Simulation Method to Evaluate Mutual Impact between Smart Community and Distribution System

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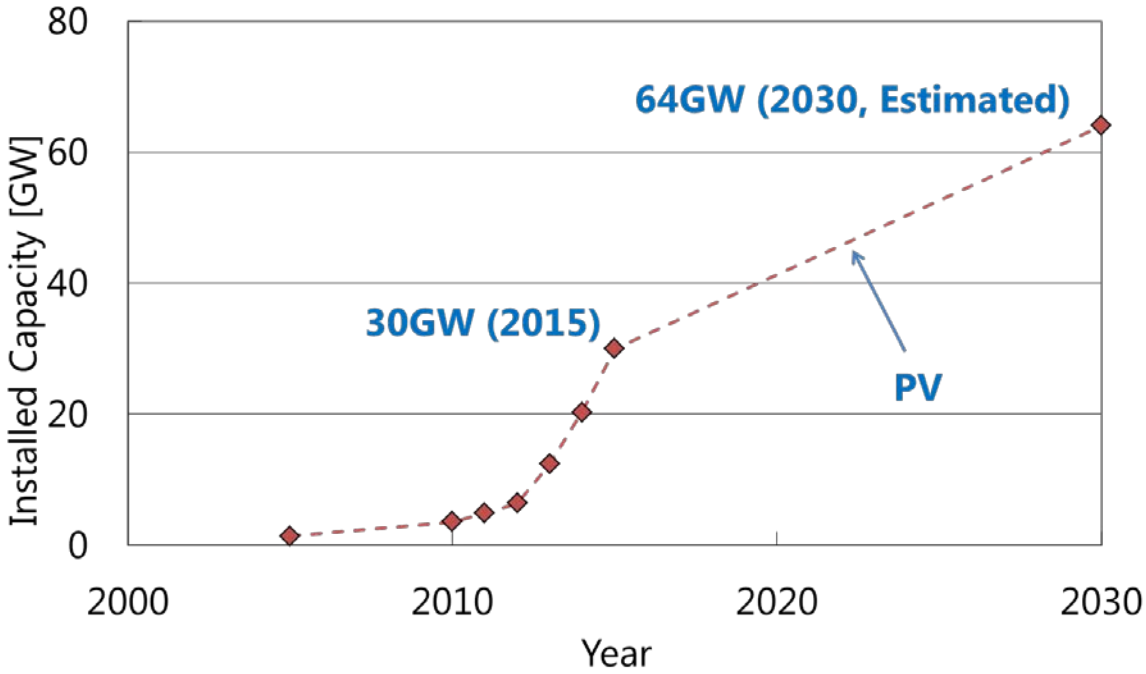
Installation of PV in Japan

- In Japan, New feed-in-tariff (FIT) scheme has been started in July 2012, then Installation of Photovoltaic (PV) is accelerated.



Installed Capacity of PV in Japan

(After 2020: "Outlook of long-term energy demand", Ministry of Economy, Trade and Industry, 2015)

Background

- In recent years, installed capacity of distributed energy resources (DERs) such as photovoltaic (PV) systems and battery energy storage systems (BESs) has been increasing.
- Then, smart communities (including virtual power plants) using DERs are expected to realize the efficient use of energy in demand area.
- If the DERs are operated by community operator (or aggregator) to optimize their local objectives, such as cost minimization, the demand fluctuations will be complicated.

To evaluate the impact of smart community operation, an impact assessment method is proposed.

