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An Examination on the Independent Micro-Grid Operation Algorithm for DC based Industrial Complex

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Abstract

Background/Objectives: In recent years, as the distributed power supply increases, stand-alone microgrids, which are easily connected to renewable energy, have attracted attention. The stand-alone micro grid is a grid that is formed separately by connecting distributed power sources independent of the existing grid. Unlike the distributed resources associated with the existing grid, the power grid is formed through the DC network, which is different from the existing AC grid in terms of basic grid configuration and operation algorithms.

Methods/Statistical analysis: The proposed stand - alone micro - grid operation algorithm is applicable to each site of micro grid constructed in industrial complex. It is an operation algorithm for self - consumption without consideration of power transactions between microgrid configuration sites. Through this, operation characteristics without considering linkage with DC grid were analyzed. In addition, the efficiency is verified by comparing with the existing algorithm.

Findings: In this paper, we apply the algorithms for self - consumption and peak reduction in each factory that construct micro grid and compared them with the existing algorithms. In order to cope with the existing algorithms, the range of SOC was used 20% and the charge / discharge operation was improved to control the SOC charging / discharging waveform to be gentle. In addition, it has been proved that ESS can be used stably under similar conditions while supplying the same power as the existing one by raising the energy efficiency.

Improvements/Applications: In this paper, the self-consumption algorithm of the existing DC microgrid construction site is presented, and the energy saving amount is increased by about 15% by presenting the optimized algorithm than the existing algorithm, and the charge / discharge stability of the ESS is increased and the rapid charge / discharge Prevented.

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I. Introduction

As climate change, such as global warming due to continuous fossil fuel use, is intensifying, the demand for electricity is also changing rapidly. The rapidly changing demand causes difficulties in stable operation of the electricity system. In this environment, microgrid have emerged as alternatives for stable power supply and energy efficiency. [1] Microgrid refers to the next generation power grid separated from the existing power system, which is a unidirectional vertical structure, and composed of several distributed power sources including renewable energy sources. [2-4] It is sensitive to the power output, the output is not constant, the operator can not control the output of the generator as desired.And the initial investment cost is high, but the use of environmentally friendly energy source helps to reduce the carbon and the resources are infinite. As a result, active research and demonstration are being conducted at home and abroad. [5-8]

However, if the renewable energy source is operated in conjunction with the grid, harmonics are generated due to unstable output fluctuations and uncontrollability of the renewable energy source, and the overall power quality of the system is lowered. There is this. Stand-alone microgrids have been proposed as a power system operation method that compensates for the shortcomings of grid-connected microgrids [9, 10].

Stand-alone microgrids are independent grids that supply power with their own distributed power sources, separated from the grid, and consist of several distributed power sources, including renewable energy sources such as solar and wind power and diesel generators. In the case of photovoltaic power generation, which is currently used as a major power source in most standalone microgrids, power generation is affected by the weather, and thus power generation itself is impossible in bad weather. Therefore, it is difficult to cover the load only by solar light, and by introducing an energy storage device (ESS), it is possible to compensate for the unstable output fluctuation of the renewable power generation source and at the same time to cover the load in the standalone microgrid with the renewable power generation source. [11]

These stand-alone microgrids are attracting attention in the industry in order to increase the grid capacity of distributed power supplies, increase the reliability of power grids and secure economic efficiency. In general, one of the main reasons for building grid-connected micro-grids is to sell electricity to the power market. However, in industrial sites with high power consumption, the self-consumption is larger than the power generation, so it is mainly operated independently for its own consumption and peak reduction. For this reason, self-consumption and peak reduction algorithms were designed by constructing a standalone microgrid and comparing it with two self-consumption algorithms. In addition, we built a standalone microgrid system for a real industrial complex and applied two self-consumption algorithms to prove each algorithm, and verified the efficiency by comparing and analyzing the two algorithms.

