Sihwa Microgrid with Renewable Energy Management System and Relay Coordination

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Abstract

The power transmission of microgrid with renewable energy source is generally distinguished with stand-alone type and grid connected type. This work introduces the EMS (Energy Management System) to maximize the generating revenue and to minimize the receiving cost by using and sending the power efficiently in the grid connected microgrid. In addition, the frequent overcurrent relay operation of wind power plant in the renewable energy source is analyzed and the solution for this problem is applied. Then, it brings to the stable power production, which will be proposed as a reference of the protection system of micro-grid wind power generation.

Introduction

Renewable energy sources such as wind and solar have a feature that the output is varied by natural phenomena. Therefore, the government induces the power business through a variety of policy, so if power producer combines the wind power and the ESS (Energy Storage System) to reduce the peak load, then some portion of generation fee is supported by the program. In this work, the EMS (Energy Management System) is developed to manage the sending and receiving energy through ESS properly and to achieve the minimum receiving cost and maximum generating revenue. Figure 1 shows the site that the system is installed in Lake Sihwa, South Korea..

Fig. 1. Site of Sihwa microgrid system.

In addition, it is essential to make the power production stable to apply this system successfully in microgrid, In the case of wind power, the generator is frequently tripped by the operation of the overcurrent relay. So based on the analysis of phenomenon, it finds out the solution to establish the microgrid successfully, which will be applied as a standard of the protection system of wind power generation.

Control of EMS

Figure 2 shows the system configuration of micro-grid that is installed near Sihwa tidal power plants. The rating of each equipment is shown in Table 1.

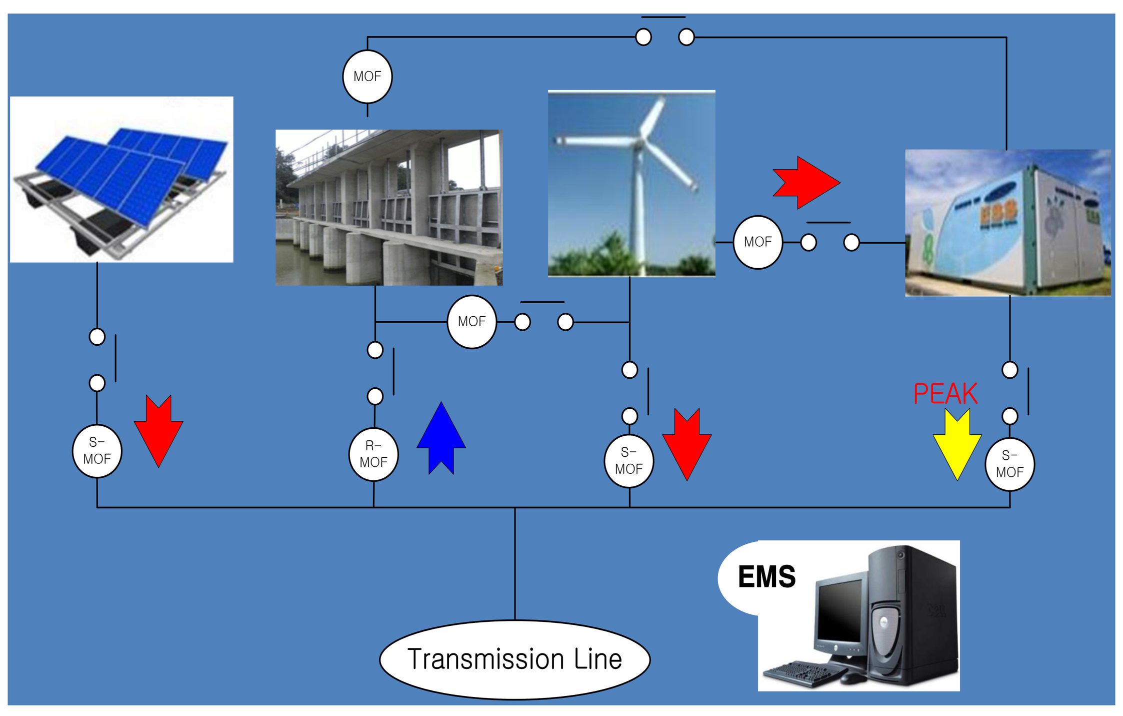

Fig. 2. System configuration of Sihwa microgrid.

Table 1. Rating of equipment

Division	Wind	Solar	ESS	Load
Capacity	1,500kW×2units	10kW×1unit	100kW/200kWh	120kW
Condition	Operation	Operation	Under Construction	Operation

Consideration for EMS

● Reduce the peak value of load

- 95% of the load is floodgates to operate for 30 minutes, 2 times/day, and it can be estimated because they are floodgates used to ensure the head of the tidal power plant as the difference of the tidal ebb and flow.

● Preferentially discharge of ESS during the peak time

- If ESS discharges during the peak time (3~4h) as shown in Table 2, it can be compensated 5.5 times weighted of generating rate in 2015.

Table 2 The weight of the REC with ESS

Division	Usual	Peak time(3~4h)		
		2015	2016	2017
Wind + ESS	1.0	5.5	5.0	4.5

● Compare SMP price with the load power rate during the time other than peak time

- If the SMP price is higher than the load power price, all power are only sent the utility, otherwise they are used on the service load.

