Microgrid R&D in KERI

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Contents

I. Short history of Microgrid in KERI

❑ Microgrid projects in KERI

✓ Development of autonomous Microgrid(2004-2005, J. B. Ahn)

- First Microgrid project in Korea
- DG infrastructure installed : PV, WT, BESS, D/E etc
- Government-support projects funded : PV-WT hybrid system etc

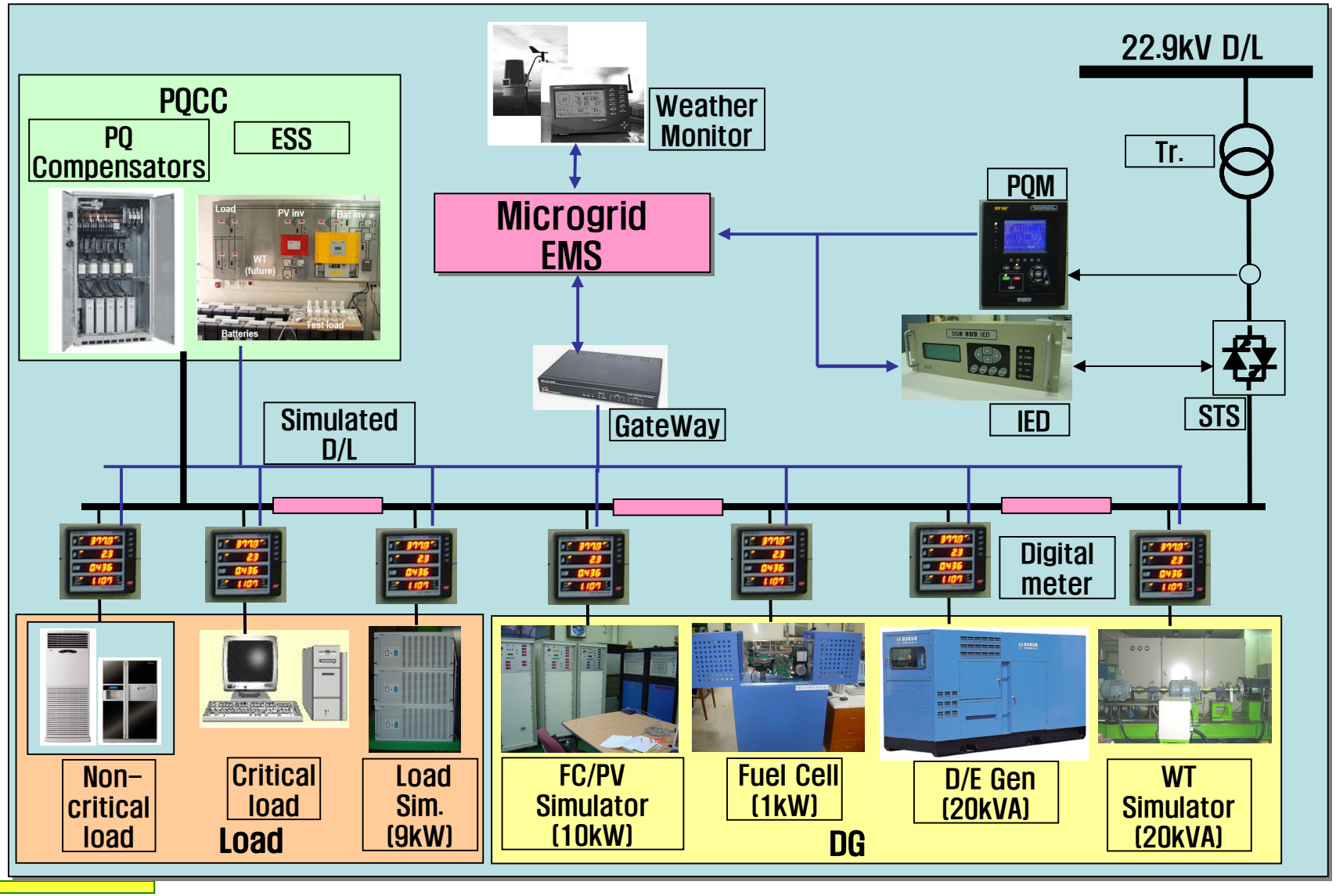
✓ Development of Prototype KERI Microgrid(2007-2009, J. H. Jeon)

- 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

Distributed Energy Resources

▲ PV Array(9kW)

▲ Fuel Cell(1kW)

▲ Diesel Generator(20kW)

▲ WindTurbine(3kW)

▲ M-G set(20kW)

Test Infra-Structure

▲ El. Load(9kW)