II. ESS optimal operation algorithm

Battery characteristics

The charging characteristics and charging speed of the battery are expressed as C-rate, which means that 1C can charge and discharge the same amount of power as the battery capacity for 1 hour. As can be seen in Figure 1, the charging characteristics of the battery are shown by the change of voltage with time for each current. The constant current test method is a constant current test method that shows a change in voltage over time by applying a constant current, through which it is possible to estimate the voltage characteristics and residual SOC due to the charge and discharge of the battery.

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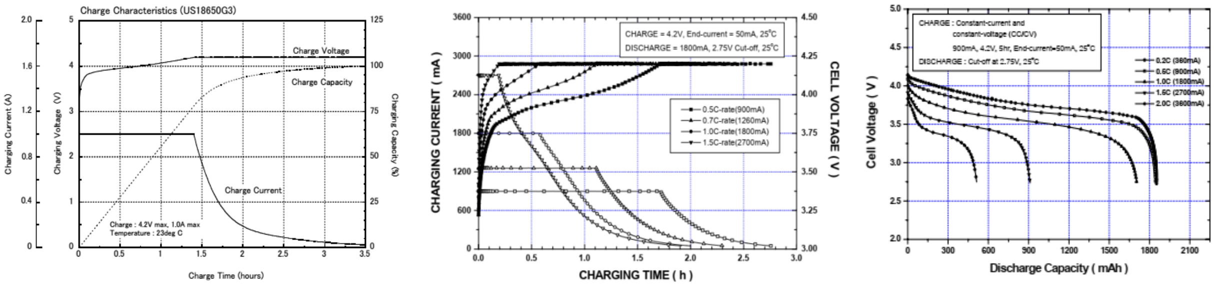

Figure 1. Charging / discharging characteristic curve of lithium ion battery

Operational Characteristics by Algorithm

Figure 2 shows the basic structure of the proposed microgrid configuration site. Each power converter is connected through a DC grid with a DC link voltage of 830V. The DC-DC converter maintains the DC Grid voltage according to PV generation and SOC and controls the ESS in the charge / discharge mode, and the PCS outputs power according to the load of the factory.

In Figure 1, DC V is DC grid voltage, Freq is PCS (inverter) frequency, DC V of DCDC master is DC grid voltage, DC P is output power of DC / DC converter. DC V of PV is solar input voltage, DC P Total (Gen P) represents solar power, DC OUT V represents battery voltage, AC Power represents inverter output power, and Load AC Active Power represents load usage.

