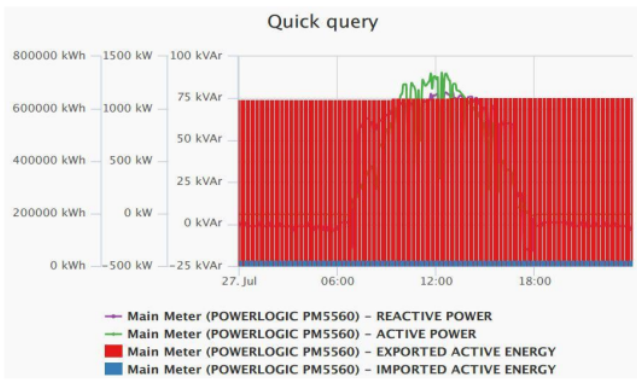

Figure 10. PV panels energy produced by Jakabaring Solar Power Plant on July 27, 2018.

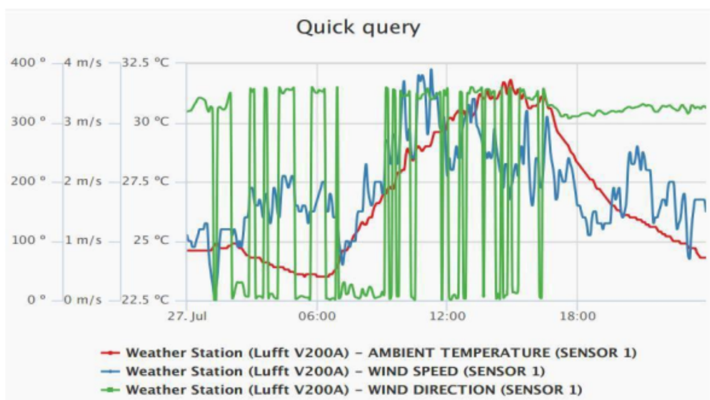

Figure 11. Weather station report at Jakabaring Solar Power Plant on July 27, 2018.

Figures 4, 6, 8, and 10 show the energy produced by Jakabaring Solar Power Plant from July 24-27, 2018. The purple lines show the reactive power and the green line shows the active power. Reactive power does not have a physical significance. However, it is an essential factor in the conception and operation of AC electric network and measured in a unit of VAR (Volt-Ampere-Reactive). Active energy is the real energy received by the customers, measured in the unit of Watt. Active energy is converted from reactive energy by multiplying it with power factor or known as . defines the efficiency of the electrical network. Ideally, should be 1, meaning the active energy is in the same phase with reactive power and the system is very efficient.

and the blue bars indicate how much power imported from PLN. Electricity will be exported when the Jakabaring Solar Power Plant produces enough energy to supply the loads and imported when it cannot provide enough. The process of exporting and importing energy is conducted by PLC automatically with SCADA as the user interface.

Figure 5, 7, 9, and 11 shows the weather at Jakabaring Solar Power Plant on July 24-27, 2018. When comparing figure 4, 6, 8, and 10, and figure 5, 7, 9, and 11, it can be seen that Jakabaring Solar Power Plant electric power production relies on the weather, as the climates are sunny, the output is up, and more energy to be exported. This paper only discusses the relation between the temperature of the day (shown by temperature sensor data) and energy produces, since temperature is the primary factor that affects the system.

Data results show the application of PLC as an ATS for a PV system, and the ATS hold an important role for the system due to the system independence of solar irradiance. Without the application of ATS, the possibility of power outage due to weather condition that can change dramatically during the day.

4. Conclusion

Jakabaring Solar Power Plant is an on-grid PV system connected to PLN. The application of PLC as an ATS at Jakabaring Solar Power Plant is to automate the switching proses of exporting and importing electrical energy to ensure no power outage in Jakabaring Sports City during Asian Games 2018. The data is taken before the event, however, the load needed to power are more-less the same. PLC and power production data at Jakabaring Solar Power Plant was taken from July 24-27, 2018 for 4 days, to show how much energy produced (energy active and reactive) by Jakabaring Solar Power Plant. The energy production data is also compared with the weather station report to show the effect of sunny days on energy production. Data results show the application of PLC as an ATS for a PV system, and the ATS hold an important role for the system due to the system independence of solar irradiance. Without the application of ATS, the possibility of power outage due to weather condition that can change dramatically during the day.

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