Construction of Komekurayama Solar Farm

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Abstract

For the joint business project by Yamanashi Prefecture and Tokyo Electric Power Company, a 10 MW solar farm (Komekurayama Solar Farm) was constructed in Komekurayama located in Shimo-mukoyama-cho, Kofu City, Yamanashi Prefecture Japan.

About 80,000 solar modules are spread all over the site area of approximately 12.5ha. The estimated annual power yield amounts to approximately 12GWh which corresponds to the power usage level of about 3400 households. The estimated reduction of CO_2 emission is about 5100 tons annually that compares with the amount of emission from about 1000 households.

We received an order on an EPC (Engineering, Procurement and Construction) basis. Construction work was started in October 2010 and completed in January 2012.

1 Preface

In order to reduce the emissions of greenhouse gases with respect to global warming, there is a high expectation for the increased use of renewable energy resources. As such, Photovoltaic (PV) generation systems are rapidly spreading from small-scale residential power to large-scale solar farms. The large-scale solar projects are mostly promoted by electric power utilities. The Act on Special Measures Concerning Procurement of Renewable Electric Energy by Operators of Electric Utilities came into effect in August 2011 and the Feed-in Tariff System was put into operation in July 2012. As an energy resource which will contribute in realizing a low-carbon society, it is expected that solar power will be actively developed and promoted in Japan.

This paper introduces the construction work for the Komekurayama Mega Solar Farm for which we are an EPC (Engineering, Procurement and Construction) contractor. This project is partly undertaken by a power utility company.

2 Introduction of the Construction Site

2.1 Climate

Kofu City, Yamanashi Prefecture is known for many hours of sunlight, ranked as top class in Japan. The lowest temperatures reported are the next lowest to those of northern area (Hokkaido and Tohoku) in Japan.

The longer the duration of sunlight, the more power is generated. It is noted that the PV module performance is better when the temperature is low as the lower temperature yields more power. This particular site is ideal for a solar farm.

2.2 Geographical Site Conditions

Komekurayama is located on the south side of the Kofu Basin Valley and the site is located on the southern slope of a small mountain. The site was already developed by Yamanashi Prefecture and there are twelve small and large flat zones which are distributed in different tiers.

2.3 Design Notes

Since the solar modules installation zone is located at the top of the mountain, such a place is subject to wind. We therefore analyzed the rate of increased wind speeds by considering the project site terrain and cell modules installation layout plan. According to the analytical results, the basic design of the supporting structures for solar modules at the wind load base accommodates for the specific site conditions.