▲ D/L for test

▲ Protection Panel

▲ Simulators

✓ Infrastructure

▲ Tr. For MG

▲ RTDS, Power Amp

▲ Weather Suite

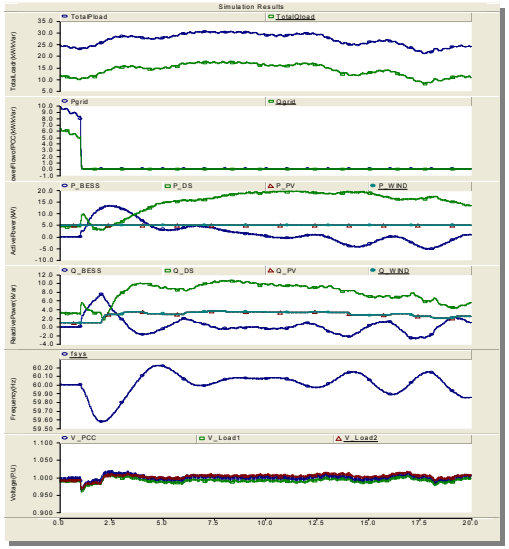
▲ Hybrid, BESS

▲ Passive Load

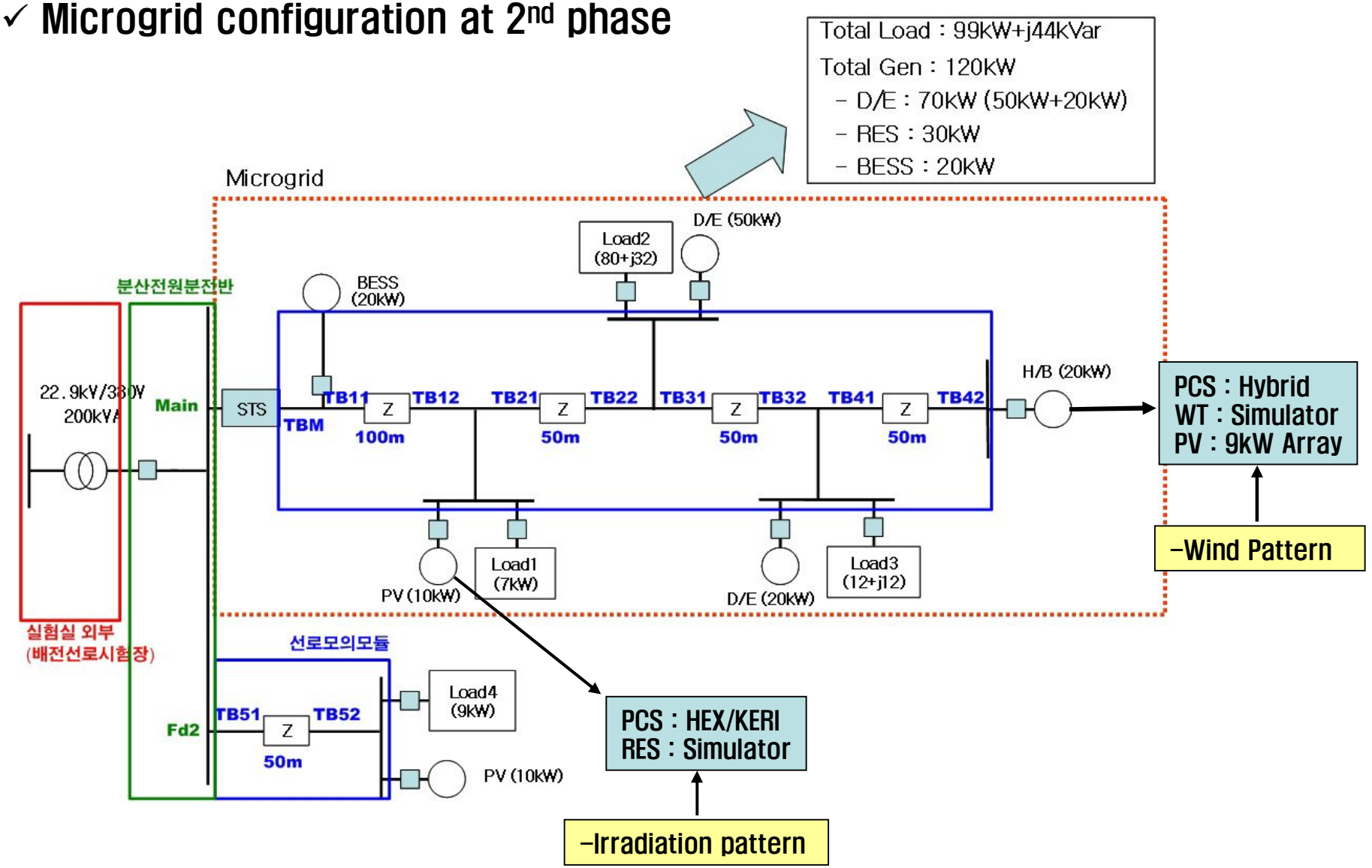
▲ D/L Module

✓ Core devices & technologies

- PCS for MG
- EMS
- STS/IED
- Design & analysis tech.
- Engineering tech.



✓ Microgrid configuration at 2nd phase



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

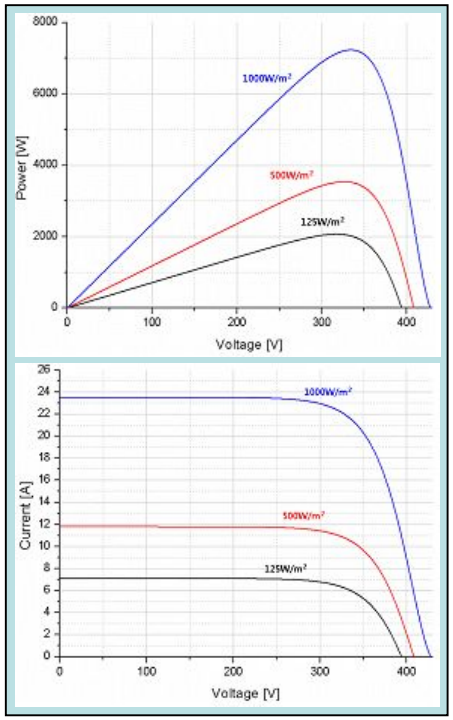
- Critical Load : keep PQ
- Sheddable Load : Supply-Demand Balance by DLC

✓ Simulated Co-generation and thermal load

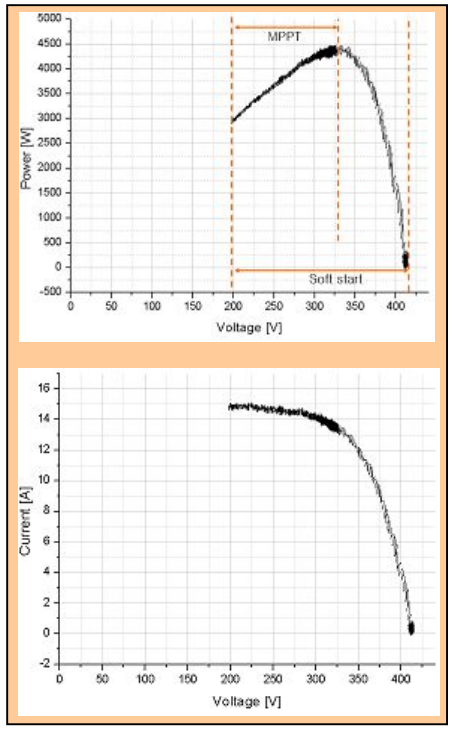
- Natural gas service and G/E not available in KERI
- Simulated thermal load and supply implemented on EMS S/W