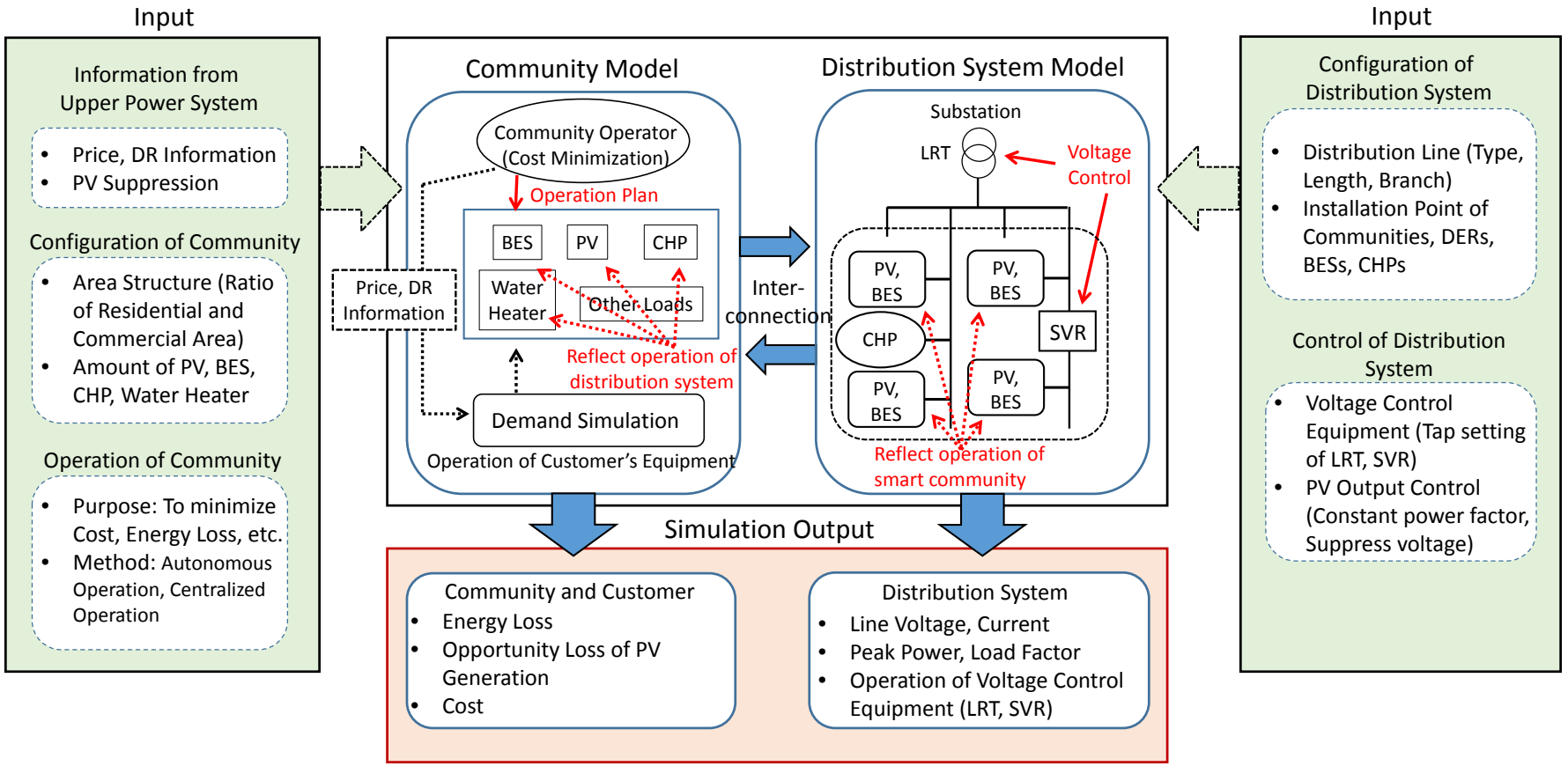
Contents

- **Proposal of impact assessment method**
  - ✓ A simulation method to evaluate the impact of the autonomous operation of a smart community using BESs on the distribution system is proposed.

- **Simulation using the proposed method**
  - ✓ By simulation using the proposed method, the impact on the voltage and current of the distribution system by smart community using BESs is estimated.