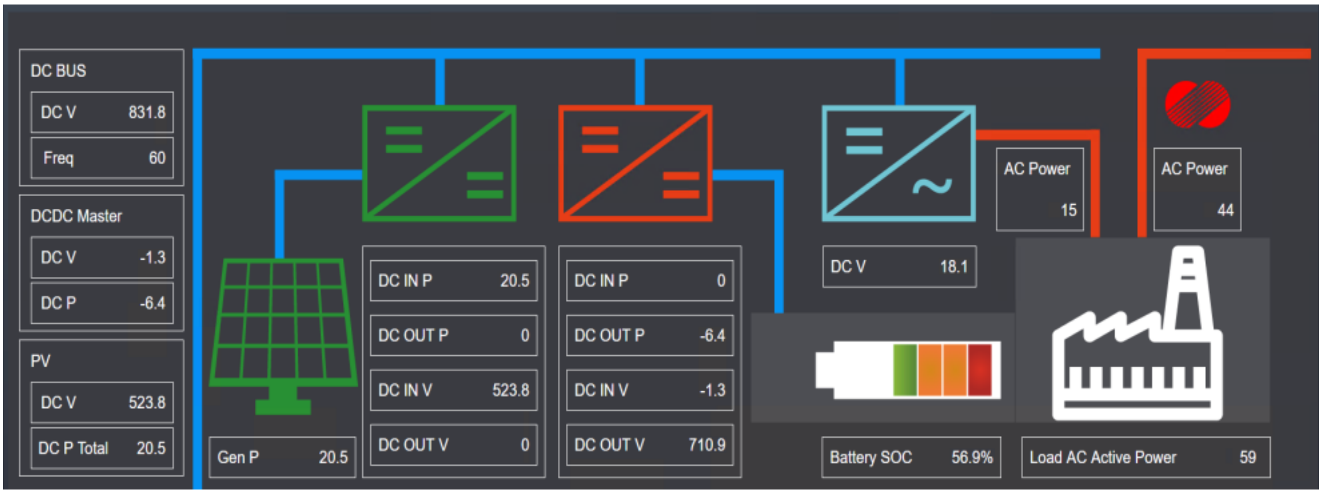

Figure 2. Configuration of factory MG system

Application algorithm (1)

The applied algorithm (1) is shown in Figure 3 below, and is operated independently of the microgrid network, so that the standard SoC is operated based on the SoC value of the ESS installed in each factory. In addition, based on the time zone scheduling, it was started based on the operation of AM 9:00 ~ PM 6:00 and additional operation or peak time zone operation was performed depending on the SoC remaining amount. The output value of the PCS is controlled by multiplying the gain value according to the load variation value.The generation amount and SoC are high for the load used, so that the output of the PCS is not returned to the grid or the output variation range is increased due to excessive load variation. The PCS output was limited.

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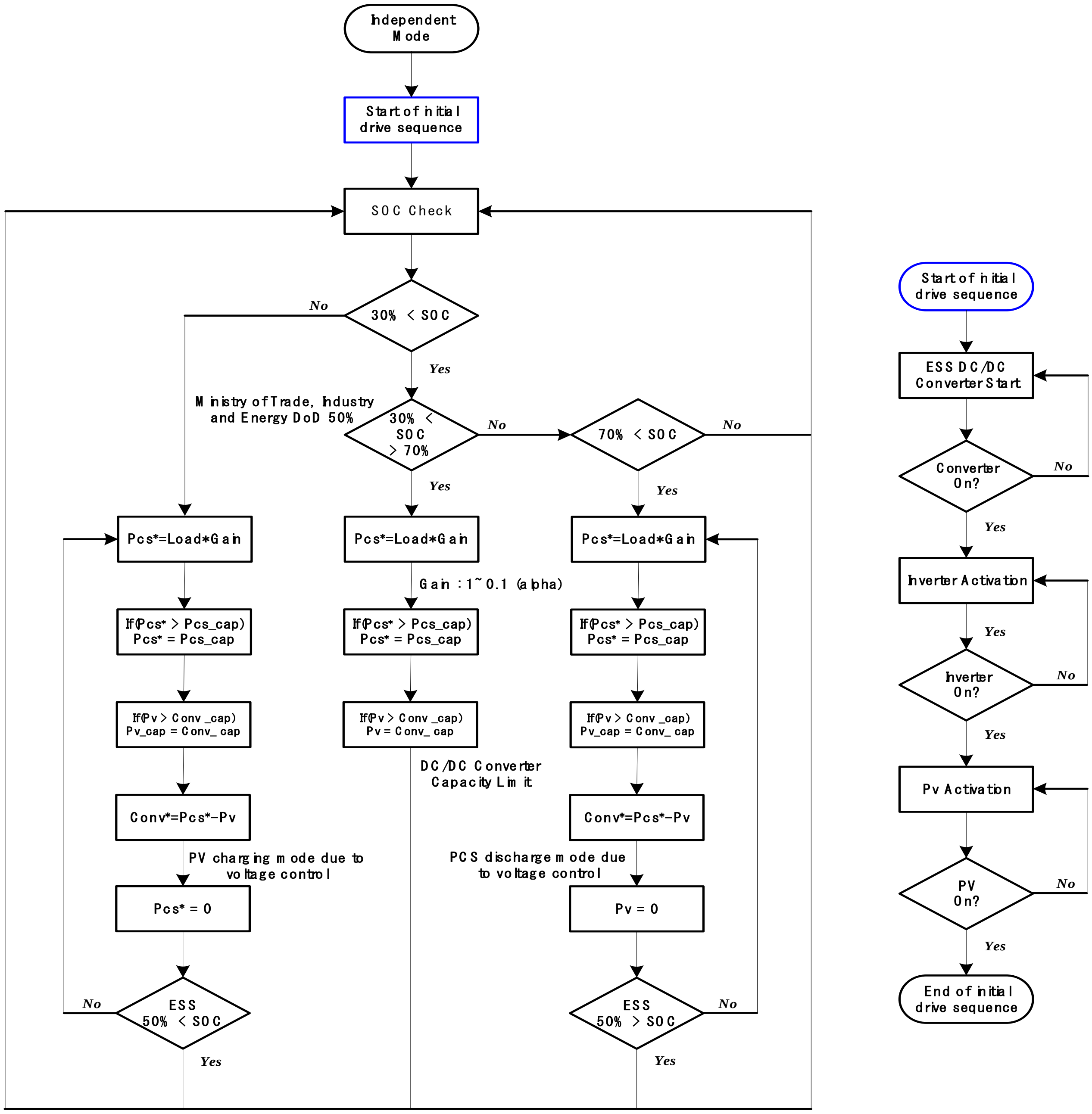