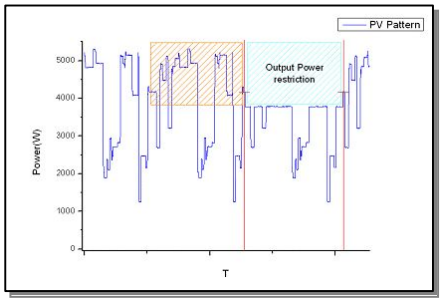
❑ PV array vs. PV Simulator

- ✓ 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



▲ PV array





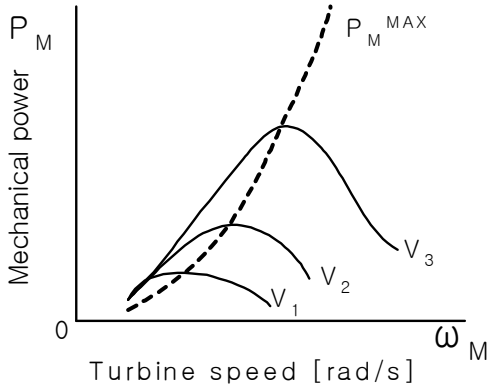
▲ PV simulator

❑ WT vs. WT Simulator

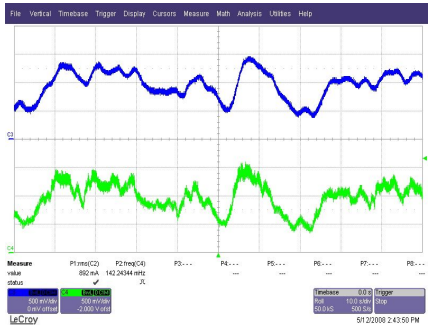
- ✓ Wind Turbine : dependent on weather condition(wind speed)
- ✓ WT simulator
  - • can change the wind pattern arbitrary
  - • M-G set emulating wind turbine and generator

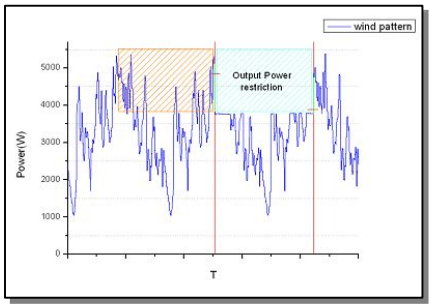
$$P_M = \frac{1}{2}\rho\pi R^2 C_P V_{WIND}^3$$

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



▲ Wind turbine char. equation

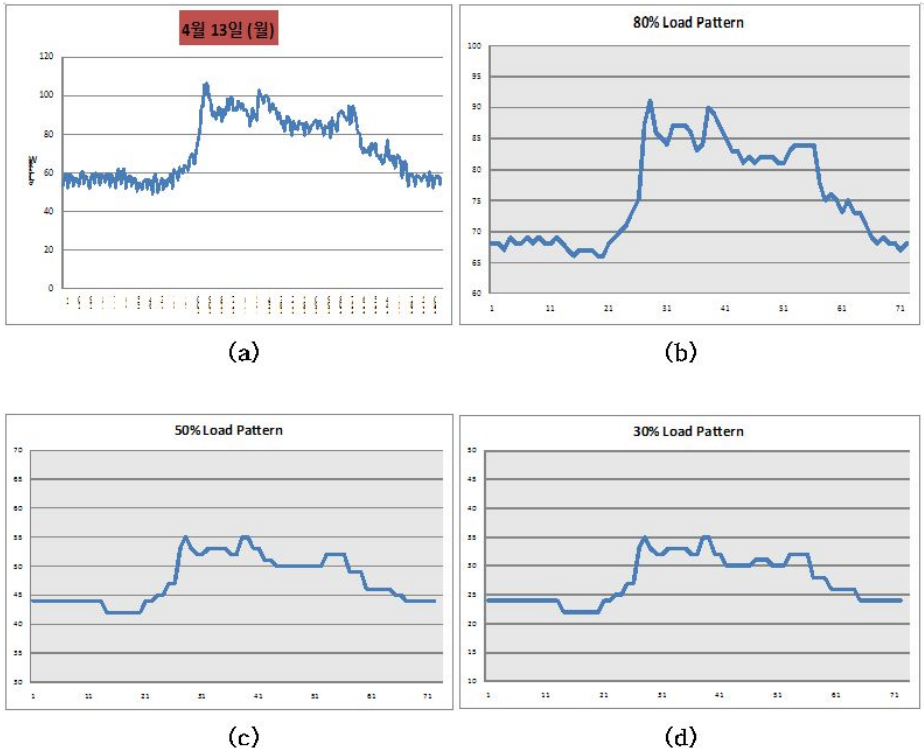




▲ Measured wind pattern & M-G set

❑ 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

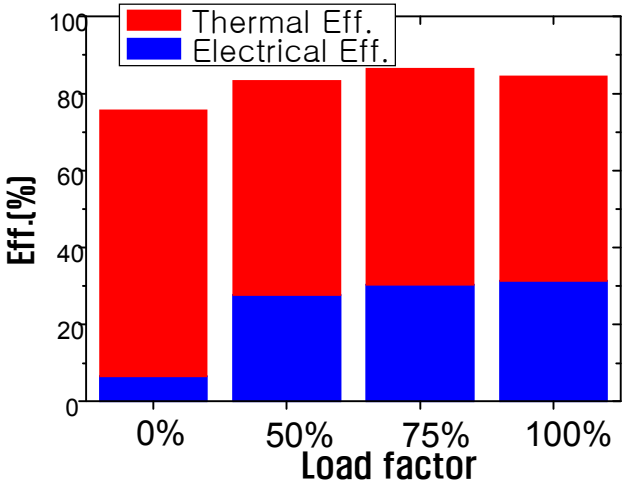


▲ Measured load pattern(a), scale-down patterns(b-d)