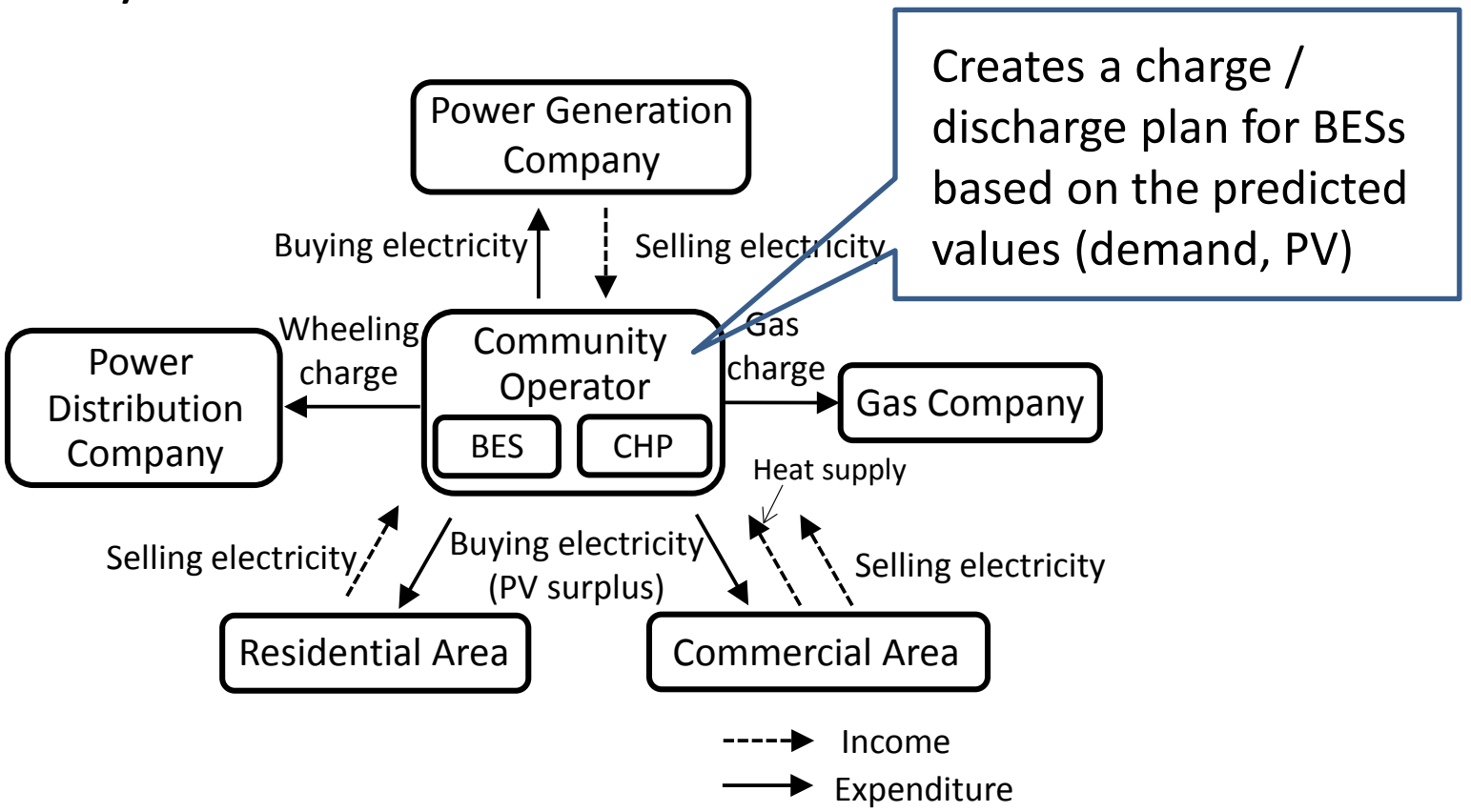
Impact Assessment Method for Smart Community

- The community model simulates the operation of a smart community and customers. The distribution system model simulates the operation of the distribution system. These models are interconnected.



