November-December 2019
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Operation Algorithm of DC-based Power Sharing Micro Grid for Industrial Complex

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Abstract

Background/Objectives: MG is divided into grid independent and grid connected, and there are various customers depending on the method. In the case of grid-independent type, it is applied to the situation where it is difficult to supply electricity directly from the power plant centering on the island area, and the goal is to supply stable power even if the production cost is high. In the case of grid-connected type, the goal is to reduce the amount of electricity by lowering peak power consumption or basic power consumption, mainly for high power consumers.

Methods/Statistical analysis: In this paper, we propose a DC grid microgrid (MG) that can be applied to industrial complexes and aim to reduce energy and electricity bills through power supply using DC grid. The ESS consisted of different types of batteries (Li-ion, LiFePO4) and analyzed the power loss and voltage drop through DC distribution. In addition, the optimum battery is proposed by analyzing the temperature characteristics according to the charging and discharging at this time.

Findings: A method of controlling DC ship prospects using renewable energy is introduced and applied to agricultural industrial complexes. The proposed algorithm proved that PV and ESS are installed in the plant, DC distribution system with 5 factories is constructed, and can operate efficiently according to the algorithm. The ESS batteries in the verification locations use different types of batteries and verify that the DC distribution is good by analyzing the efficiency of the DC distribution in terms of temperature characteristics and renewable energy.

Improvements/Applications: In this paper, we analyze the actual data derived from algorithms and power transactions designed by constructing real microgrids and aim to reduce energy and electricity bills.

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November-December 2019
ISSN: 0193-4120 Page No. 422 - 428

1. Introduction

As climate change due to excessive use of fossil fuels increases, the demand for environmentally friendly power is also increasing, and the increasing demand for renewable energy has a great impact on the stability of the power system. In this environment, microgrids are emerging as alternatives for stable power supply, energy efficiency, and system availability. Microgrid refers to the next-generation power grid separated from the existing power system and composed of several distributed power sources (DG) including renewable energy generation sources [1-3].

The MicroGrid (MG) concept has been proposed for the efficient and flexible use of distributed energy resources. According to the US Department of Energy (DOE) and the Electric Power Research Institute (EPRI), MG is a group of interconnected load and distributed energy resources, which can be connected or disconnected to the grid to operate in grid-independent, grid-connected or "island" mode. have. In this way, a more flexible and stable energy system is provided. Integrating and controlling various types of distributed energy sources and generators (DGs) such as renewable energy, storage systems and CHP improves the efficiency of the system.

Micro Grid (MG) is the most promising new structure in the power grid. MG includes distributed systems and storage devices (flywheels, power capacitors and batteries) and flexible loads of low voltage distributed energy resources (DER) (micro turbines, fuel cells, PV, etc.). These systems can operate standalone when disconnected from the public grid or in interconnection mode via a DC or AC grid. In a broader context, placing the DC power grid as part of an AC / DC hybrid system or as a standalone DC microgrid (DC MG) that can operate independently of the public power grid improves the reliability and safety of the system. The MGs can be interconnected to form a supply block capable of supplying much larger power to meet the needs of the power consumer. In the case of interconnected MGs, each central controller (CC) must coordinate closely with the neighboring CC to exercise control. Thus, the interconnected MG will allow greater stability and control capability with a distributed control structure. In addition, redundancy will be greater to ensure better supply reliability. DC MG has less loss and can distribute 1.41 times more power than the equivalent configuration of AC MG (AC microgrid) for the same wire cross section. . The most important advantage of DC MG compared to AC MG is the easy control of the power flow direction. Therefore, power control can be performed through current control. [8-11]

In this paper, we introduce the control method of DC ship prospect using renewable energy and apply it to agricultural industrial complex. The proposed algorithm proved that PV and ESS are installed in the plant, DC distribution system with 5 factories is constructed, and can operate efficiently according to the algorithm. The ESS batteries in the validated locations use different types of batteries and verify that the DC distribution is good by analyzing the efficiency of the DC distribution in terms of temperature characteristics and renewable energy.

2. Proposed MG structure

Micro Grid is conducting various demonstration projects for technology development and commercialization mainly in the US, Japan and Europe. In Korea, we are expanding to our own power islands, smart campuses and military bases. Industrial complex microgrids are the best demonstration place for microgrid operation with different power consumption patterns in different plants.