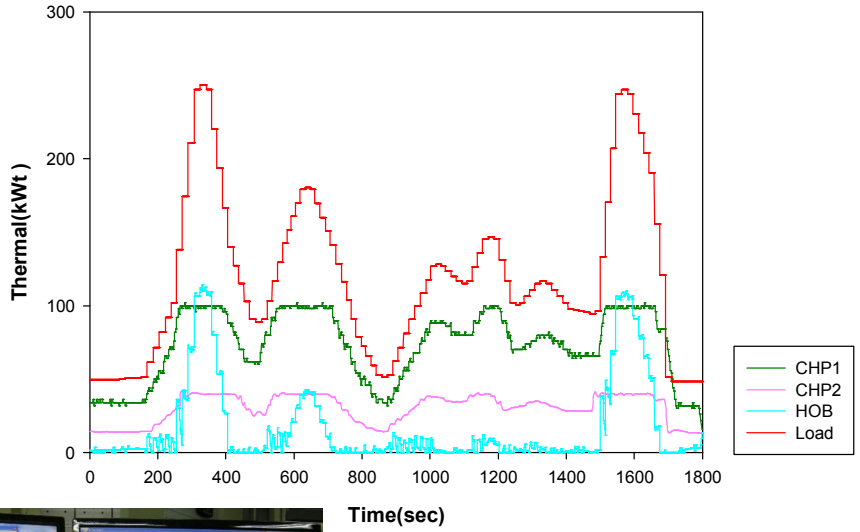
▲ Load bank & controller

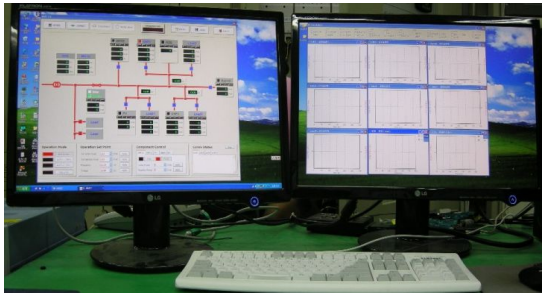
❑ CHP Simulator

- ✓ 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



▲ Typical G/E output char.





