

Jeju 2011 Symposium on Microgrids

Power Supply Reliability Analysis
of Microgrid
considering Switching Operation

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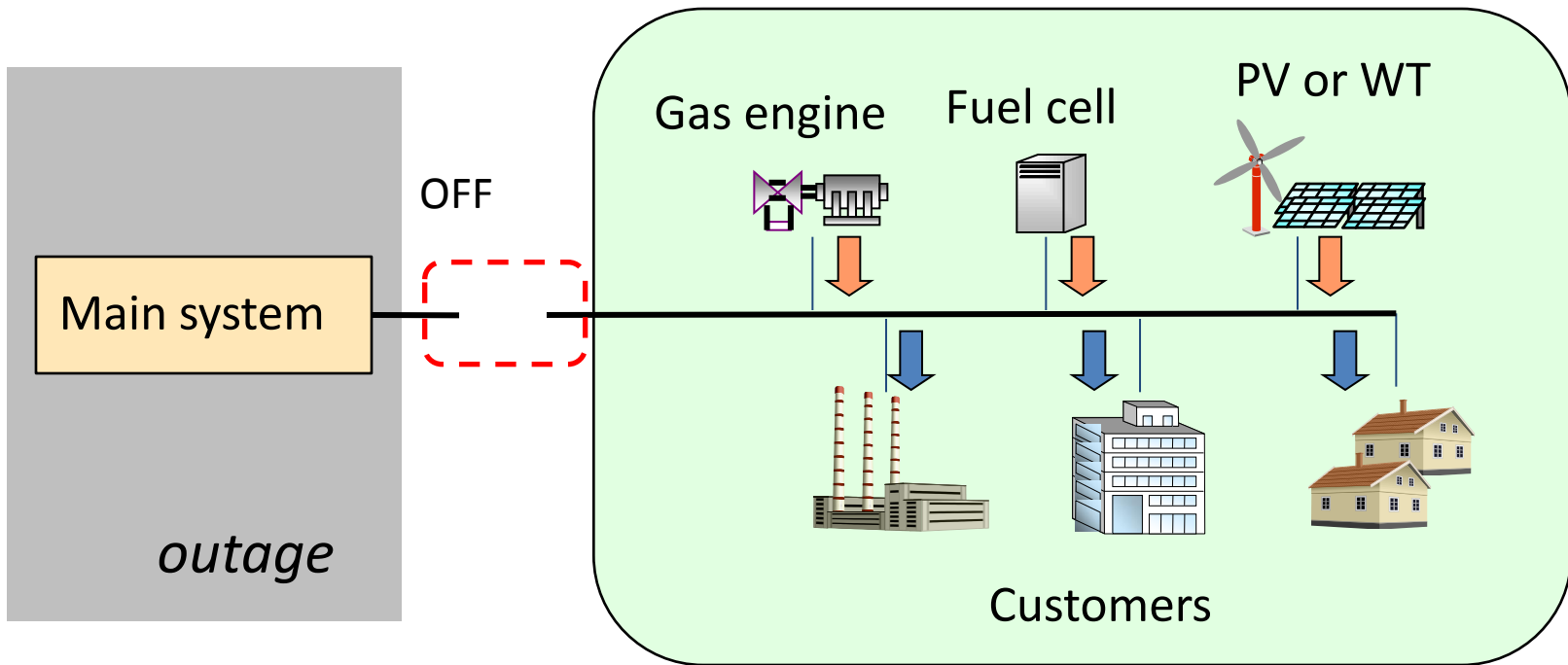
Takao Tsuji

Yokohama National University



Background

" Microgrid " with many Distributed Generators



Electric Power Supply Reliability can be improved in microgrid because it can operate even in the case of outage in utility grid

Power Supply Reliability Analysis

Power Supply Reliability Analysis Method based on “*Enumeration method*” have been developed

Following probabilistic factors are considered,

- Fault occurrence
- Probabilistic change of Renewable energy and load



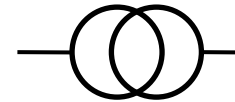
- [1] Realistic way of *Switching Operation* is considered.
- [2] The required amount of load shedding is calculated by *convolution integral method*.

Components of Microgrid Model

Bus



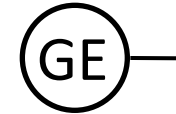
Transformer



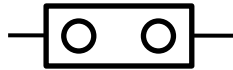
Disconnecter



Gas Engine



Circuit Breaker



Wind Turbine



Distribution line



Load



The Concept of Multi Quality Power Supply is introduced.

load (high reliability)



load (low reliability)



Example of Microgrid Model

PCC receives power from primary substation using 66kV loop distribution line.