November-December 2019
ISSN: 0193-4120 Page No. 422 - 428

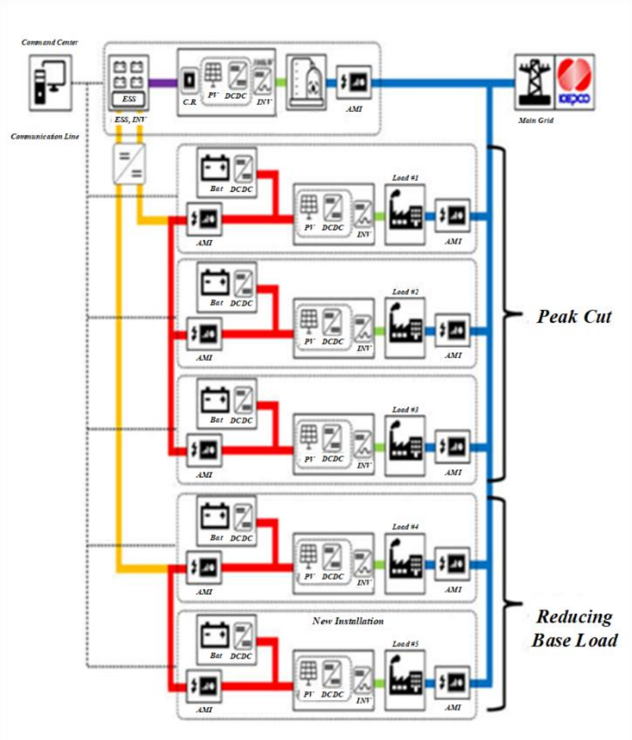


Figure.1 Proposed MG structure

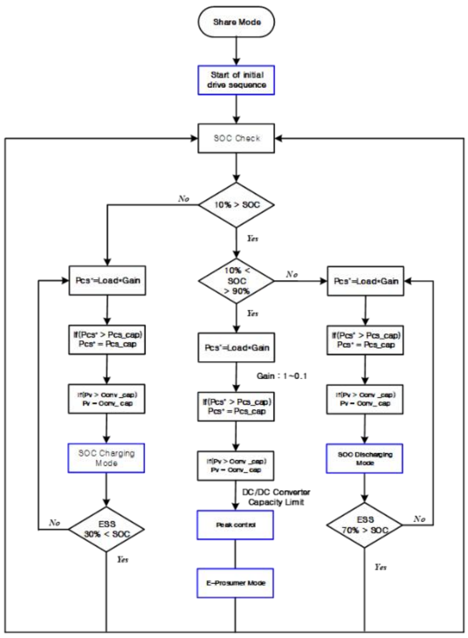


Figure.2 Operation Algorithm

In this paper, a pilot project was pursued with the aim of stable power network operation and power saving. Microgrids are connected to the AC network to perform transactions virtually. In addition, it was confirmed that stable operation is possible through direct trading through DC distribution. At this point, DC distribution power loss and battery temperature characteristics were analyzed. The control algorithm consists of the control block of the main ESS and the control block of each plant as shown in the block diagram and is driven by the stabilization of the main ESS. The load of each plant applies Load × Gain to supply power in proportion to the load and maintains DC divider voltage 830 [Vdc] through the Main ESS. Figure 1 is a schematic diagram of the actual MG system. The photovoltaic power source was used as a renewable energy source, and the lithium ion battery (Li-ion) and lithium iron phosphate battery (LiFePO4) were used for the ESS battery.

Figure 2 shows the operation algorithm of the linked operation mode. The energy pattern analysis based on the main ESS is possible. Based on the SoC of the battery of each plant, it performs the supply or demand operation when the power support request occurs according to the SoC situation of another plant during the operation under the same condition as the standalone mode. . Since the energy of each plant is shared and used in connection with MG's DC Grid, the standard SoC should consider SoC of Main ESS and SoC of each plant. Therefore, active energy sharing is performed according to the sharing request. It is based on AM 9:00 ~ PM 6:00 operation by scheduling according to time zone, and started with additional operation or peak time zone operation depending on SoC remaining. In order to prevent the output of PCS from being sent back to the grid or the output fluctuation increases due to excessive load fluctuation, the PCS limit was set or canceled in parallel to start the load. The output of is given a reference by multiplying the gain value according to the load, but the rated output is applied during operation in response to the peak time and DR request.

