Development and Demonstrations of Microgrid Energy Management Solutions in Korea

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Smart Grid Laboratory

LS IS

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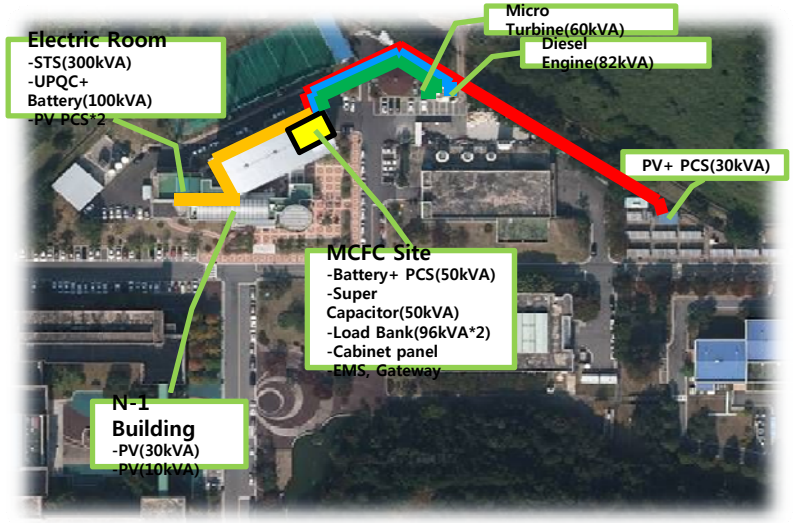
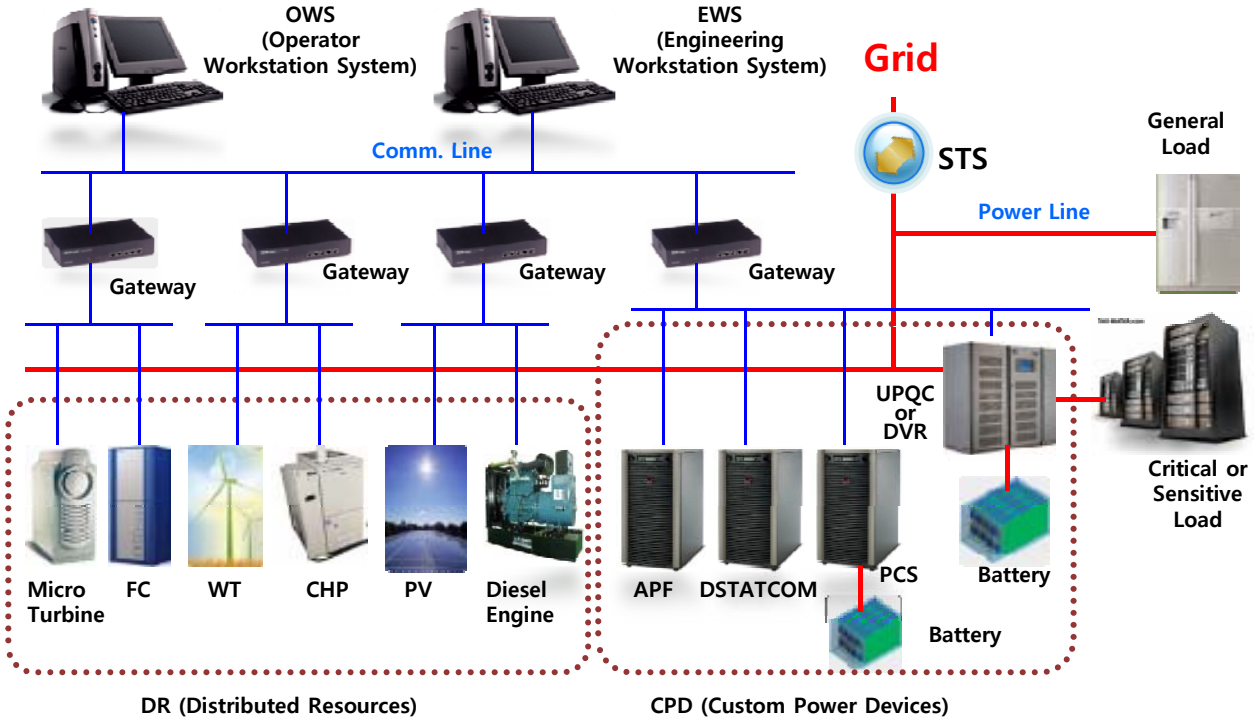