▲ EMS & thermal load pattern

❑ 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

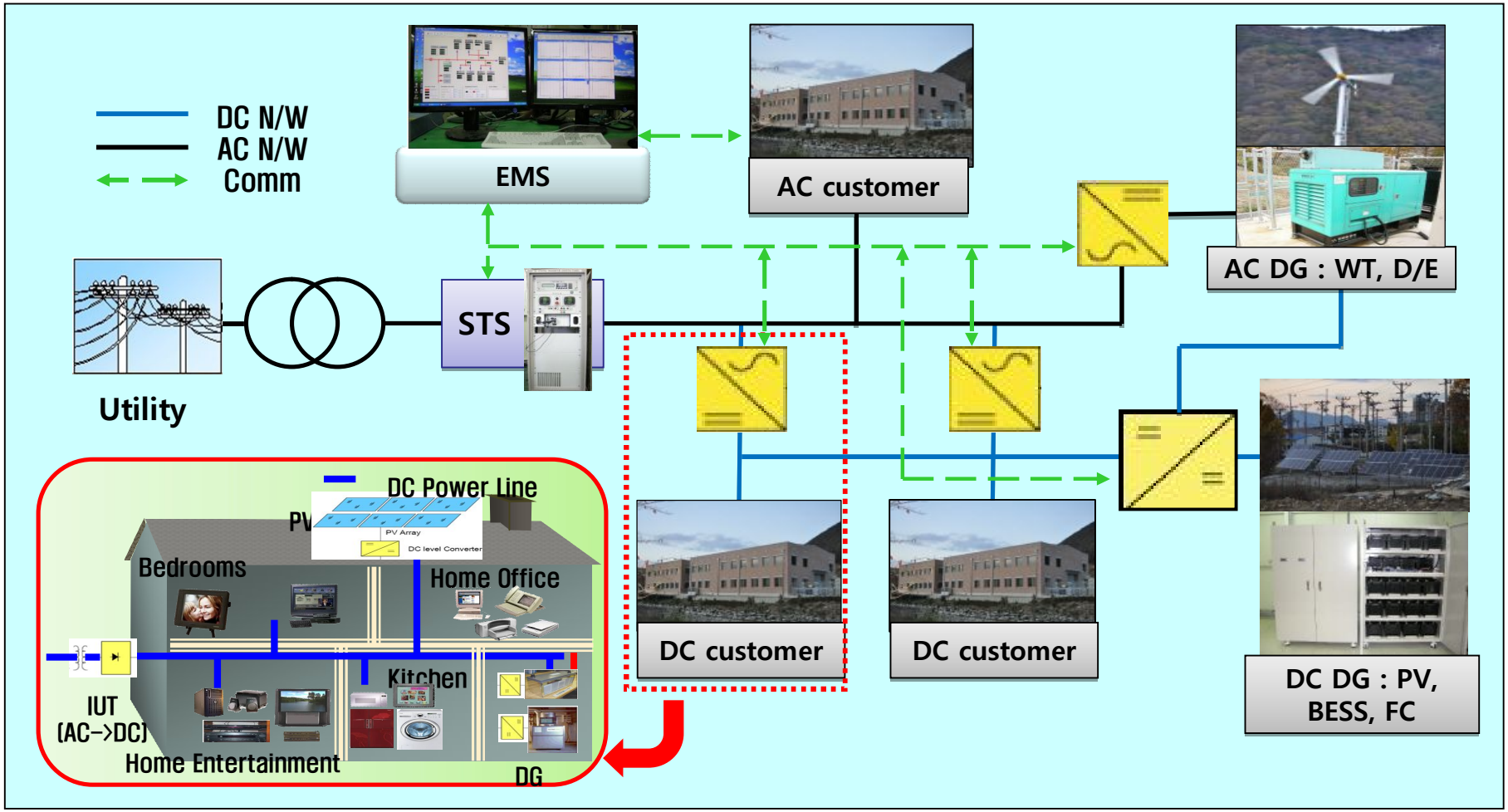
▲ IED

▶ IED/STS Panel

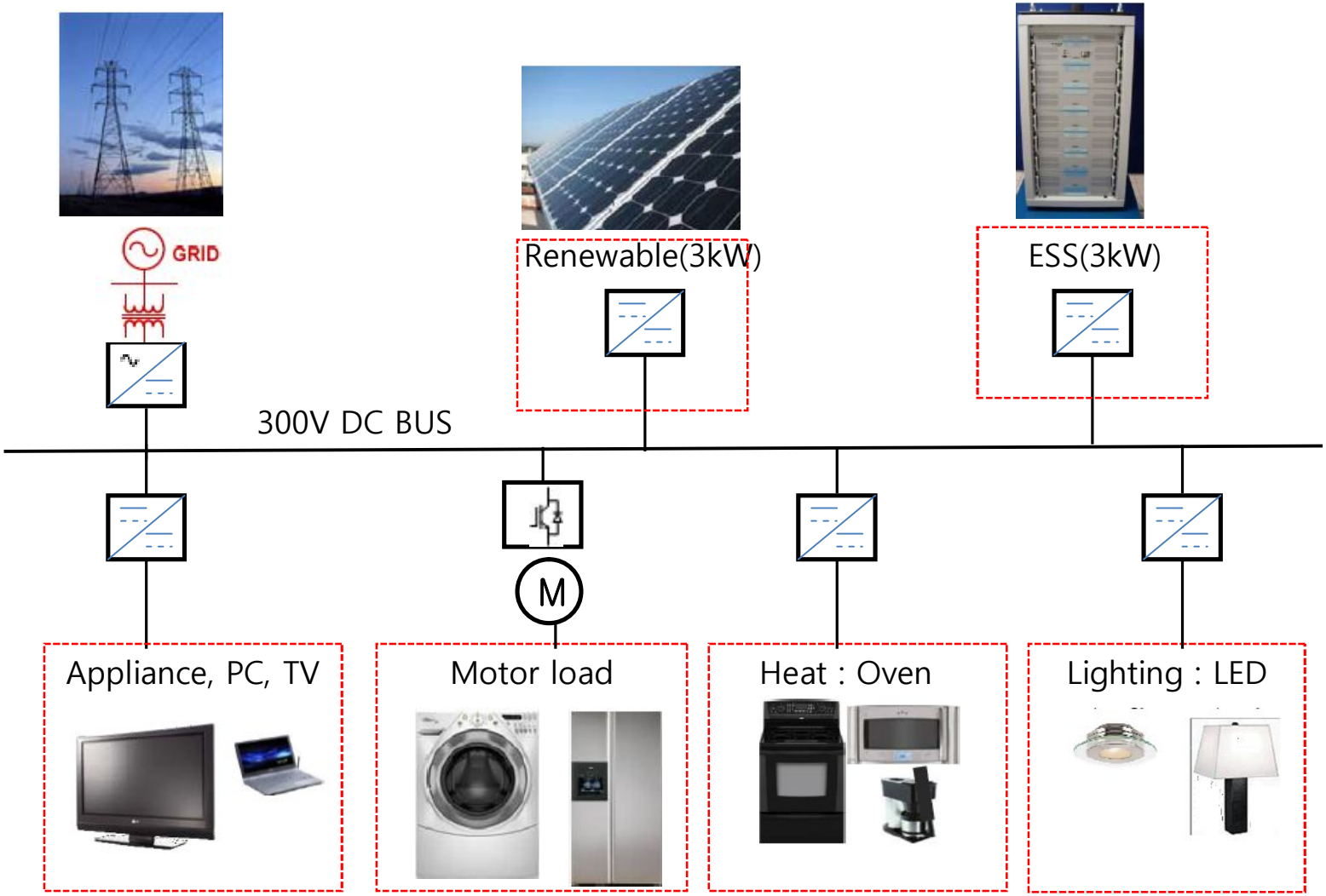
III. On-going projects & Future works

❑ KERI Microgrid projects : Target

- ✓ AC-DC integrated power system for LV customer
- ✓ Actual load test in demonstration site : building in KERI