The target sites were tested at a total of four sites. According to the initial driving sequence, DC Grid 830Vdc was

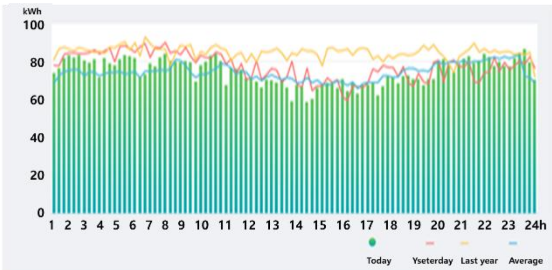
November-December 2019
ISSN: 0193-4120 Page No. 422 - 428

generated at the wastewater treatment plant, which is the main ESS, and the zero current control was performed according to the inverter operation. Maneuver After confirming SoC of ESS applied to wastewater treatment plant according to algorithm, check SoC of each plant ESS. After the stabilization of the main wastewater treatment plant, each plant's power converter reflects the operating characteristics according to the SoC status in the plant after generating the setpoint, but does not limit the PV or the capacity of the DC / DC converter and then generates the setpoint by the load. Operate within the rated range of. When the minimum SoC reaches the minimum value (10%), it checks the charge level of the SoC of the main ESS and performs the charging mode.When the maximum value (90%) is reached, the SoC performs the discharge mode after checking the charge amount of the SoC of the main ESS. do. The set values returning to the normal operation state are minimum 30% and maximum 70%, respectively, and the operation mode operates based on the ESS SoC in each factory. Electricity trading can be carried out if electricity supply and demand is required at each plant.

Factory 1

Factory 2

Factory 3



Factory 4

Figure 3. Power consumption at each plant

Linked mode is designed as an algorithm to perform power sharing while maximizing SoC's power generation and supply power. SoC was set at 10 ~ 90% to improve energy utilization, and by intermittently starting PV and PCS in each section, the amount of power generation and load supply was high, reducing wasted energy. In addition, the load reduction rate of each plant achieved more than 10%, and the energy sharing through the DC / DC converter exceeded 50%.

Table 1: Initial Set of features used for the experimentation

division	Saving ratio(%)	Savings(kWh)
Factory 1	47.76	53.78
Factory 2	37.76	74.47
Factory 3	22.65	10.66
Factory 4	22.59	15.15

TEST Engineering & Management
November-December 2019
ISSN: 0193-4120 Page No. 422 - 428