Figure 3. Independent mode(1) algorithm

As mentioned above, the output of the PCS in the normal operation period is changed by multiplying the gain value corresponding to the load amount, but when the peak control starts, the output of the PCS maximum rated output is controlled.

According to the initial driving sequence, DC link voltage of DCDC converter was generated 830Vdc, zero-current control according to inverter operation was started, and PV converter was started after inverter normal start.

Then, after generating the command value of each power converter, it was operated to reflect the operating characteristics according to SoC, and each power converter limited the power within the available capacity of the PV converter or DC / DC converter according to the characteristics of the factory. SoC of ESS is designed to run in charge mode and discharge mode when reaching 30% and 70%, respectively, and configured to return to normal state after SoC reaches 50% after entering each mode.

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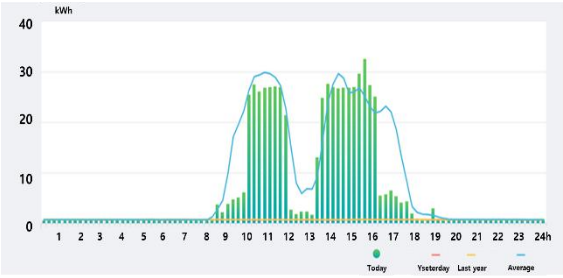
Factory 1

Factory 2



Factory 3

Factory 4

Figure 4. Power Consumptions by each Factory – mode(1) algorithm

Table 1: Initial Set of features used for the experimentation

Distribution	Reduction ratio(%)	Reductions (kWh)
Factory 1	63.33	40.15
Factory 2	22.26	77.50
Factory 3	25.4	12.0
Factory 4	20.59	12.15

Independent mode (1) algorithm is designed for stable operation of the SoC. Set low SoC upper limit to 30-70%, use low energy, stop PV and PCS in each section. It has been confirmed that a lot of energy is wasted. For sufficient PV power generation, we found that Plant 1 can reduce 63.33% compared to conventional load under conditions. Other plants showed power reductions as shown in Table 1. Depending on the transmission, limit adjustment may enable more effective operation.

Application algorithm (2)

The applied algorithm (2) is shown in Figure 3 below, SoC was set at 10% to 90%, normal start return criteria was set at 30% at 10%, 70% at 90%, and other basic conditions. It is driven under the same conditions as the algorithm (1).

As mentioned above, the output of the PCS in the normal operation period is changed by multiplying the gain value corresponding to the load amount, but when the peak control starts, the output of the PCS maximum rated output is controlled.