Case Study : LSIS EMS Solutions

Microgrid EMS(Energy Management System) Solution in Korea

General Configuration

Renewables Gen. Forecast	Elec/Heat Load Forecast	Fluctuation Stabilization	Demand Response
SCADA	Generation Schedule	Economic Dispatch	Automatic Gen. Control



Test-beds

Microgrid Project – 1st Phase	
Period	`07.08~`09.07
Location	KERI (Changwon, Korea)
Functions	SCADA, AGC

Microgrid Project – 2nd Phase (On-Grid)	
Period	`10.02~`13.01
Location	KEPRI (Daejon, Korea)
Functions	On-Grid (Full Functions)

Microgrid Project – 2nd Phase (Off-Grid)	
Period	`10.02~`13.01
Location	Mara-island, Korea
Functions	Off-Grid(Stabilization, Gen Schedule)

Smart Renewable Project	
Period	`09.12~`13.05
Location	Cheju-island, Korea
Functions	On-Grid(Stabilization, BESS Schedule, Electricity Transaction for Market)

Components

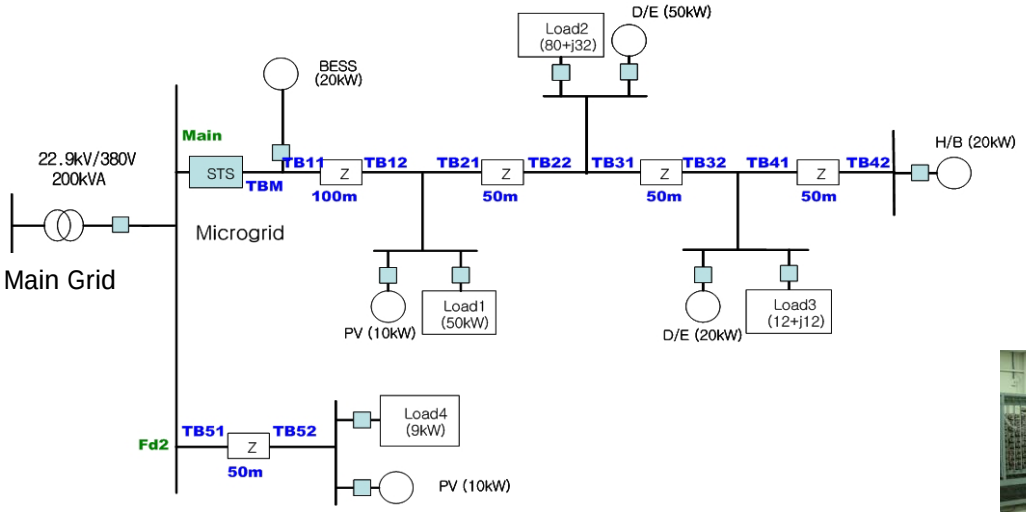
- KERI, Changwon / `07.08~`09.07 (2 years)

Microgrid EMS

- SCADA
- Economic Dispatch
- Automatic Gen. Control

Renewable Energy	Photovoltaics, Wind Simulator
Dispatchable Generations	2 x Diesel Engines (50kW, 20kW)
Energy Storages	Battery (10kW)
Controllable Load	