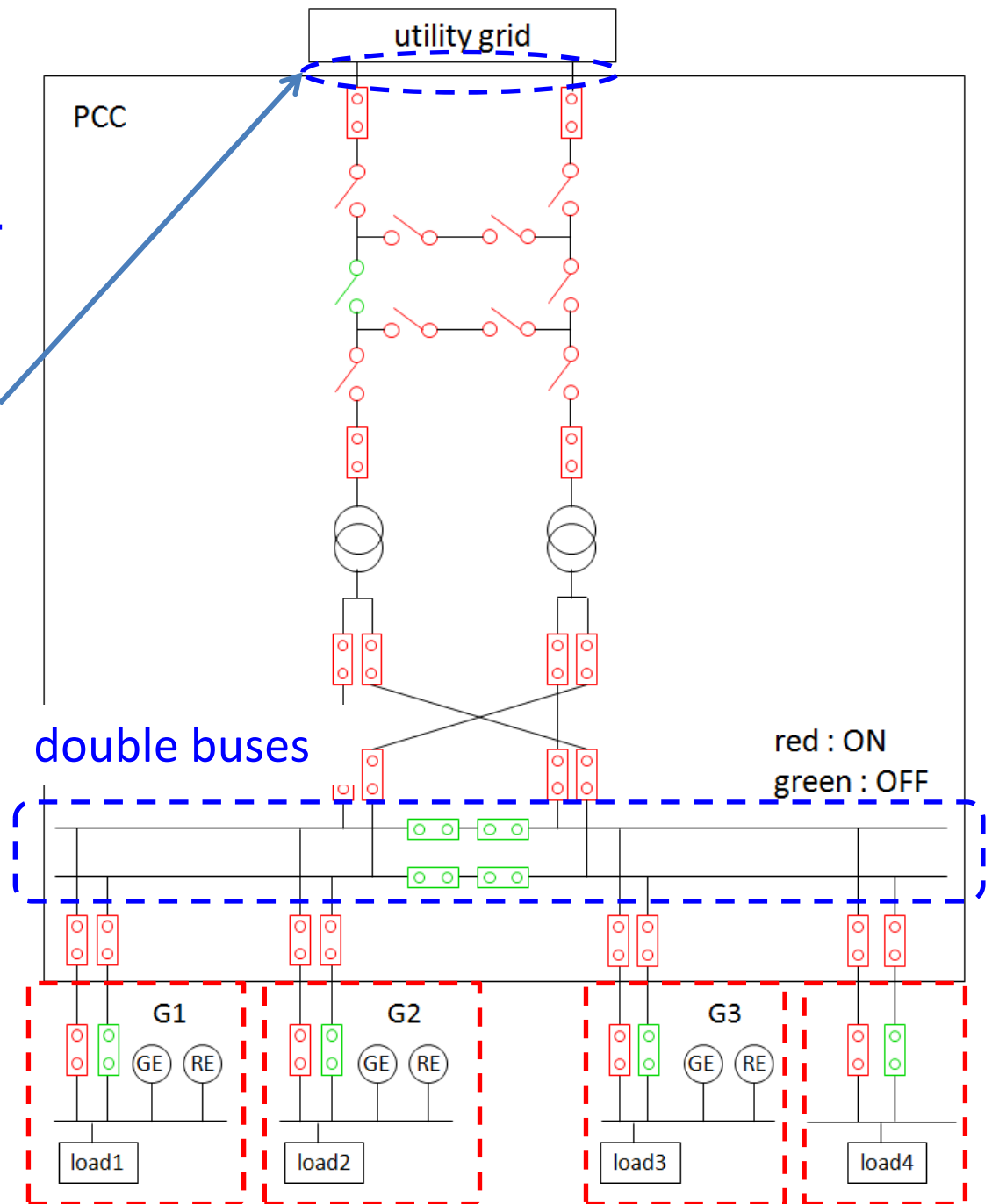
There are four customers including DGs (Gas Engine and Renewable energy)