3 Outline of Electrical Facility Configuration

3.1 Overall System Configuration

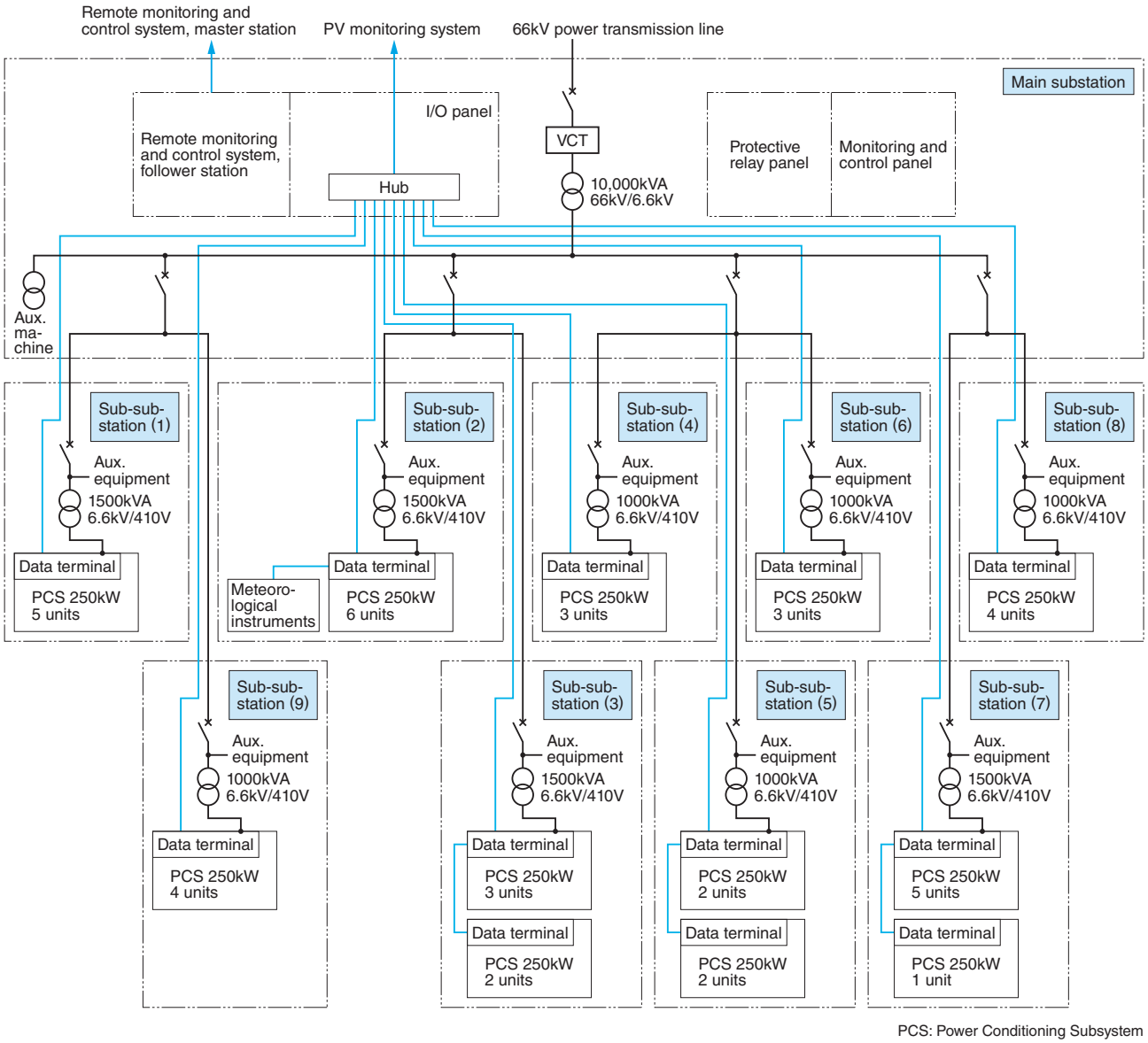
Fig. 1 shows a configuration outline of the Komekurayama Solar Farm. In most solar farms, solar modules are concentrated in a vast area however, on this solar farm, the installation zone is separated into 12 zones and the solar modules are laid out according to each zone. Each zone comes with a sub-substation and the generated power is transmitted through overhead distribution lines on the premises and gathered at the main substation. The power is then fed into the grid.

3.2 Solar Modules

The solar modules employ a Copper Indium Selenide (CIS) type polycrystalline thin-film for 87.5W and 155W per module, respectively. The adequate number of modules is distributed in proportion to the area of each zone. The total number of modules is 32,202 (87.5W) and 46,340 (155W). The features of the CIS type cell module are as follows:

(1) Outstanding spectrum-response characteristics help to absorb a wider range of wavelength components compared with crystal silicon type solar cell module.

(2) In the case of the CIS type, shadows are less likely to impact all over the modules because of unique characteristic of cell connection compared with that of the crystal silicon type.



PCS: Power Conditioning Subsystem

Fig. 1 Outlined Facility Configuration

Configuration of facilities installed on the premises of the power station is shown.

3.3 PV Inverters

Forty units of Meiden PV inverters (SP300-250) are employed. As shown in Fig. 2, each inverter is accommodated in an enclosed casing. Since the area of the each zone is different from one other, each package is designed to accommodate the required number of inverters according to the output capacity of the solar modules. Table 1 shows the outline of the inverter's specifications. For system interconnection within the solar farm, a transformerless system is adopted in order to avoid the use of any insulation transformer inside the inverter casing. We are then able to realize a very high conversion efficiency of 96.4%.

According to commands from a PV monitoring system, it is possible to restrict power output and to generate reactive power for power network stabilization.

Fig. 2 PV Inverters

Inverters are accommodated in the enclosed casing specified for outdoor use. According to the project site area of each division zone, there are multiple types of casings where 1 to 6 inverters are accommodated.

Table 1 Outline of Specifications for SP300-250

Outline of specifications of SP300-250 type PV inverters are shown below.

Item		Rating and performance	Remarks
Type		SP300-250/410/50	Transformerless
Circuiting system		Self-excited voltage type PWM inverter	
Type of rating		100% continuous	
Rated capacity		250kW	
No. of phases		3-phase 3-wire	
DC input	Rated voltage	400V	
	Max. permissible voltage	600V	
	Rated operating voltage	250～550V	Max. power follow-up operation
	Reduced-rating operating voltage	225～250V, 550～600V	
AC output	Rated voltage	410V	
	Permissible voltage deviation range	Rated voltage ±10%	Continuous operation
	Rated frequency	50Hz	
	Permissible frequency deviation range	Rated frequency ±3%	Continuous operation
	Output power factor	0.99 lagging or above	For rated operation
	Output current distortion	Total 5% Max., each order 3% Max.	
Power conditioning efficiency		96.4% or above	JIS C 8961

3.4 Substation Facilities

Figs. 3 and 4 show the sub-substation and the main substation, respectively. The inverter outputs are collected at the sub-substation and then the voltage is stepped up to 6.6kV. The generated electric power is transmitted through overhead lines inside the solar farm and collected at the main substation. The system voltage is increased to 66kV by the main transformer and the power is fed to the 66kV power network system of the Tokyo Electric Power Company, Incorporated.

