Microgrid R&D in KERI

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New & Renewable Energy System Research Center
Smart Grid Research Division
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I. Short history of Microgrid research in KERI
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III. On-going projects and future works
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   - National project
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I. Short history of Microgrid in KERI

- Microgrid projects in KERI
    - First Microgrid project in Korea
    - DG infrastructure installed: PV, WT, BESS, D/E etc
    - Government–support projects funded: PV–WT hybrid system etc
  
    - Focus on developing core technologies and devices: u–EMS, IED/STS
    - 120kW class prototype Microgrid completed: Testbed for devices and system
    - Real/Simulated DG, Simulated Load, EMS, Grid–connected/Stand–alone mode, Re–Sync.
    - Unique Microgrid system in Korea
  
  - Development of 200kW LV Microgrid commercialized version (2009–, S.M. Kwon)
    - System upgrade for actual load: Network, ESS, PV, WT 등
    - Planed for operation in KERI research building
    - Attempt to commercialize MG for building: enhanced power quality, CHP/ESS applied, integrating BEMS with MG
✓ System configuration in 1st phase
DG & Infrastructure

- PV Array (9kW)
- Fuel Cell (1kW)
- Diesel Generator (20kW)
- Wind Turbine (3kW)
- M-G set (20kW)
- DAG Infra-Structure
- D/L for test
- Protection Panel
- Load (9kW)
- Simulators
✓ Infrastructure

▲ Tr. For MG

▲ RTDS, Power Amp

▲ Hybrid, BESS

▲ Passive Load

▲ D/L Module

▲ Weather Suite
✓ Core devices & technologies
  • PCS for MG
  • EMS
  • STS/IED
  • Design & analysis tech.
  • Engineering tech.
Microgrid configuration at 2nd phase

Total Load: 99kW + j44kVar
Total Gen: 120kW
- D/E: 70kW (50kW + 20kW)
- RES: 30kW
- BESS: 20kW

- Wind Pattern
- Irradiation pattern
II. Pilot Microgrid in KERI

Distinguishing features of KERI Microgrid

- Controllable/Uncontrollable DG
  - Controllable DG: D/E, BESS, FC
  - Uncontrollable/Intermittent DG: PV, WT
  - For functional test of EMS considering operational characteristics of DG's

- Real/Simulated DG
  - Real DG: PV, D/E, FC, BESS
  - Simulator: PV, WT, CHP
  - For low initial investment, repetitive test on same condition, easy operation regardless of weather condition

- Critical/Sheddable Load
  - Critical Load: keep PQ
  - Sheddable Load: Supply–Demand Balance by DLC

- Simulated Co–generation and thermal load
  - Natural gas service and G/E not available in KERI
  - Simulated thermal load and supply implemented on EMS S/W
PV array vs. PV Simulator

- PV array: dependent on weather condition
- PV simulator
  - can change the solar irradiation arbitrary
  - DC power supply emulating I–V characteristic curve of PV array
WT vs. WT Simulator

- Wind Turbine: dependent on weather condition (wind speed)
- WT simulator
  - can change the wind pattern arbitrarily
  - M-G set emulating wind turbine and generator

$$P_M = \frac{1}{2} \rho \pi R^2 C_P V_{WIND}^3$$

$$= \frac{1}{2} \rho \pi R^5 C_P \frac{\omega_M^3}{\lambda^3}$$

Wind turbine char. equation

Measured wind pattern & M-G set
Load vs. Load Simulator

- Measured the actual load pattern
- Load Simulator
  - Scaling from actual load pattern: light/heavy load
  - Active/Reactive load changing by PLC controlled RLC passive load bank

▲ Measured load pattern(a), scale-down patterns(b–d)

▲ Load bank & controller
**CHP Simulator**

- CHP is essential for economic point of view in Microgrid
- Thermal load, CHP equipment and gas supply needed
- CHP Simulator
  - Gas engine : emulated by diesel engine
  - Thermal load : use pattern data in EMS
IED/STS

- IED (intelligent electronic device)
  - Integrated measuring and protection
  - Re-synchronization
  - Power quality monitoring
- STS (static transfer switch)
  - Thyristor-based switch
  - Auto/Manual/Bypass mode
III. On-going projects & Future works

- KERI Microgrid projects : Target
  - AC–DC integrated power system for LV customer
  - Actual load test in demonstration site : building in KERI