GE output

Case 1: 1000kW

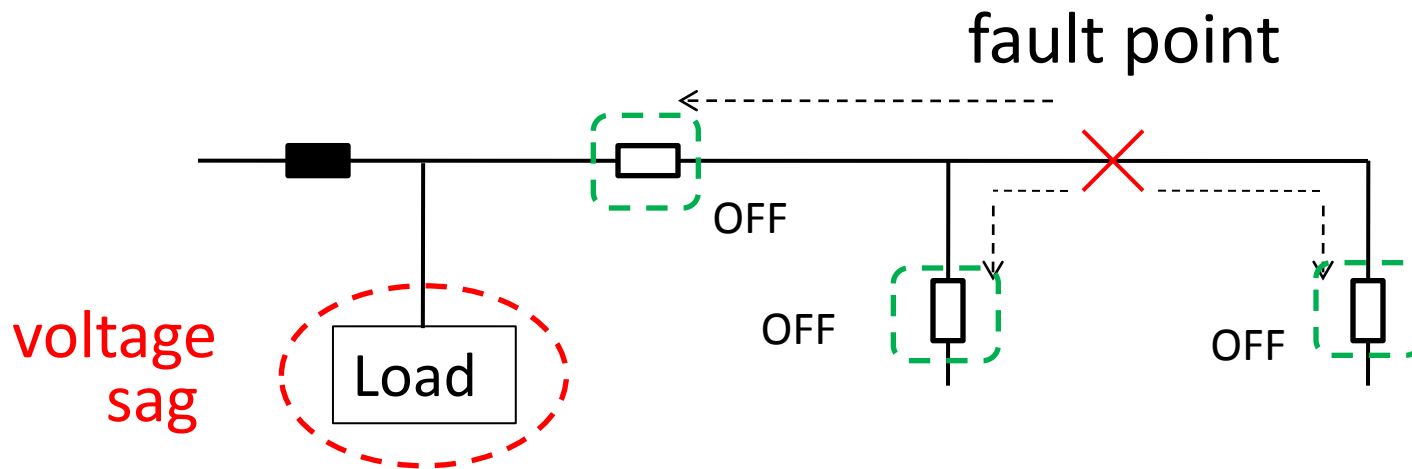
Case 2: 1500kW

Case 3: 2000kW



Action of Protection Relay

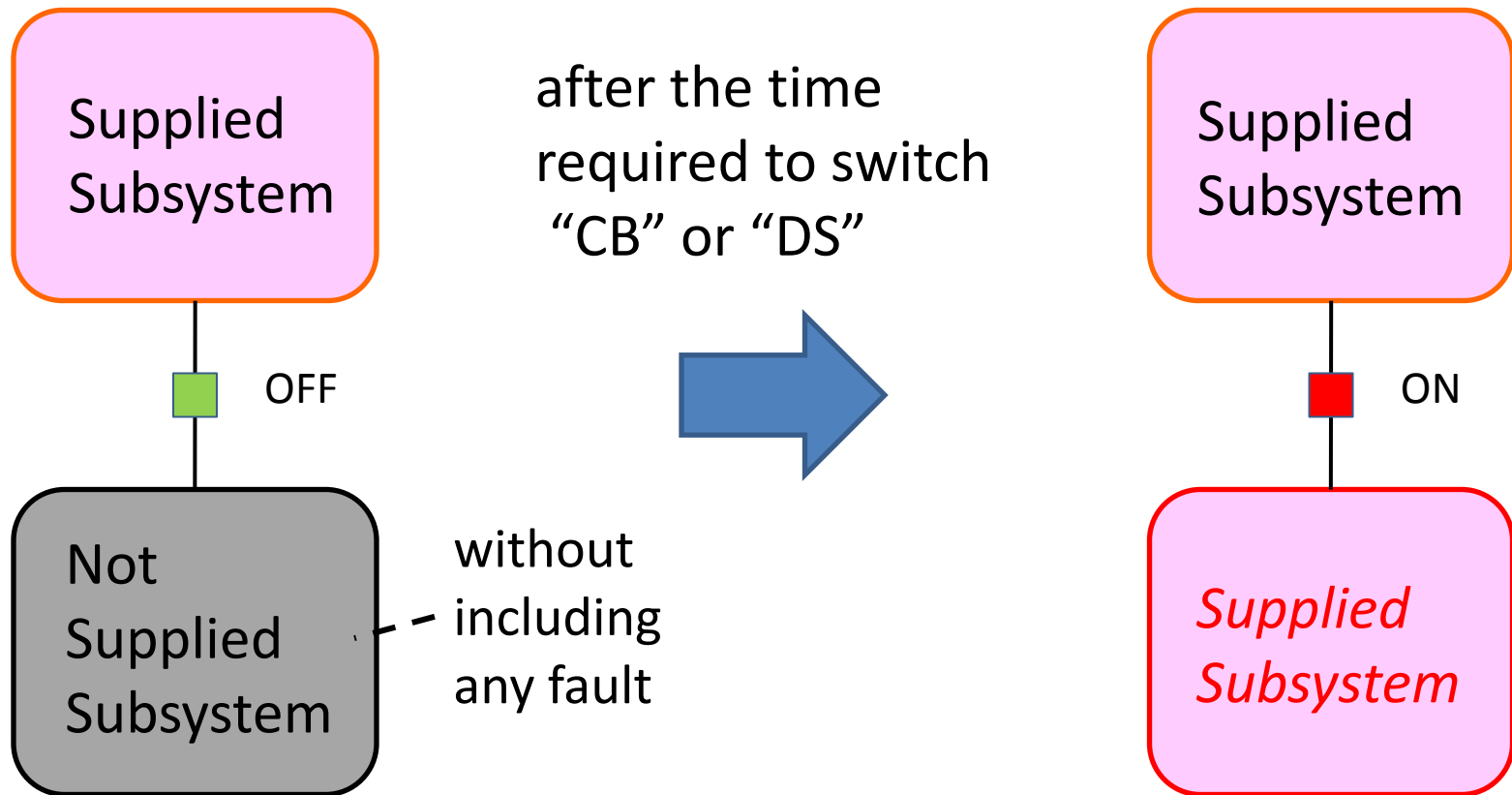
“ground fault” or “short circuit fault”