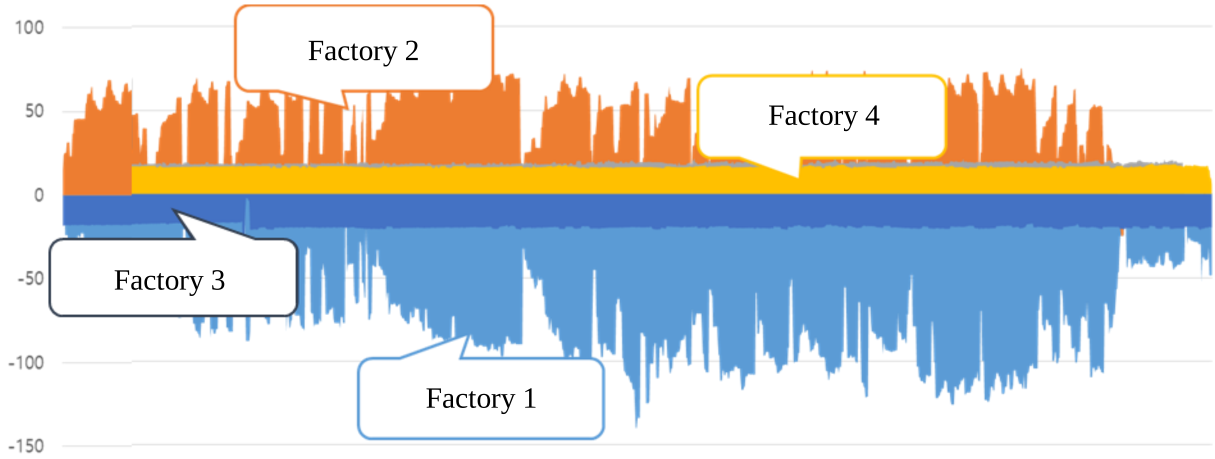


Figure 4. Energy Sharing of each factory

Figure 4 shows the energy share of each plant over time. The positive value of 0 is the amount of power sharing, and the negative value is the amount of power sharing. According to the algorithm on the EMS, power sharing occurs, and the amount of power savings and the saving ratio based on one hour are shown in Table 1 above.

3. Experimental results

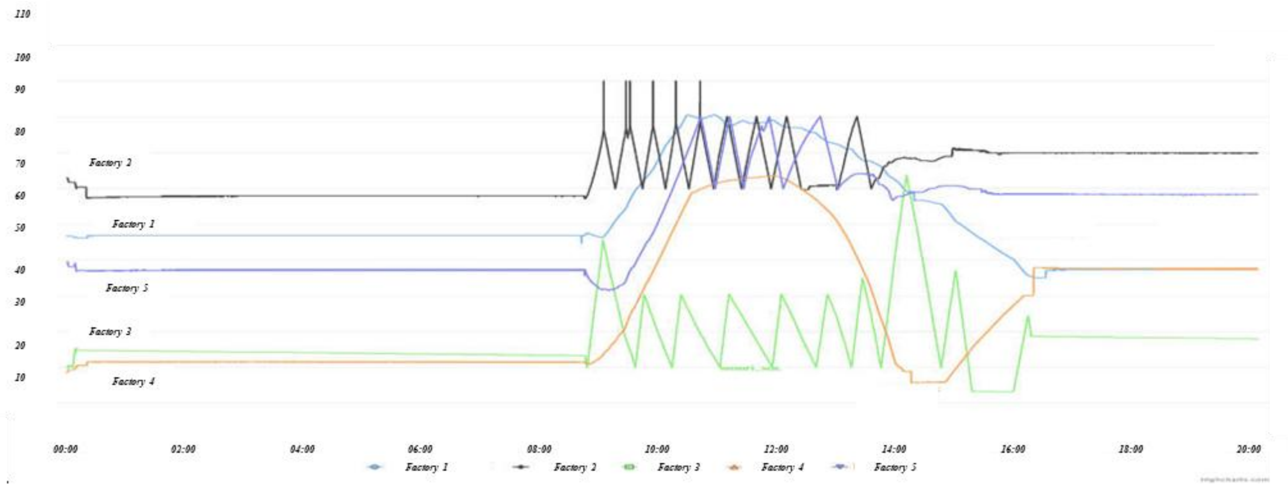


Figure 5. Characteristic of SoC

The figure 5 waveform shows that the ESS of each plant including Main ESS is stable to charge anddischarge in the range of 10 ~ 90[%] while the error due to BMS reset occurs due to state of charge(SoC)operation characteristics according to the control algorithm.

The following figure 6 ~ 11 waveforms represent the power analysis for the short-range and long-range of thedemonstration site and express the DC distribution loss and the loss of the power converter at this time.As the power increases, the voltage decreases and the current increases accordingly, so it should be taken into account when calculating the capacity.