System Configuration



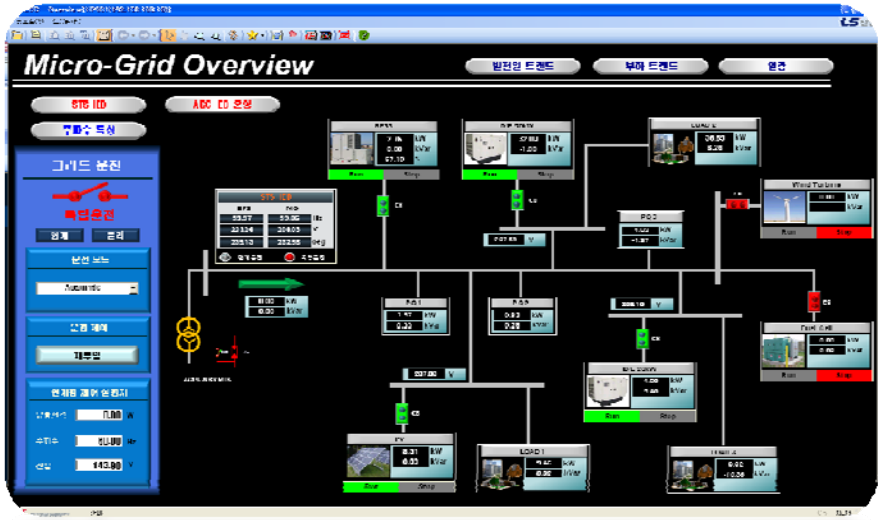
Equipments in Laboratory






Off-grid transition test

- AGC Mode: Constant Tieline Flow Control & Constant Frequency Control
- Set Flow: within 5% of full load
- Control Unit: 2 x Diesel Engines



No AGC Operation

AGC Operation

Components

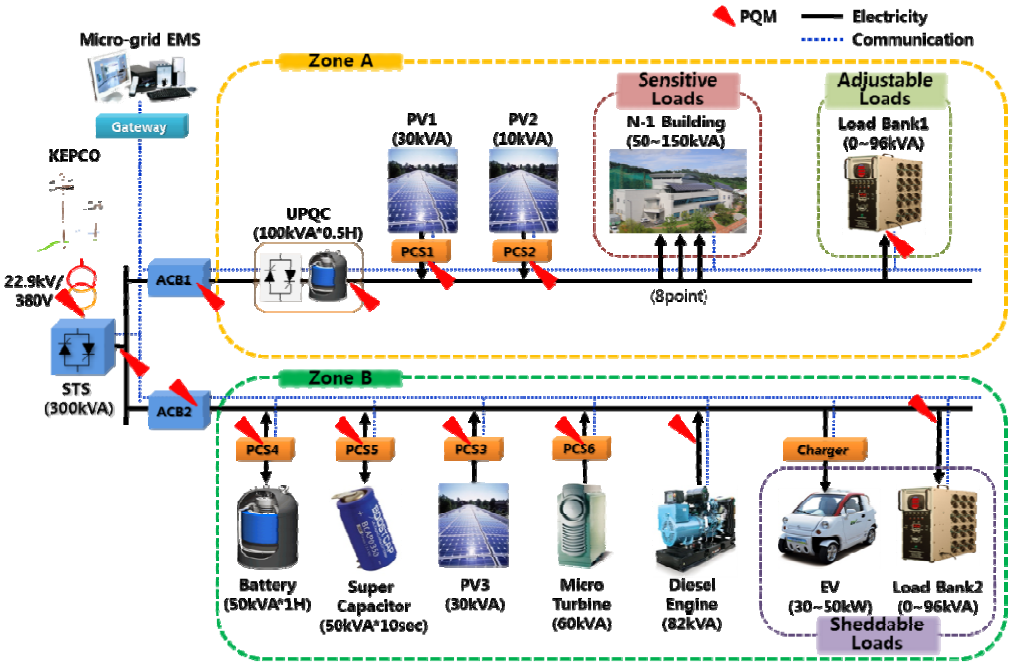
- KEPRI, Daejon / `10.02~`13.01 (3 years)