- It is assumed the **circuit breakers which are located nearest to the fault point, are switched off.**
- “**Voltage sag**” occurs in all customers which have electrical connections with the fault point.

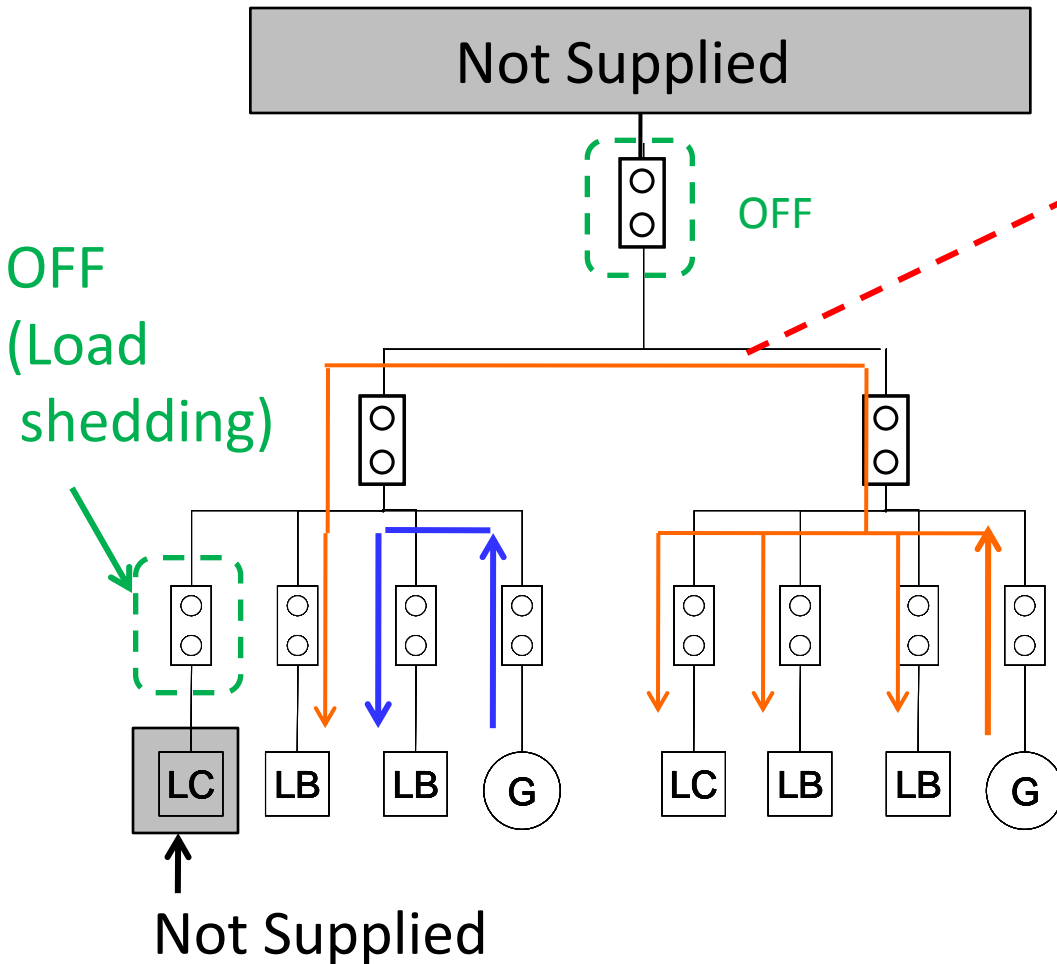
Switching Operation

CBs or DCs are switched to minimize the outage area.



