Resilient networked microgrid systems: A Gifu model case in Yaotsu, Gifu

Hiroshi Asano
Gifu Renewable Energy System Research Center
Institute for Advanced Study, Gifu University
Tokai National Higher Education and Research System
1-1, Yanagido, Gifu 501-1193, JAPAN

Hirotaka Takano
Faculty of Engineering, Gifu University
Tokai National Higher Education and Research System
1-1, Yanagido, Gifu 501-1193, JAPAN

Abstract

Energy resilience is becoming an increasing point of focus for utilities, policymakers, regulators, and community leaders. As options are explored to help the grid withstand disruptions caused by natural disasters, microgrids are a popular emerging solution to mitigate the consequences of outages. Microgrids are electricity distribution systems containing loads and Distributed Energy Resources(DERs) such as distributed generators, storage devices , and controllable loads that can be operated in a controlled, coordinated way either where connected to the main grid or while islanded. From FY 2012, all renewable energy power except for large-scale hydro power is purchased by the electric power companies and retailers supplied to consumers under the Feed-in Tariff(FIT) Law in Japan. Installed solar photovoltaics (PV) generation capacity in Japan has increased rapidly from less 10 GW in 2012 to around 62 GW in 2019.

As more variable renewable energy power resources such as solar PV and wind turbines (WT) are being introduced into power systems, uncertainties in demand-side and supply-side increases drastically due to variable generation; PV and WT, depends on weather conditions. FIT-certificated PV systems have been waiting for interconnection due to transmission constraints at many areas in Japan. Microgrids contribute to the aggregated utilization of DERs to support more integration of variable renewable generation such as solar PV generation. As clusters of multiple smart communities expand, the microgrids leveraging renewable energy will make efficient energy management available. A microgrid with storage battery is one of promising solutions to relax the T&D constraints for further interconnection of renewable generation.

Conventional microgrid has a single point of coupling with the main grid. Since the early 2000s, extensive research and development has been in progress to figure out efficient solutions for microgrid operations. Furthermore, demonstrative field tests for microgrids have been actively promoted. Networked microgrid is a virtual microgrid covers DER at multiple sites and coordinated such as a single controlled entity, networked with local distribution system. There are two operating modes; independent operation of a microgrid and cooperative operation of multiple

microgrids. Our case is two microgrids in two local communities, Yaotsu (central district of the town)and Kutami(remote community), mountainous and electrically vulnerable remote area due to terminal feeder from power grid. We had identified important loads in emergency for a disaster prevention center (town hall) and public evacuation centers, mostly schools. We had a research grant on a feasibility study of local microgrid construction in FY2020 from Ministry of Economy, Trade and Industry(METI), Japan. This project focus on networked microgrids for emergency. We assume three-day power supply infrastructure in the microgrids, 100% PV + battery system without fossil fuel generators. We efficiently make a stable and profitable schedule of microgrids with PV and storage battery.

The operation scheduling problem of the microgrid is to determine start-up/shut-down timing and output share of generators, charging/discharging of storage battery system and amount of electricity trade with the main grid for each time slot during a certain period. The objective of this operation schedule is to minimize an operation cost and cost of storage battery. We conducted simulation study, using actual load data in normal operation and assume important loads in emergency. Coordinated operation of two microgrids may reduce optimal capacity of battery system approximately one sixth from 1.17MWh to 203 kWh. Our simulation study proves 100% renewables disaster prevention center in this town where solar PV penetrate richly. We had proved a Gifu model case in Yaotsu successfully and plan to develop design of this local microgrid from FY2021.

This work is supported in part by Gifu Renewable Energy System Research Center, Gifu University.