According to the initial driving sequence, DC link voltage of DCDC converter was generated 830Vdc, zero-current control according to inverter operation was started, and PV converter was started after inverter normal start.

Then, after generating the command value of each power converter, it was operated to reflect the operating characteristics according to SoC, and each power converter limited the power within the available capacity of the PV converter or DC / DC converter according to the characteristics of the factory. The SoC of ESS is designed to run in charge mode and discharge mode when reaching 10% and 90%

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respectively, and return to normal after reaching 30% in SoC mode and 70% in discharge mode after entering each mode. Configured.

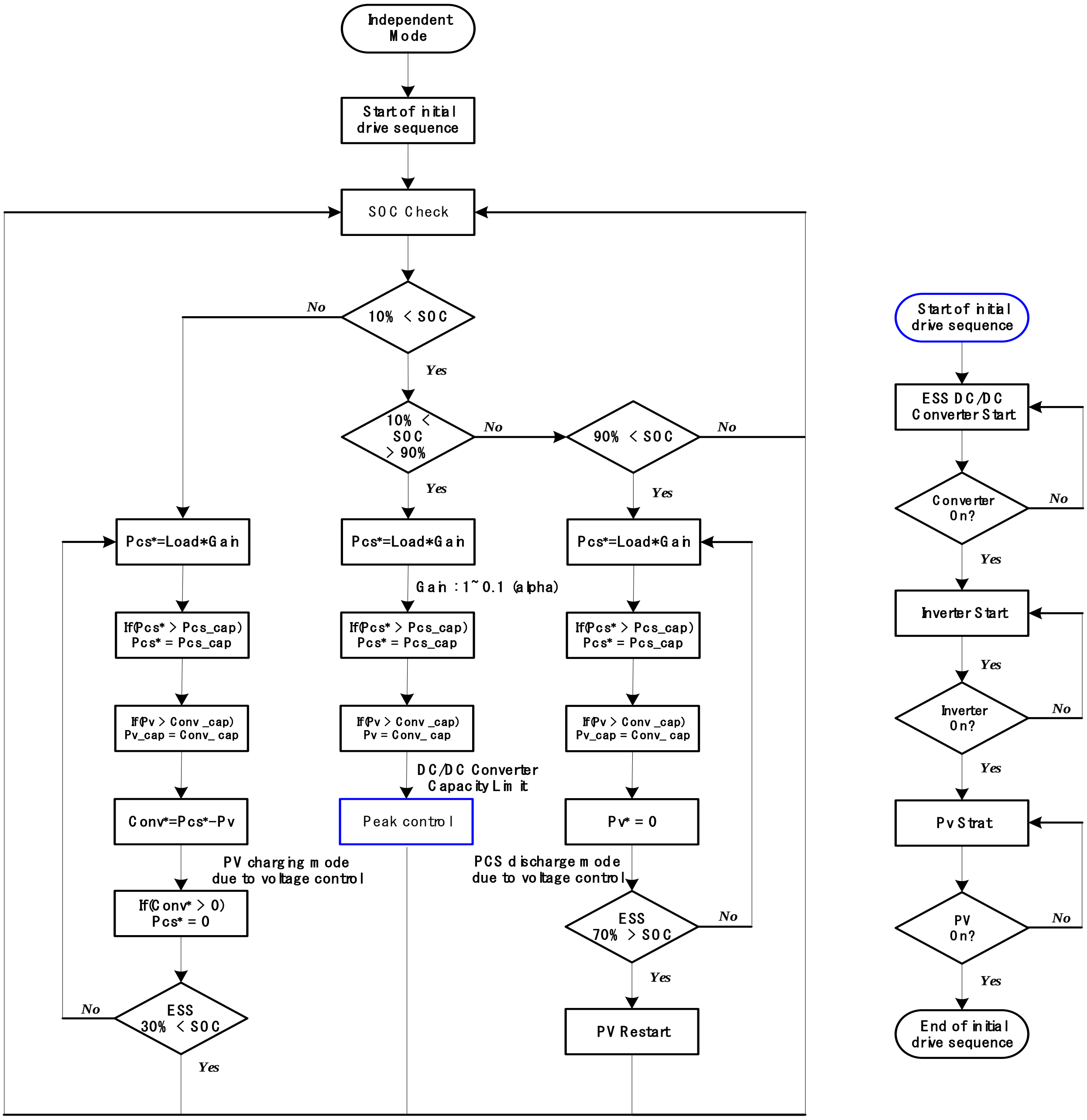
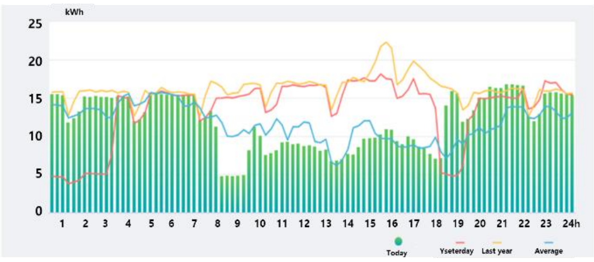