"Short duration outage" occurs at the loads whose outages are restored by the switching operation

Load Shedding (1)



Surplus power is transferred to other customers.

In the case the total capacity for power supply in island subsystem is not sufficient, some loads are shed according to **priority based on Power Quality**.

Load shedding causes a "Long duration outage".

Load Shedding (2)

- Probabilistic Load Model in Island Subsystem

$$q(y) = \sum_{y=y_1+y_2+\dots+y_l} q_1(y_1) \cdot \underline{q_2(y_2)} \cdots q_l(y_l)$$

Probabilistic model of each load

- Outage probability in the Island Subsystem

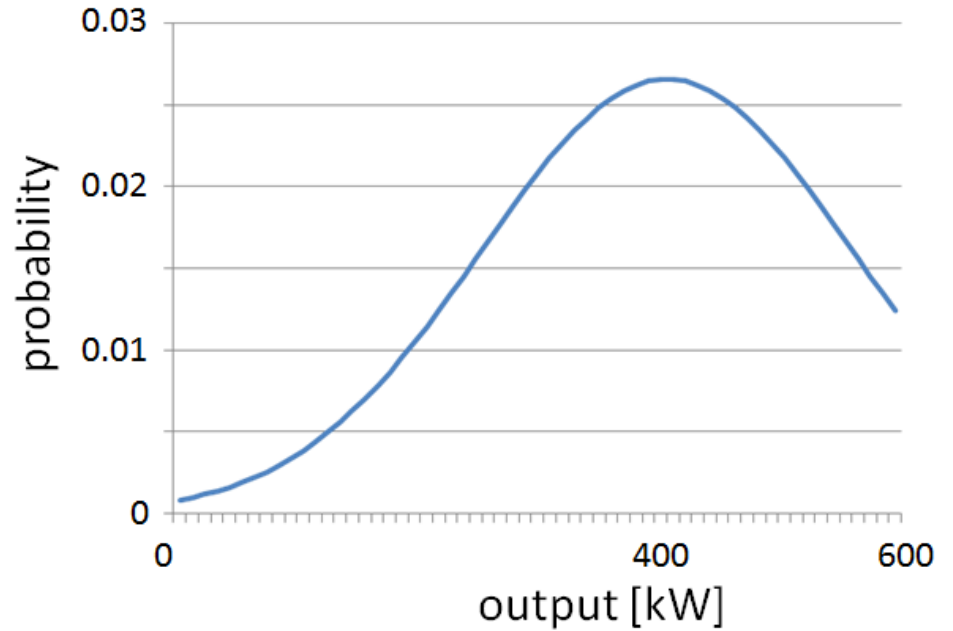
$$r(z) = \sum_{\underline{g+mx-y=z}} \underline{p(x)} \cdot q(y)$$