✓ Integration of DC distribution equipments – Home & building



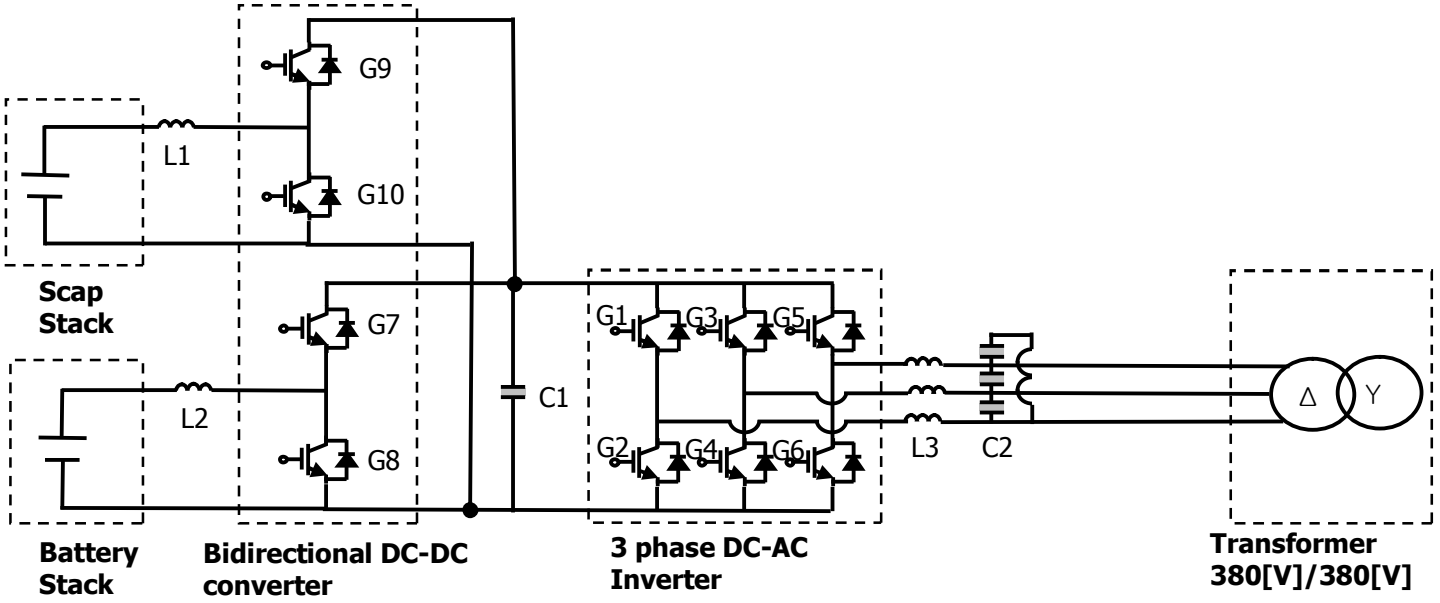
✓ System upgrade(I) : EMS

- Functions implemented
  - Export/Import control at PCC
  - Supervisory control of BESS
  - Thermal load following
- Functions planed
  - Forecasting : load & generation
  - Generation scheduling : Unit Commitment
  - Economic dispatch

Generation Schedule & Dispatch	Supervisory Control
• Make the balance between demand and supply • Optimize the objective function related to Microgrid system • For the generation schedule & dispatch : Forecast (Load & Renew Gen), UC and ED Algorithm	• Tie-line control (Power and voltage control at PCC) • Upstream power system fault detection and disconnection • Reconnection to upstream power system • Secondary regulation regarding energy storage system

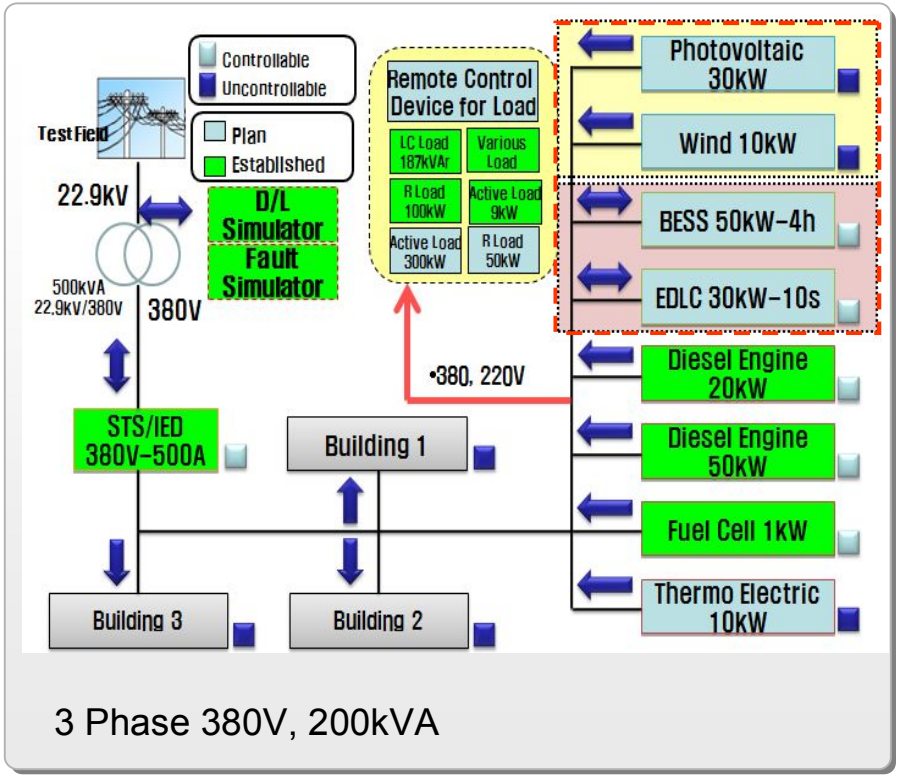
✓ System upgrade(II) : ESS(energy storage system)