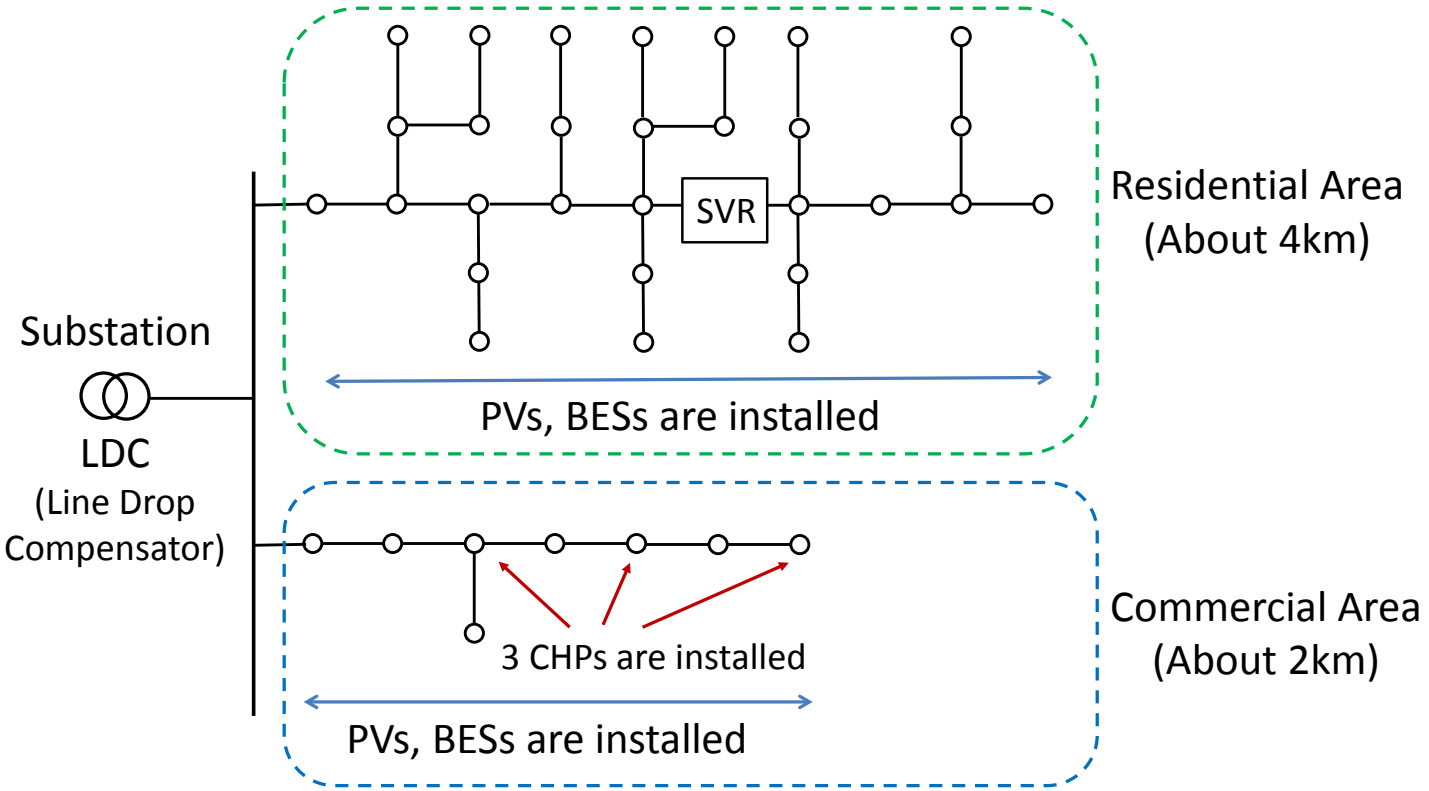
Community Operation

- Community operator creates an optimal plan to operate equipment (BESs) considering economic efficiency of the smart community.



Distribution System Model

- Voltage and current of the distribution system were simulated using the parameters, such as ratio of residential and commercial area, installed amount of PV and BES, etc.



Simulation Conditions (1)

- Voltage and current of the distribution system are simulated when the BESs are operated by community operator to minimize cost of the community.
- Total charging capacity of the BESs is equal to 2 hours of the capacity of the distribution line.
- Simulation cases:
  - Residential case: there are only residential areas
  - Commercial case: there are only commercial area
  - Mixed case: residential and commercial areas are mixed