Figure 5. Independent mode(2) algorithm



Factory 1

Factory 2

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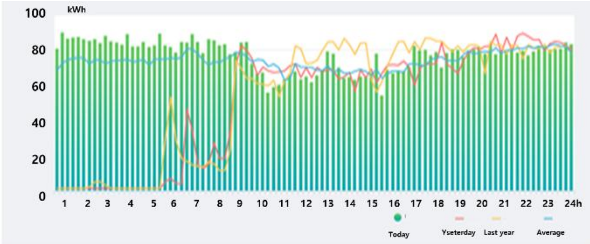
Factory 3



Factory 4

Figure 6. Power Consumptions by each Factory – mode(1) algorithm

Table 2: Initial Set of features used for the experimentation

Distribution	Reduction ratio(%)	Reductions(kWh)
Factory 1	55.71	54.42
Factory 2	30.88	69.8
Factory 3	25.7	13.39
Factory 4	27.95	18.99

In the stand-alone mode (2), the algorithm can make the most of the SoC's power generation and supply power, and the energy utilization is set by setting the SoC upper limit value to 10-90% to efficiently run the EMS algorithm according to the load characteristics of each beneficiary factory. It is designed to reduce the energy wasted by setting the generation amount and the load supply amount high by intermittently starting the PV and PCS in each section. In case of sufficient PV power generation, it was verified that the Factory 1 could reduce 55.71% of the existing load under the condition of, and the characteristics of load reduction decreased due to the decrease. The savings were verified to be the same. In addition, As Table 2 shows,Factory 2 reduced 30.88%, Factory 3 25.4% andFactory 4 27.95%. Other factories except Factory 1 set Gain to 0.7 in Algorithm (1). In comparison, it is confirmed that the efficiency is increased, and it is confirmed that an appropriate setting is important for a site in which the load fluctuates significantly due to the gain set to 0.5 in the algorithm (2).

III. Conclusion

Applying their own consumption and peak reduction algorithms at each plant of the microgrid. To compare each algorithm, we compared the power saving rate and power savings through the load waveform of I-Smart of KEPCO. Compared to the algorithm (1), the algorithm (2) improved the charging and discharging operation to gently control the SOC charge and discharge waveform. In addition, it has been proven that the ESS can be used stably under similar conditions while supplying the same power as the existing power by increasing energy efficiency. In addition, by applying the microgrid system of independent mode, power savings of up to 63.33% for each beneficiary factory were verified, and the operation of the independent mode according to the algorithm was verified. In the future, the microgrid system of each plant will be linked to provide a system that can supply more than its own solar power generation capacity, or supply power to other plants when power is left. In addition, it will be applied to a power sharing algorithm that can have the optimum efficiency.

IV. Acknowledgment

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