- 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



3 Phase 380V, 200kVA

✓ 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

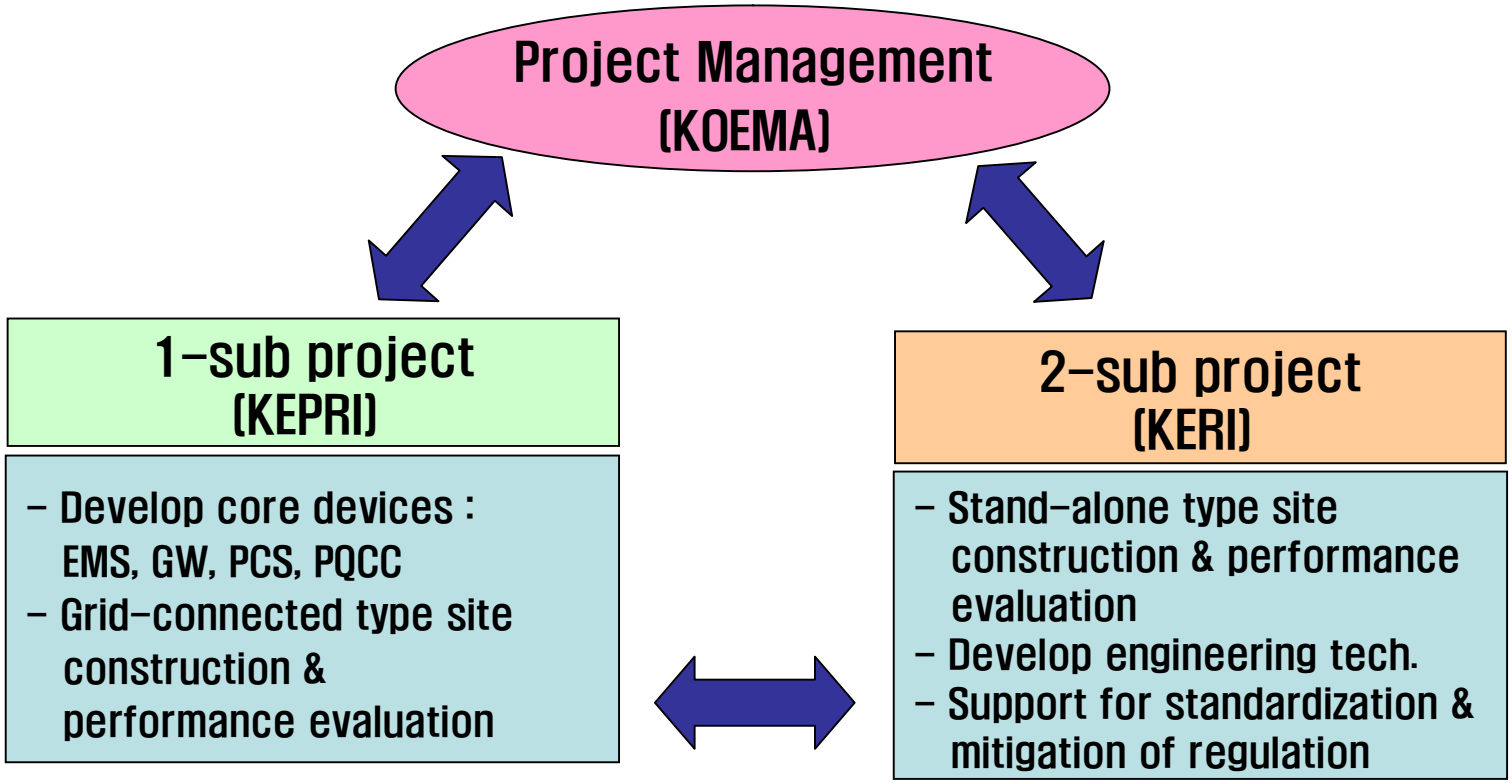
- PCC Power Flow Control in connected Mode
- Transition to Islanded Mode/Resynch.
- Frequency and Voltage Control in Island Mode
- Economically Optimized Dispatch
- Black Start, Power Quality Compensation

✓ Purposes

- Operation Test with Real-Site Load
- Demonstrate a Low Voltage Commercial Power Supply System

❑ National projects on Microgrid

✓ Phase II(2010-2012) plan

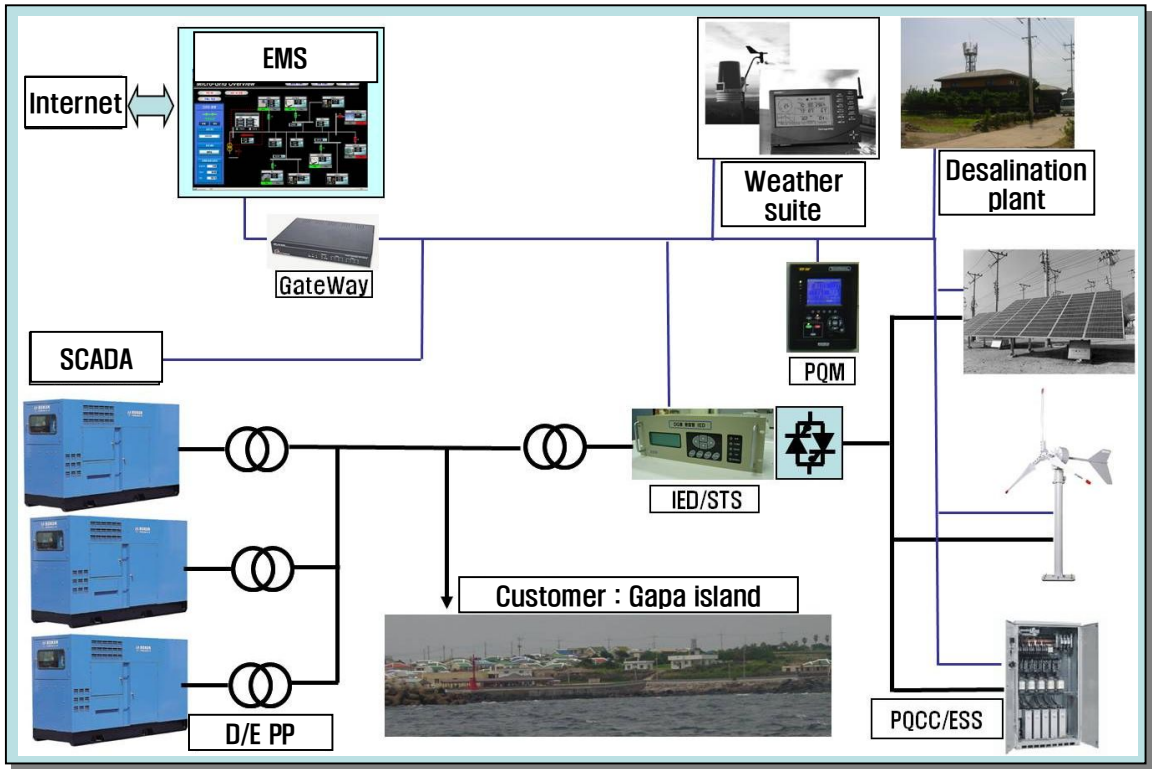


- Device provides : EMS, GW, PCS etc
- Device test : Before installation
- Technical support for grid-connected type : Basic design, spec., procedure of test

✓ Construction of Stand-alone MG site & Development of engineering tech.