● Charge and discharge schedule that utilizes weather information

- The charge and discharge schedule of ESS should be planned after considering the weather information to charge as much as possible before the peak time.

OCR Coordination

There are some difficulties for the control of microgrid EMS due to the frequent operation of the overcurrent relay at the wind power generator. So the problems and solutions for this phenomenon are considered in detail, which will be proposed as the protection standard of overcurrent relay in the wind power generator [1][2].

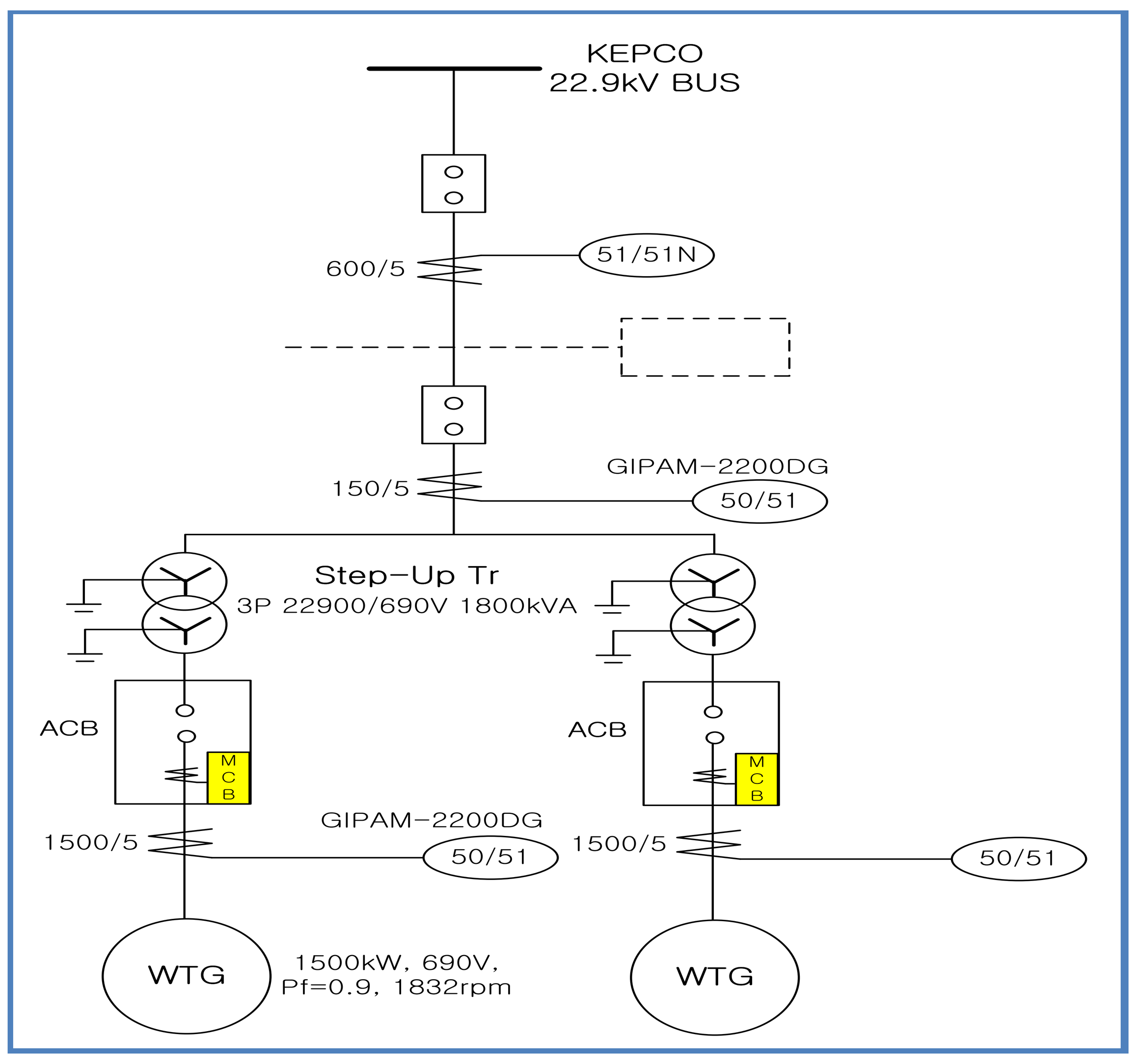

Fig. 3. Single line diagram WT.

● Configuration of overcurrent relay
  - GIPAM2200-DG for transformer
  - GIPAM2200-DG and MCB for generator
  - GIPAM2200-DG for generator operated only.

● Operation history of overcurrent relay
  - 39times/unit (19 Oct. 2011 ~ 29 Dec. 2013)
  - Operating points are shown in Fig. 4.

● Analysis of overcurrent relay operation
  - A, B, C phases operated simultaneously.
  - Time delay element operated only.
  - Other relays didn't operate.
  - In operation, the wind speed was higher than the reference.