Probabilistic model of RE output

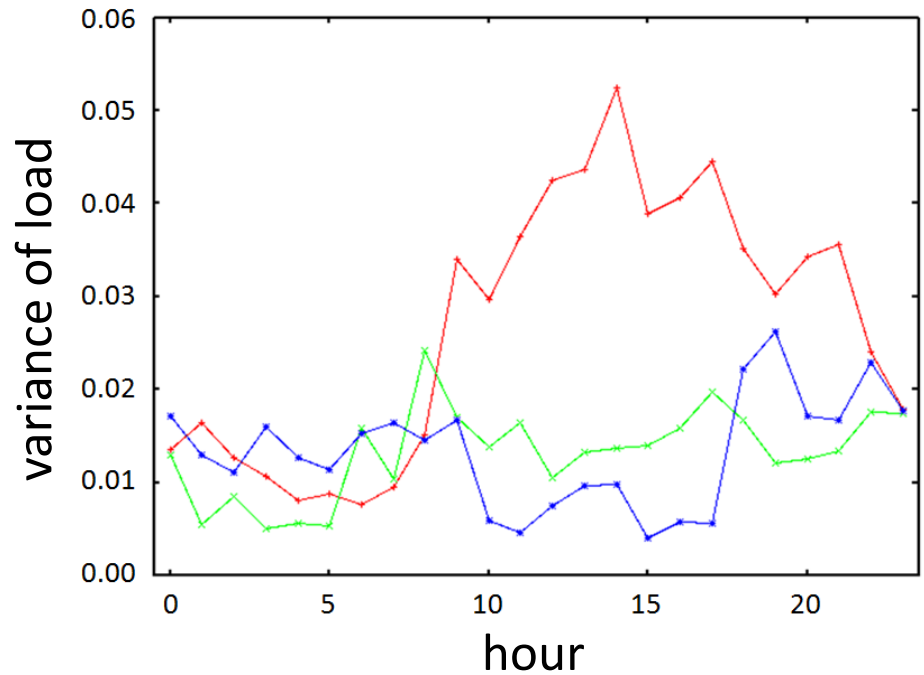
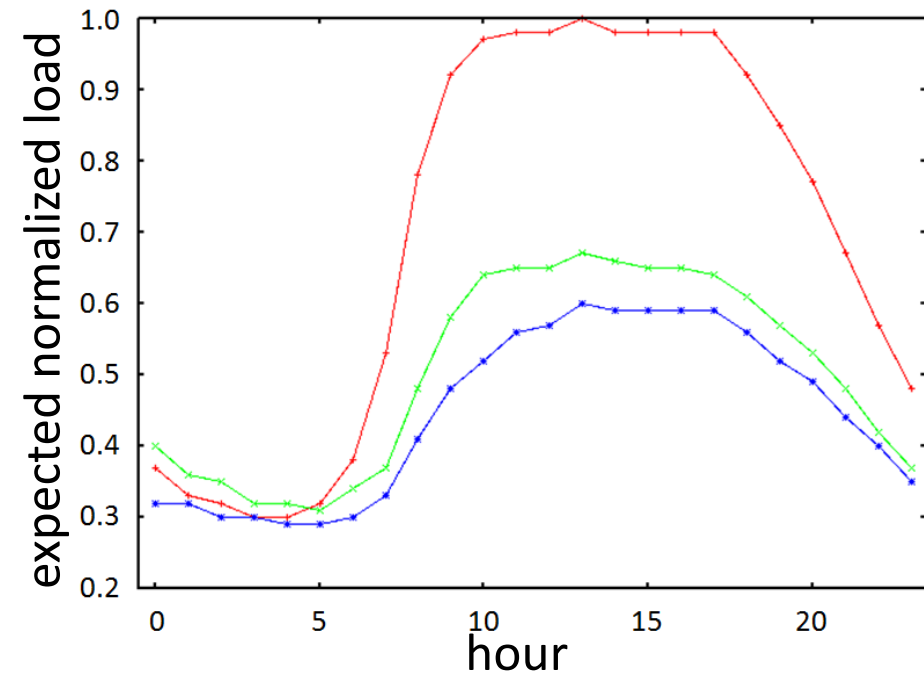
g : GE output