Diagram:
- DC N/W
- AC N/W
- Comm
- EMS
- AC customer
- STS
- Utility
- Bedroom Home Office
- Kitchen
- Home Entertainment
- DG
- DC DG : PV, BESS, FC
- AC DG : WT, D/E
- AC N/W
- Comm
- Utility
- Bedroom Home Office
- Kitchen
- Home Entertainment
- DG
- DC DG : PV, BESS, FC
- AC DG : WT, D/E
Integration of DC distribution equipments – Home & building

- GRID
- Renewable (3kW)
- ESS (3kW)

300V DC BUS

Appliance, PC, TV

Motor load

Heat: Oven

Lighting: LED
System upgrade(I) : EMS

Functions implemented
- Export/Import control at PCC
- Supervisory control of BESS
- Thermal load following

Functions planned
- Forecasting : load & generation
- Generation scheduling : Unit Commitment
- Economic dispatch

<table>
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<tr>
<th>Generation Schedule &amp; Dispatch</th>
<th>Supervisory Control</th>
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<td>• Make the balance between demand and supply</td>
<td>• Tie-line control (Power and voltage control at PCC)</td>
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<tr>
<td>• Optimize the objective function related to Microgrid system</td>
<td>• Upstream power system fault detection and disconnection</td>
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<tr>
<td>• For the generation schedule &amp; dispatch : Forecast (Load &amp; Renew Gen), UC and ED Algorithm</td>
<td>• Reconnection to upstream power system</td>
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<td>• Secondary regulation regarding energy storage system</td>
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✓ System upgrade(II) : ESS(energy storage system)
  • Modular PCS for Supercapacitor & Battery
  • Battery operational technology for prolonging battery life
  • Technology for minimizing ESS at stand-alone mode : variation of load and DER output
    : Wind turbine
  • Combined ESS : Supercapacitor & Battery → Fast response & battery life prolongation
✓ System upgrade(III) : Energy sources

Phase 3 Pilot Plant Structure

Components
- 9 Sources, MMS, IED/STS, Loads
- 2 DGs (20kVA D/E, 50kVA D/E)
- 5 Renewables (20kVA PV/Wind Hybrid, 30kW PV, 10kW Wind, 10kW Thermo-Electric, 1kW Fuel Cell)
- 2 Storage (50kW BESS, 30kW EDLC)

Operations
- PCC Power Flow Control in connected Mode
- Transition to Islanded Mode/Resynch.
- Frequency and Voltage Control in Island Mode
- Economically Optimized Dispatch
- Black Start, Power Quality Compensation

Purposes
- Operation Test with Real-Site Load
- Demonstrate a Low Voltage Commercial Power Supply System
National projects on Microgrid

- Phase II(2010–2012) plan

Project Management (KOEMA)

1-sub project (KEPRI)
- Develop core devices: EMS, GW, PCS, PQCC
- Grid-connected type site construction & performance evaluation

2-sub project (KERI)
- Stand-alone type site construction & performance evaluation
- Develop engineering tech.
- Support for standardization & mitigation of regulation

- Device provides: EMS, GW, PCS etc
- Device test: Before installation
- Technical support for grid-connected type: Basic design, spec., procedure of test
✓ Construction of Stand-alone MG site & Development of engineering tech.

Summary

- [Definition] Proof of platform for smart renewables
- [Target] Construction of Independent MG Site(Several 100kW class)
- [Period] 2010–2012(3yr)
- [Budget] $2M

Internet
SCADA

EMS

Gateway

Weather
suite

Desalination
plant

Customer: Gapa island

New and Renewable Energy System Research Center
IV. Conclusion & Vision

- KERI Microgrid Vision

- Cleaner Grid
- Self-healing
- Mass-scale Renewables
- Clean Power Market

Microgrid can be core technology under smart grid: KERI will lead microgrid technologies.
Conclusion

- Brief history of Microgrid research in KERI
  - 1st phase: Basic infrastructure implemented
  - 2nd phase: Pilot plant rated 120kW with simulated load/DG's
  - 3rd phase: Actual demonstration site rated 200kW with real load/DG's
- System upgrade for demonstration site
  - Upgrade: EMS, ESS, Network etc
  - AC/DC integrated power supply system in KERI building
- Construct independent Microgrid in Gapa island by 2011
- Vision of KERI Microgrid technology

Thank you for attention!