● Cause of overcurrent relay operation
  - Relays might operate as the increase of input energy due to the sudden raise of wind speed
  - Blade angle couldn't adjusted quickly, so it is recommended to keep a time to adjust the blade angle at a blast.

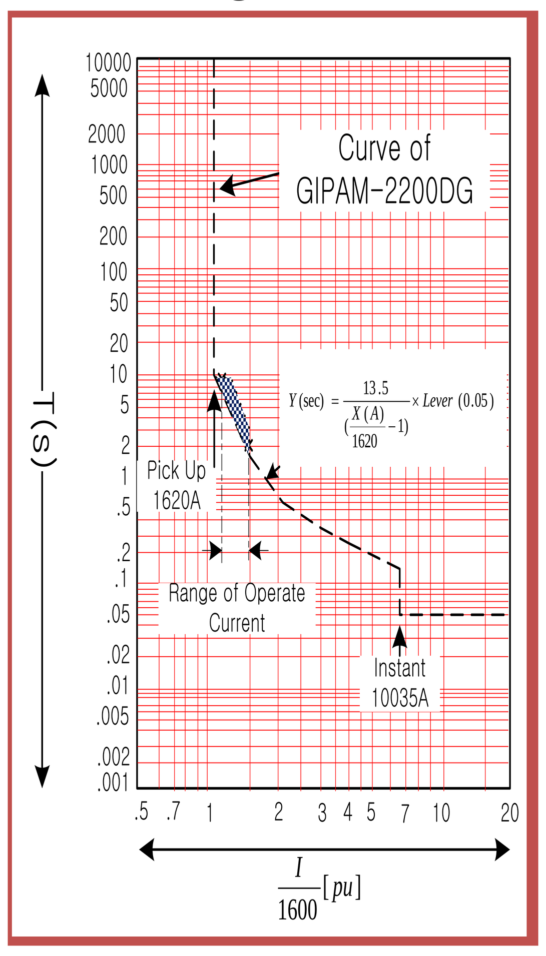

Fig. 4. Operating points

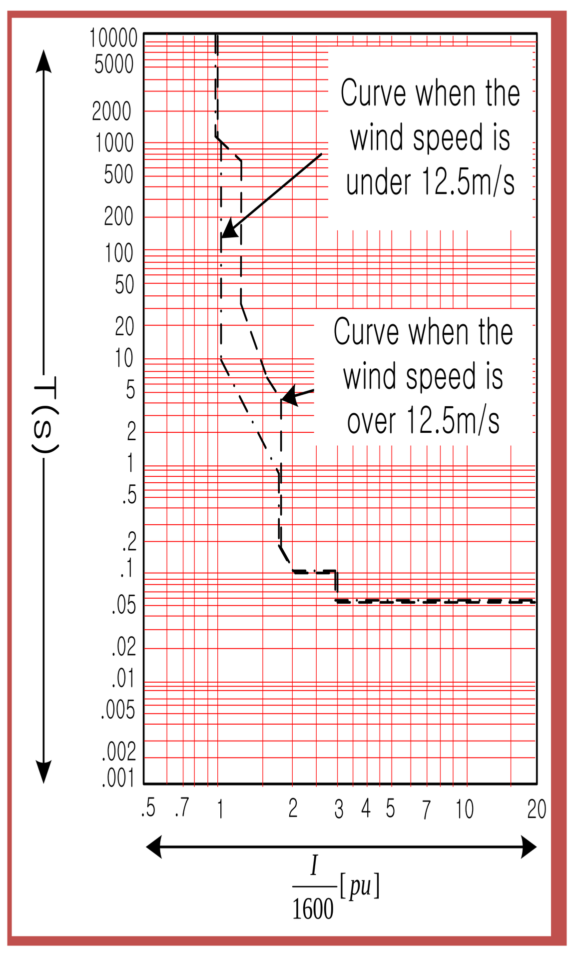

Fig. 5. Re-coordination graph

Three treatments to prevent the operation of over current relay at a blast of wind.

● Power factor

Generally, power factor isn't considered in case of renewable power source because the current doesn't increase abruptly without faults, but it should be considered in wind power system due to the blast.

● Lever

The present time delay curve is EI (Extremely Inverse), but it is necessary to change it to close VI (Very Inverse) by changing lever from 0.05 to 0.15. Because it needs time to adjust the blade angle without operating of the over current relay at momentary gust.

● Coordination curve according to wind speed

For protection in case of any accident under the reference wind speed, the curve is re-coordinated by two as the higher or lower wind speed than that of reference as shown in Fig. 5.

Conclusion

● Increased revenue as the government policy to encourage the linkage of wind power and ESS

● Maximize the generating revenue with reduced receiving cost through EMS within microgrid

● Stable power transmission through re-coordination of wind generator in microgrid.

● Investment of microgrid with wind power and ESS can be activated through this case study.

Acknowledgement

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References

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[2] Slavomir Seman, Jouko Niiranen, and Antero Arkkio, "Ride-through analysis of doubly fed induction wind-power generator under unsymmetrical network disturbance," *IEEE Trans. on Power System*, vol. 21, no. 4, pp. 1782-1789, 2006.