Microgrid Projects for Remote Islands in Japan

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Fuji Electric Co., Ltd
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What is Microgrid in remote islands

- Isolated power system, which is composed of multiple distributed power sources including **renewable energy**, **electric energy storage units** and **its control system**
- Control system will be able to control power generation depending on power demand in the grid

**Without** the ability to disconnect from and to parallel with the other Electric Power systems

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**Expected effects:**

- “Local production for local consumption” of energy
- CO₂ reduction through installing of renewable energy generations
Background of microgrid projects in small islands

Society needs
low-carbon power supply systems

Utility needs
reducing the fuel costs

Demand needs
stable electric power

Installing of renewable energy in small islands
Installing energy storage system for keeping power quality

Microgrid Systems Demonstrative Project

* Japan’s first Isolated microgrid systems for small islands from 2009
Characteristics & problems in isolated islands

- **Features of ICE (Internal Combustion Engines)**
  - High Fuel Cost due to Shipping
  - Fast response control
    - Hot Start within a few ten sec. and Cold Start in a few min.
    - Gov. control; High Controllable performance

- **Effect of Renewable Energy**
  - Small smoothing effects because of relatively large particle of load & generation

- **Rapid reflection to frequency deviation by power fluctuation**
  - Small Inertia energy due to Smaller inertia of ICE, different from turbine as prime mover
Control Overview for microgrid

Local Control (Cooperation)
- Load Disturbance
  - Power from ICE
- Discharge & Charge
- EES

Control Unit
- Local Control
  - (Power fluctuation/Sudden disturbance)
  - (Cooperation)

Integrated Microgrid Control
- (Balancing Demand & Supply)
  - Scheduling
  - Dispatch Control (Peak cut etc.)
  - Frequency control

Grid
- Control Unit
- Frequency
- ESS for grid
- Management System (EMS)

Power from ICE
- Internal Combustion Engine
- Solar Power
- Wind Power

EES; Electrical Energy Storage
Suppress power fluctuation by hybrid stabilized control

Power Grid

- Total output power

Wind Power

- Output from wind power
- Wind+EDLC Power output

Stabilized Control for EDLC

- Stabilized Control for rechargeable battery

Inverter for EDLC

- Compensated Power by EDLC
- Charge/Discharge Target

Inverter for Rechargeable battery

- Compensated Power by rechargeable battery

Electric double layer capacitor (EDLC)

- Suppression range: from seconds to minutes

Rechargeable battery (Lead or Ni-H)

- Suppression range: from few ten seconds to hours

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Coordination with ICE and EES is controlled by the Advanced UPS technique

Such as Power Walk-in (soft start) and Absorber function

ICE: Internal Combustion Engines
EES: Electrical Energy Storages
Integrated microgrid controller & Inverter system (PSC) dedicated EES need high-speed frequency detection

Rapid frequency change due to Internal Combustion Engine with light inertia

High-speed frequency detection

Improved EMS & Improved PCS with tracking ability of high freq. change

Input Freq.  PCS Freq.

Freq. Tracking ability of Conventional PCS is less than 1Hz/second

Conventional PCS  Time (second)  Proposed PCS

Freq. Tracking ability ⇒ higher than 5Hz/second
Integrated microgrid control

Scheduling interval: 30～60min

Control interval: 1～5min

Control interval: 1～5sec.

Unit Commitment

Economic Dispatching Control

Load Frequency Control

Micro Grid

Gen
EES
PV
WT

Database

Predict Load & Power from RE

Long term prediction

Short term prediction

Meteorological Data
Forecasts:
- Wind direction
- Wind speed
- Solar insolation
- Temperature
- Humidity

atmosphere

Schedule

dispatching

control

System Frequency
Line flow
Input data is forecasted numerical atmosphere conditions (wind speed, temperature, humidity, pressure, cloud etc.) forecasted using Global Climate Model.

Predict wind speeds at wind farm
Insolation at PV panel

Predict the Output Power from Renewable energy

Predict the power with Estimating future error bar

Power output vs. time
Projects of a Microgrid System for Remote Islands


Target
Promote the high penetration of renewable energy (RE) such as PV & WT to achieve a low-carbon society and low cost of electricity power supply.
➢ Establish the countermeasure for RE which cause rising voltages & surplus power and also the unavailable frequency regulation.
➢ Clarify the issue toward the future grid system with RE

Demonstration Term; from 2009 to 2014

Trustee; Kyushu Power Company and Okinawa power company
## Demonstrative projects in Kyushu & Okinawa

<table>
<thead>
<tr>
<th>Location</th>
<th>PV</th>
<th>Battery Type</th>
<th>Lithium Battery</th>
<th>Wind Power</th>
<th>Pop.</th>
<th>Grid Scale</th>
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<tr>
<td>Kuroshima</td>
<td>60kW</td>
<td>lead-acid</td>
<td>66kW</td>
<td>10kW</td>
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<td>2.9kWh (LIC)</td>
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<td>1.2MW</td>
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</table>

**LIC:** Lithium-Ion Capacitor
Stabilizing control for power fluctuation

Compensation for sudden disturbance

Conventional Control with suppression for power fluctuation

Developed Control with suppression for power fluctuation & sudden disturbance

The power compensation function using storage is confirmed to able to solve a problem of the fluctuated frequency due to PV power fluctuation in small islands.
Example result

- Peak shift operation for high-efficiency operation of diesel generators

rück

Shift of surplus power output period using batteries
· High-efficiency operation of diesel generators

K. Ishida, "Demonstration tests of microgrid systems using renewable energy for small remote islands", C1-116, CIGRE(2012)
Demonstrative projects for microgrid systems in small islands

- Constructions

  - Construction scenery
  - Unloading scenery
  - Wind turbine setting construction
  - PV panel setting construction
Conclusion

Microgrid in a remote island is supported by advanced control technologies with the renewable energy and Electric Energy Storage.

Microgrid control system consists of local control and integrated control for detecting on-site power output and system frequency.

The term of the microgrid projects is from FY 2009 to FY 2014.

Moreover, Microgrid system can be applied for the disaster prevention facilities and community energy system.
Reference


Thank you for your attention!