(1) Sub-substation

The sub-substation is composed of a step-up transformer (oil-immersed, natural air-cooled type) to raise the voltage up to the distribution voltage. The other is an outdoor cubicle casing enclosing a circuit-breaker, a local transformer, and protective

Fig. 3 Sub-Substation

For local power distribution in the substation, the PV inverter output voltage is increased from 410V to 6.6kV. The substation transformer has two types of capacities, 1500kVA and 1000kVA, to be chosen according to the site area.

Fig. 4 Main Substation

At the main substation, output voltage from the solar farm is increased from 6.6kV to 66kV for interconnection with the grid. The photo shows the 66kV power receiving facilities and the 66kV/6.6kV main transformer, the feeder panels for local power distribution, and the monitoring casing containing incoming power protective relay units, monitoring and control panels, and remote monitoring and control system.

Fig. 5 Screenshot of the PV Monitoring System

At the PV monitoring system, it is possible to monitor the overall operating conditions in the solar farm. It is also possible to start and stop inverters and set up the scheduled operation.

relays. According to the area size, two sizes of transformers (1500kVA and 1000kVA) are used.

(2) Main Substation

The 66kV main substation facilities are equipped with the super-clad, conduit-coupling type gas-insulated switchgear, a 10,000kVA step-up main transformer (oil-immersed, natural air-cooled type), and a gas-insulated VCT and EVT.

3.5 Monitoring and Control System

The monitoring and control system for the solar farm comes with the following two units:

(1) Remote monitoring and control system

(2) PV monitoring system

3.5.1 Remote Monitoring and Control System

The remote monitoring and control system performs the monitoring of the ON-OFF operation of the circuit-breaker and the assessing of the status of equipment in the main substation. This system also monitors (in batch mode) the status of equipment in the downstream side form the intermediate substation, as well as various telemetry data values at the grid-connection point with the power station. It is managed from the monitoring system of the Tokyo Electric Power Company, Incorporated

3.5.2 PV Monitoring System

The PV monitoring system performs the monitoring of the ON-OFF operation of the circuit-breaker in each sub-substation and the assessing of the status of equipment in each sub-substation. It also controls run and stop of each PV inverter and monitors the status of the PV inverter. It displays various telemetry values. Fig. 5 shows an example of the screen of the PV monitoring system.

For the automatic control functions of the solar farm, the following two functions are available:

(1) Output limiter function

According to the demand and supply conditions in the grid, power output from PV generation may be restricted in some cases. In such a case, by using the output limiter function, it is possible to restrict the inverter output below the specified level. When a calendar feature is used, the output limit values can be registered for the predetermined days such as the Golden Week (a series of holidays in May), New Year's Holiday, and other national holidays.

(2) Grid stabilization function

While the status of grid system voltage and frequency is monitored, this function is used to compute the active and reactive power required to maintain the power quality in a favorable state and transmit commands to each inverter. In regard to the PV monitoring system of this solar farm, the grid stabilization function offers the features as described below.

(a) Voltage stabilization function

If the voltage at the grid connecting point of the solar farm is found to be beyond the preset dead band, this function is used to compute the necessary reactive power to control such variation.

(b) Constant power factor operation

A voltage rise is caused when electric power from PV generation flows into the grid. In order to

restrain this voltage rise, this function is used to compute the necessary reactive power in proportion to the amount of active power output.

(c) Frequency control function

If the monitored grid frequency is found to be beyond the preset dead band, the output limit value described in (1) above is controlled in the direction for controlling the frequency variation.

4 Postscript

This paper described the features of the Komekurayama Solar Farm that started its commercial operation in January 2012.

According to the Act on Special Measures Concerning Procurement of Renewable Electric Energy by Operators of Electric Utilities which is coming into effect, many solar farm constructions are under planning stages throughout Japan. We are confident that our experiences and expertise we acquired through the construction of the Komekurayama Solar Farm will help us in other solar farm constructions and will contribute to realizing a low-carbon society.

We would like to express our sincere thanks and gratitude to all of those who offered invaluable suggestions and provided steadfast cooperation during the construction of this solar farm.