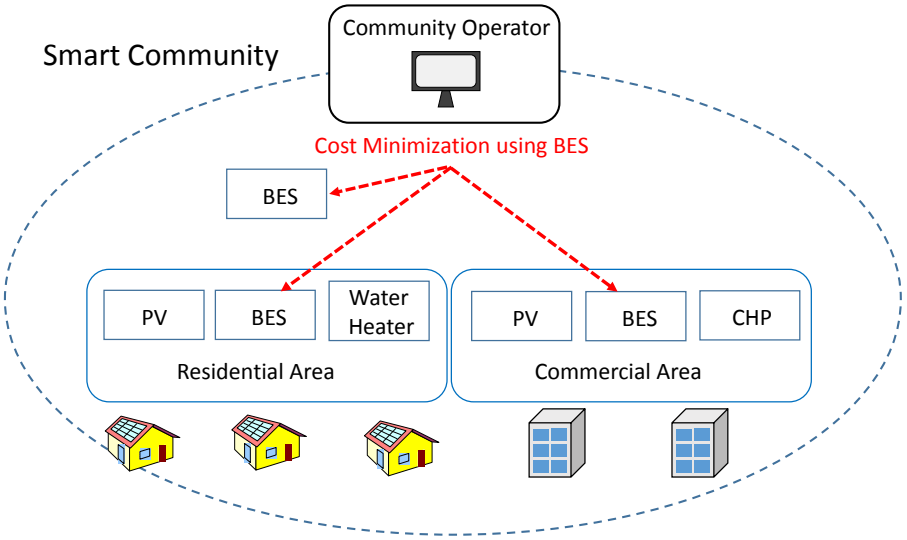
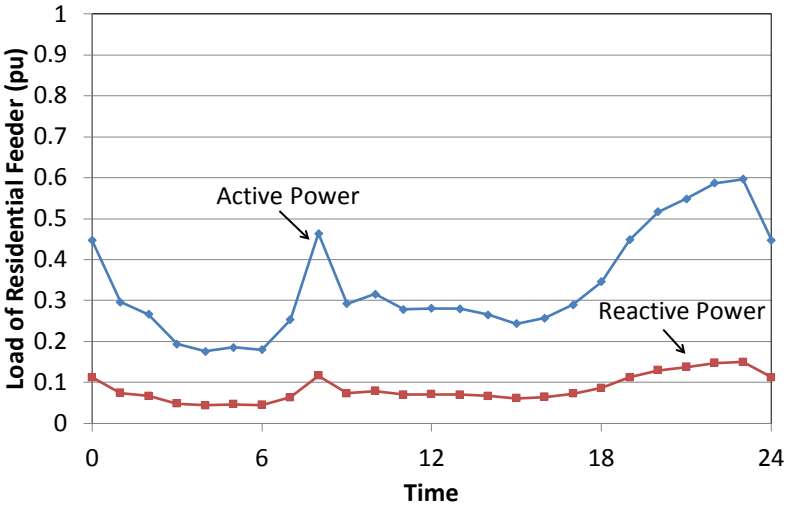


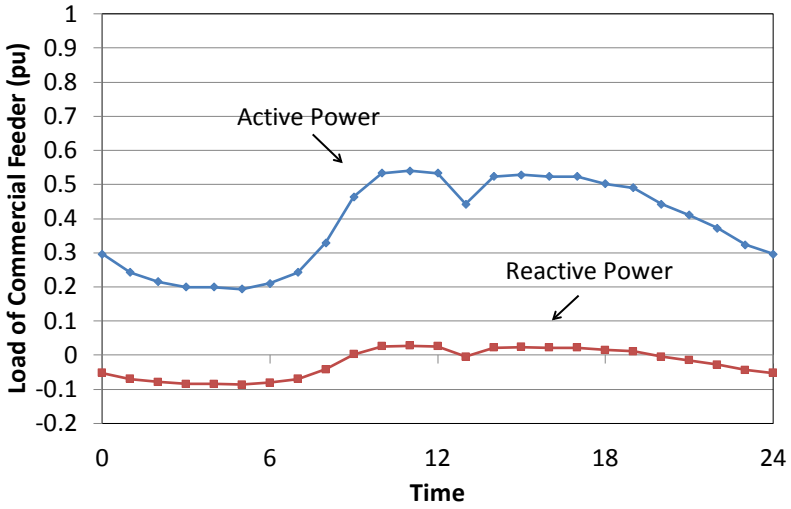
Table: Electricity Prices in each time period

Buyer	Time Period	Electricity Price
Community (from upper grid)	8-22	11.82 yen/kWh
	22-8	8.6 yen/kWh
HV Customer (commercial)	8-22	15.39 yen/kWh
	22-8	11.11 yen/kWh
LV Customer (residential)	7-23	28.62 yen/kWh
	23-7	11.07 yen/kWh