November-December 2019
ISSN: 0193-4120 Page No. 422 - 428

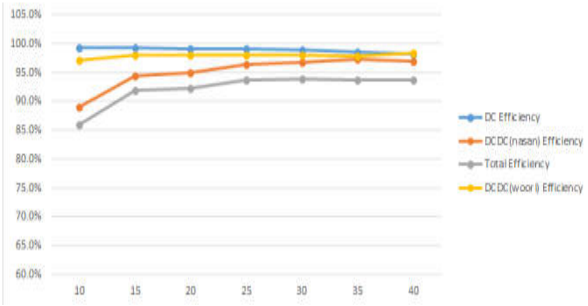


Figure.6 Configure DC Grid

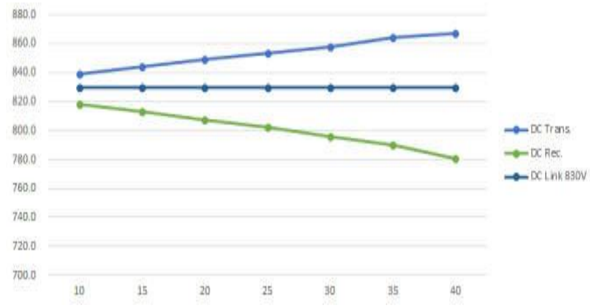


Figure.7 Fluctuation of DC Grid voltage

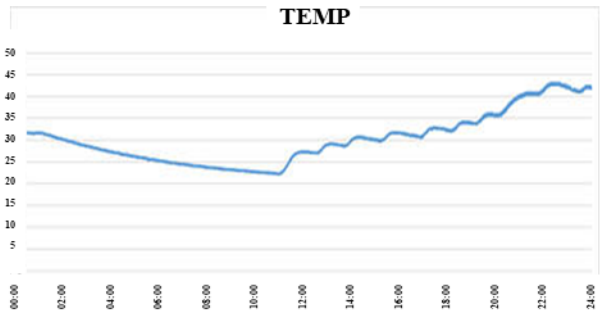


Figure.8 Characteristic of temperature(LiFePO4)

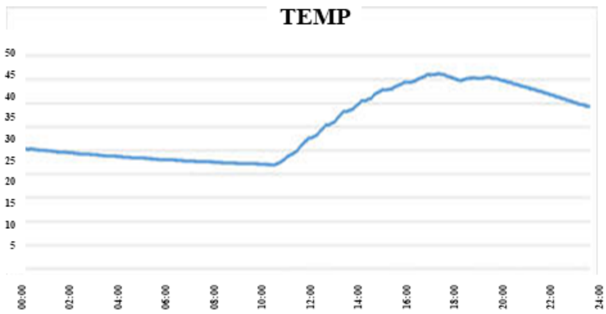


Figure.9 Characteristic of temperature(Li-ion)

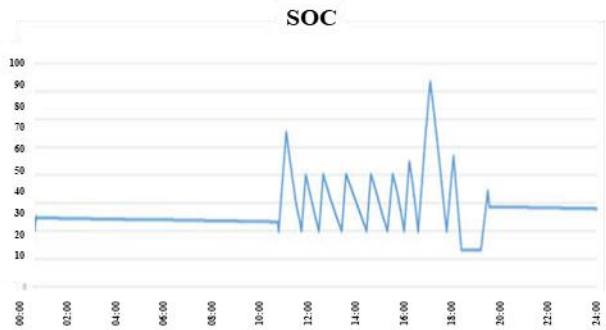


Figure.10 SoC(LiFePO4)

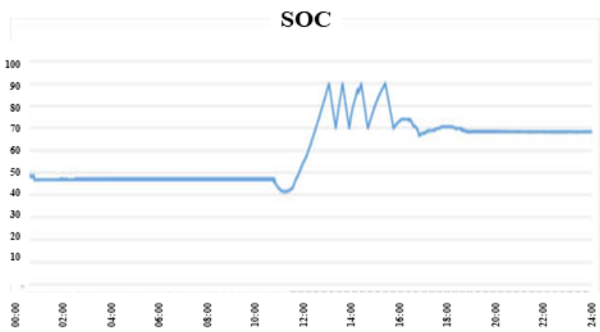


Figure.11 SoC(Li-ion)

4.Conclusion

In this paper, we applied the power reduction algorithm at each factory to verify that power can be reduced while SoC is stably maintained. The temperature characteristics of Li-ion and LiFePO4 were analyzed. Unlike the general method of charging and discharging of long period, it is confirmed that LiFePO4 is superior in temperature characteristics to MG which performs frequent charging and discharging while operating ESS in a wide operating range. Also, the voltage drop was analyzed through the efficiency analysis of the DC network and the current allowable capacity at that time was calculated. It is verified that the current allowable capacity should be increased by 5% under the condition of voltage drop ± 50 [Vdc] compared to the ideal condition at power transmission and power receiving end.

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