m: total number of REs

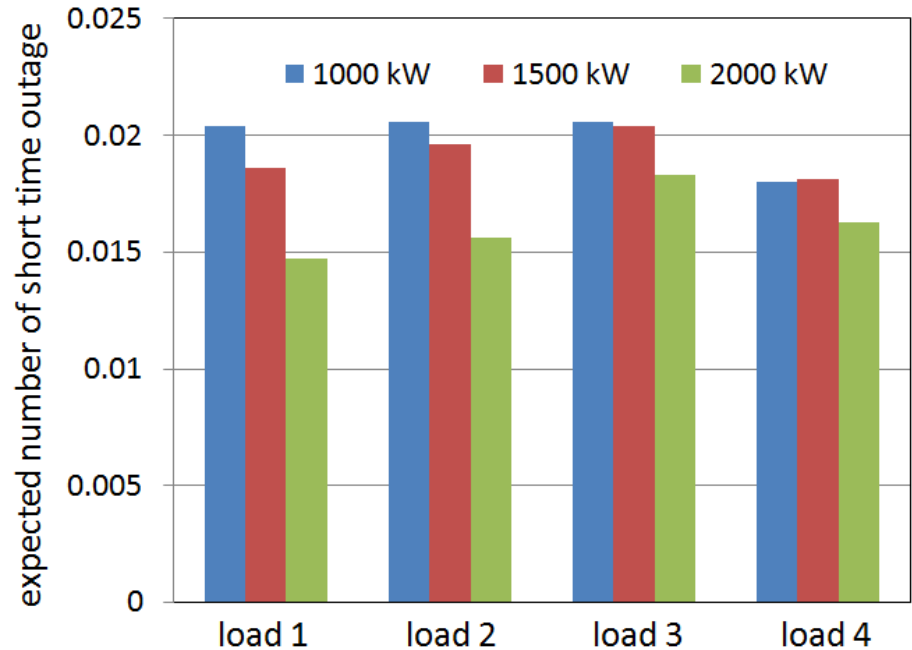
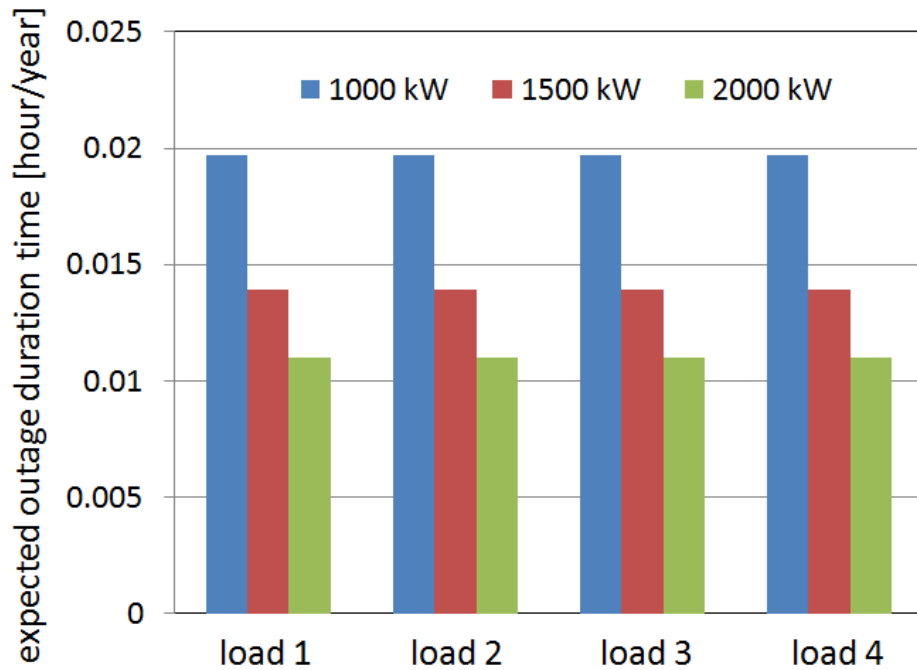
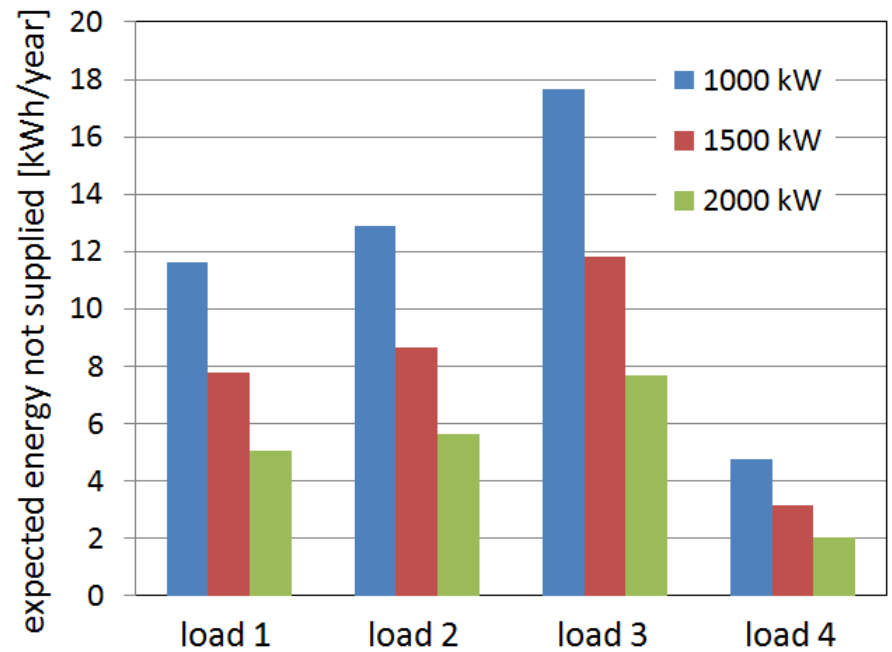
Probabilistic Model of RE and Load