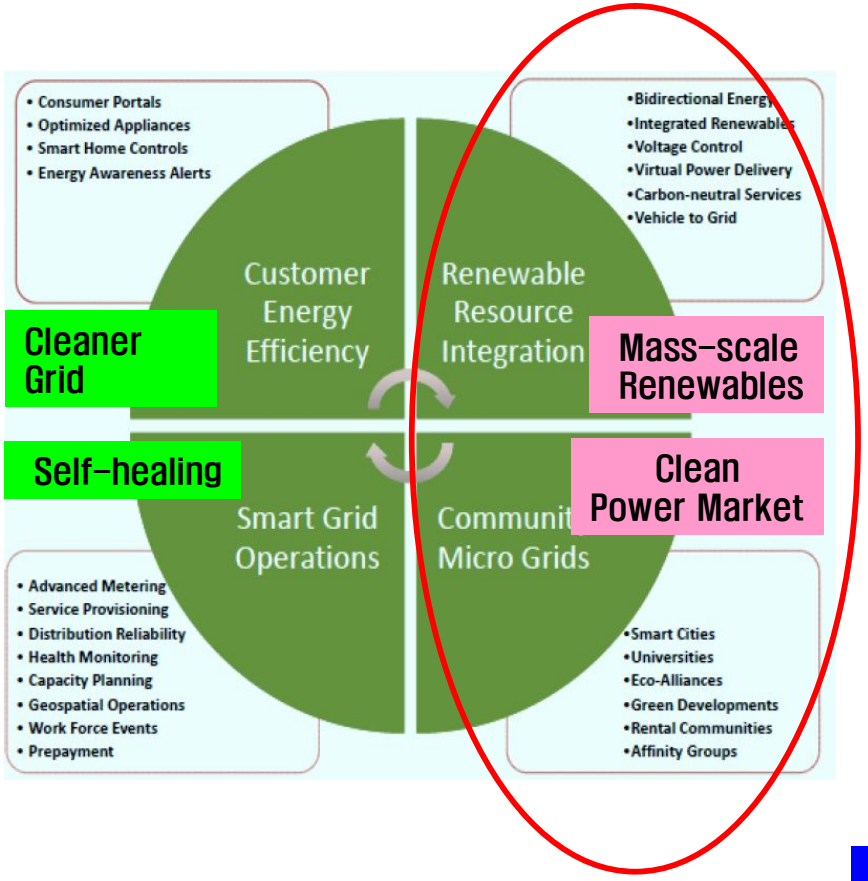
Summary

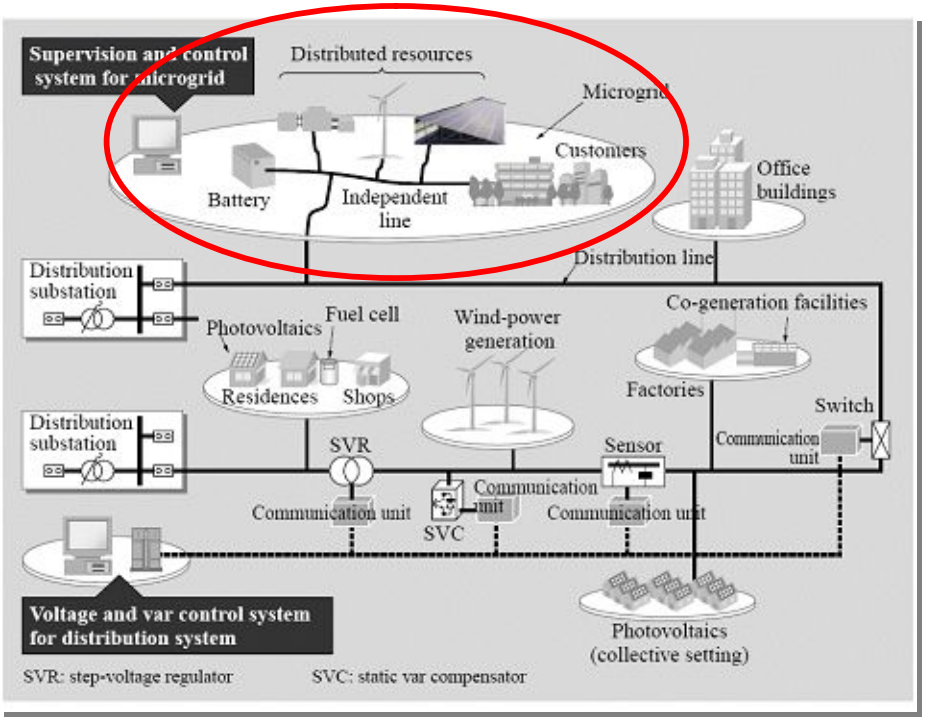
- [Definition] Proof of platform for smart renewables
- [Target] Construction of Independent MG Site(Several 100kW class)
- [Period] 2010-2012(3yr)
- [Budget] $2M



IV. Conclusion & Vision

❑ KERI Microgrid Vision





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!