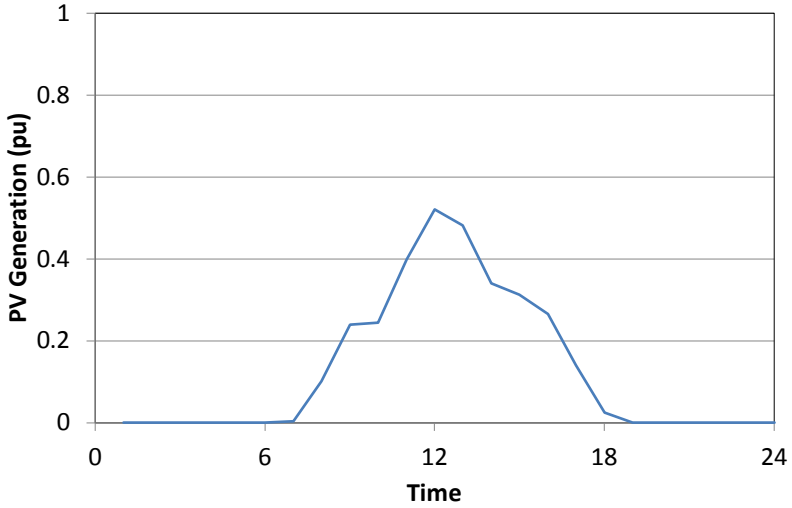
Simulation Conditions (2)



Load Curve of Residential Area



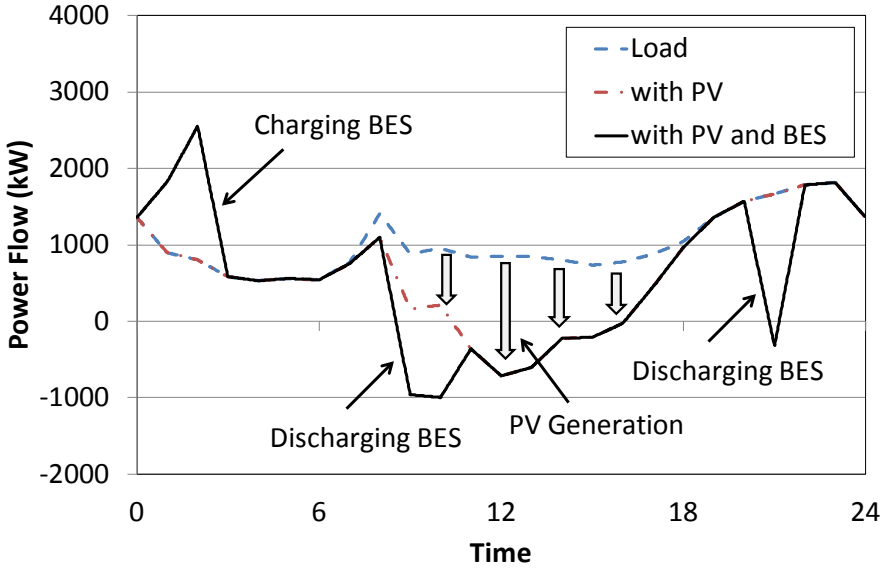
Load Curve of Commercial Area

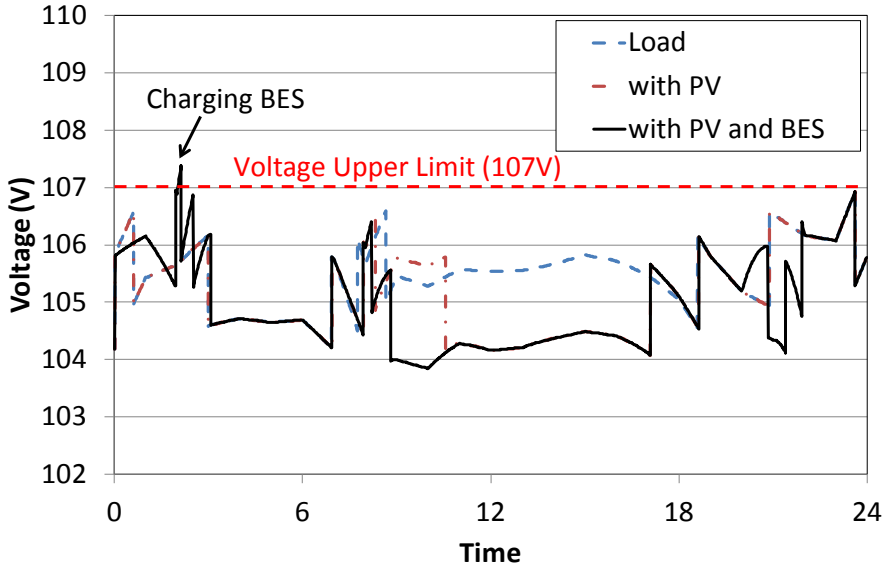


PV Generation

Simulation Results (1)