probabilistic density curve of RE



Simulation Results 1

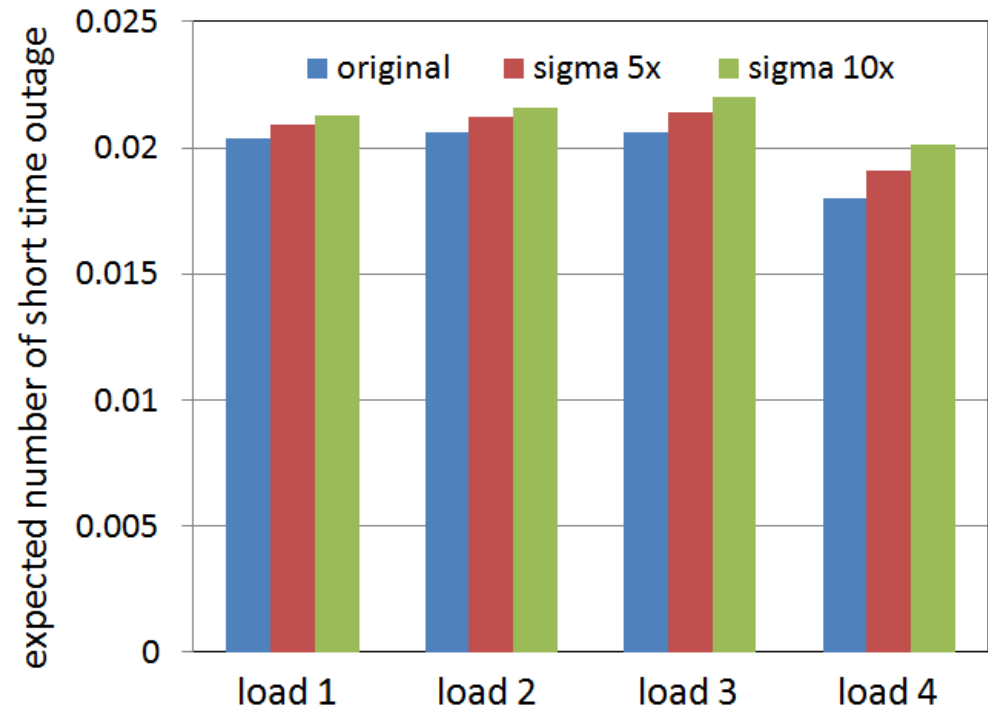
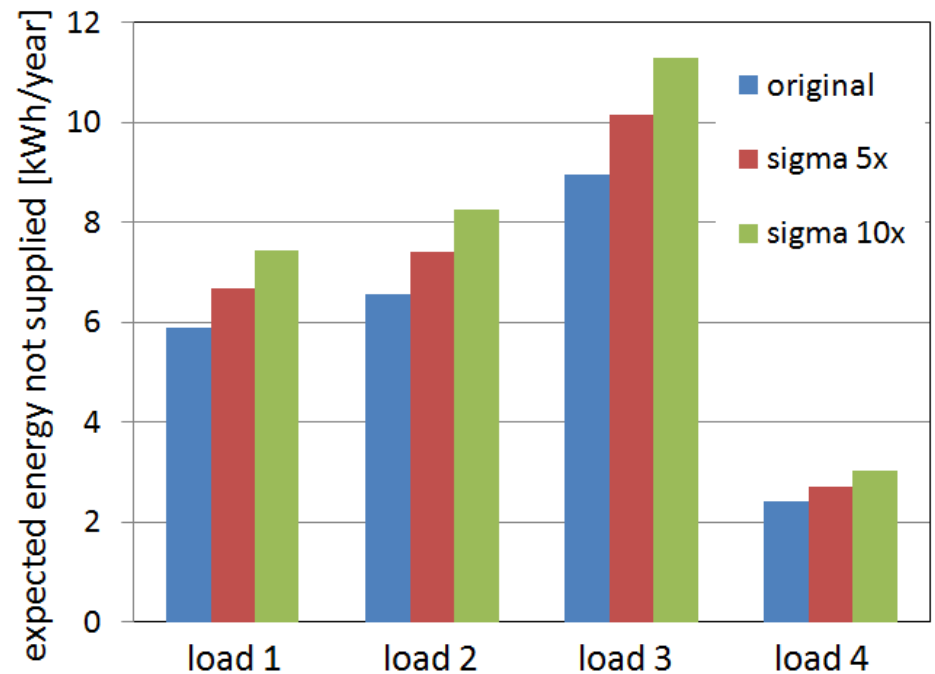


Simulation Results 2

standard deviation of load model is modified to five and ten times.



The importance of considering probabilistic load change is shown



Conclusions

- A new Reliability Analysis Method of Microgrid based on Enumeration Method Is developed
- Switching operation is effectively memorized by “Switching Operation Matrix” and the demand – supply balance of each islanding system is calculated by convolution integral method

- *Future works* -

- The impact of Scheduled maintenance, other kind of faults, and multiple faults should be considered
- The proposed method should be tested in more complicated large scale model and its calculation time must be evaluated