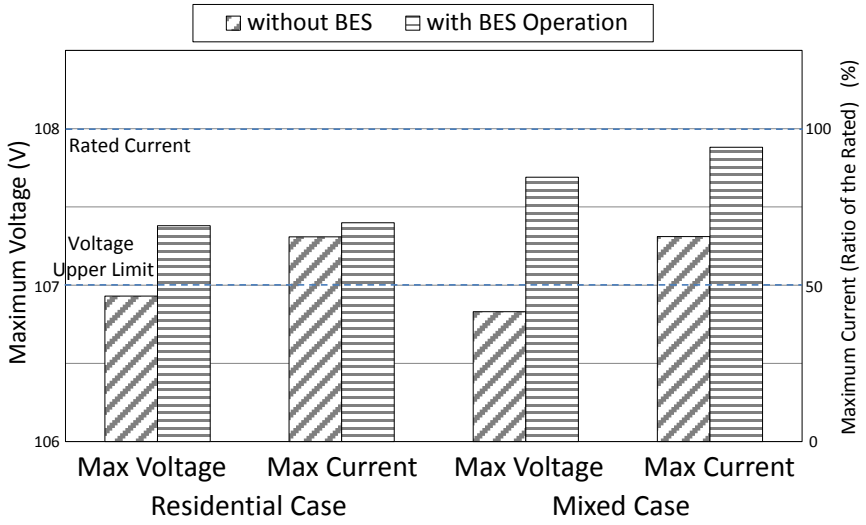
- If the BESs are operated according to the charging schedule created by the community operator, the BESs are charged in the midnight because the price is cheapest.
- The voltage drop of the distribution line increases, then the voltage of the distribution line is controlled by LRT tap at substation.
- Then, the voltage near the substation may exceed the upper limit because the LRT tap is controlled to maintain the voltage at a remote point distant from the substation.



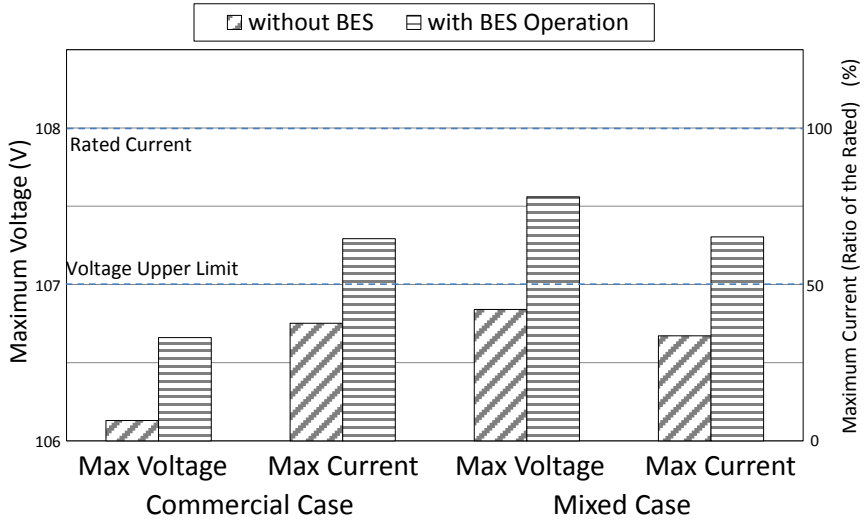


Simulation Results (2)

- Influences on the distribution system are compared in each case.
- At the residential feeders, the influence on both the voltage and current is increased in the mixed case than in the residential case, because the daytime power demand in the commercial area is larger.
- In the commercial area, the impact on the distribution line current is almost the same in the commercial case and the mixed case. But, the impact on the voltage is larger in the mixed case because the LRT tap is controlled for the residential feeder which is longer than the commercial.



Residential Feeder



Commercial Feeder

Conclusions

- ✓ An impact assessment method for Autonomous Operation of Smart Community was proposed. Then, the impact on the voltage and current of the distribution system was estimated.
- ✓ The results show that if a smart community aims to the local optimization such as cost minimization, the power quality becomes worse.
- ✓ Therefore, interoperation methods between a smart community and the power system may be necessary in future power grids.

Thank you