Microgrid EMS

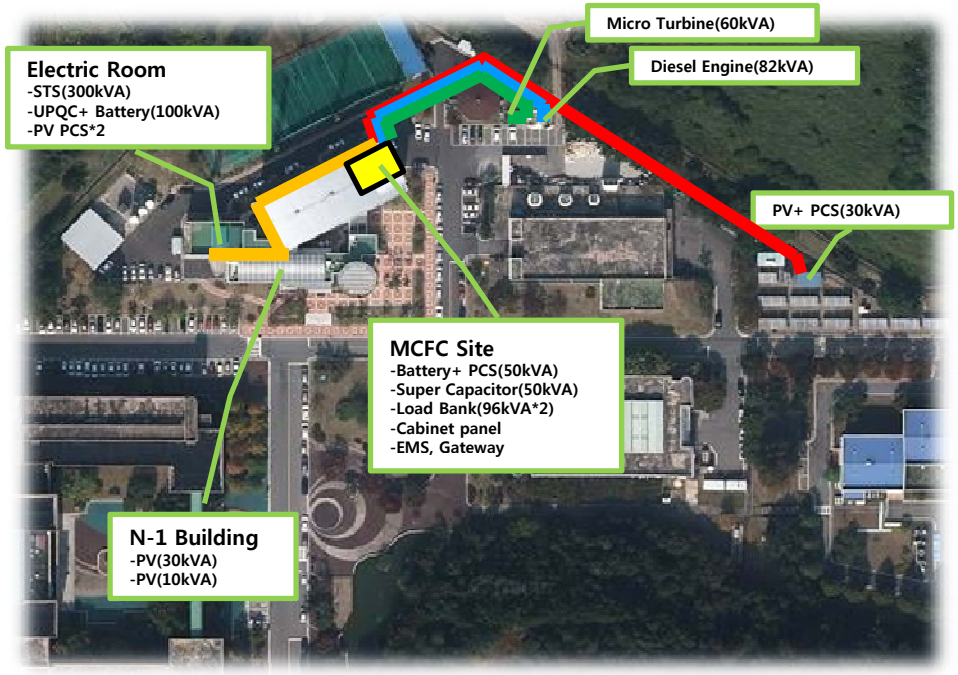
- SCADA
- Load/Gen Forecasting
- Generation Schedule
- Economic Dispatch
- Automatic Gen. Control
- Demand Response

Renewable Energy	Photovoltaics
Dispatchable Generations	Micro Gas Turbine, Diesel Engine
Energy Storages	Battery, Super Capacitor
Power Quality Compensator	UPQC

System Configuration



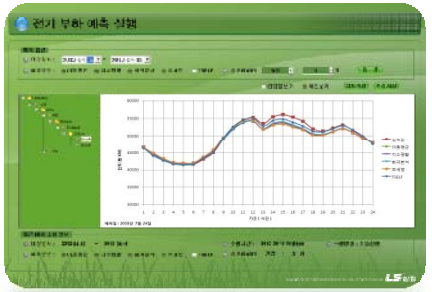
Air view



Load Forecasting

Electric Load Forecasting Results

- TSELF method has lowest mean error.



Forecast Method	Mean Error
Moving Average	1.57%
Exponential Smoothing	1.71%
Regression Analysis	1.43%
Trend Method	1.88%
TSELF	**0.87%**

Heat Load Forecasting Results

- TSELF method has lowest mean error.

Forecast Method	Mean Error
Moving Average	28.75%
Exponential Smoothing	25.87%
Regression Analysis	22.26%
Trend Method	31.18%
TSELF	**15.25%**

Generation Forecasting

PV Generation Forecasting Results

- KMA Connection Method has lowest mean error.

Forecast Method	Mean Error
KMA Connection	**2.65%**
KMA Disconnection	14.45%
3 Days Average	4.34%

Wind Generation Forecasting Results

- KMA Connection Method has lowest mean error.

Forecast Method	Mean Error
KMA Connection	**44.50%**
KMA Disconnection	57.30%
3 Days Average	51.70%

Under Further Development for better performance

General Setting

- Operate run and stop
- Input and change data about generation output characteristic

Special setting for each function

Generation Schedule

Economic Dispatch

Automatic Generation Control

Comparison to tariff

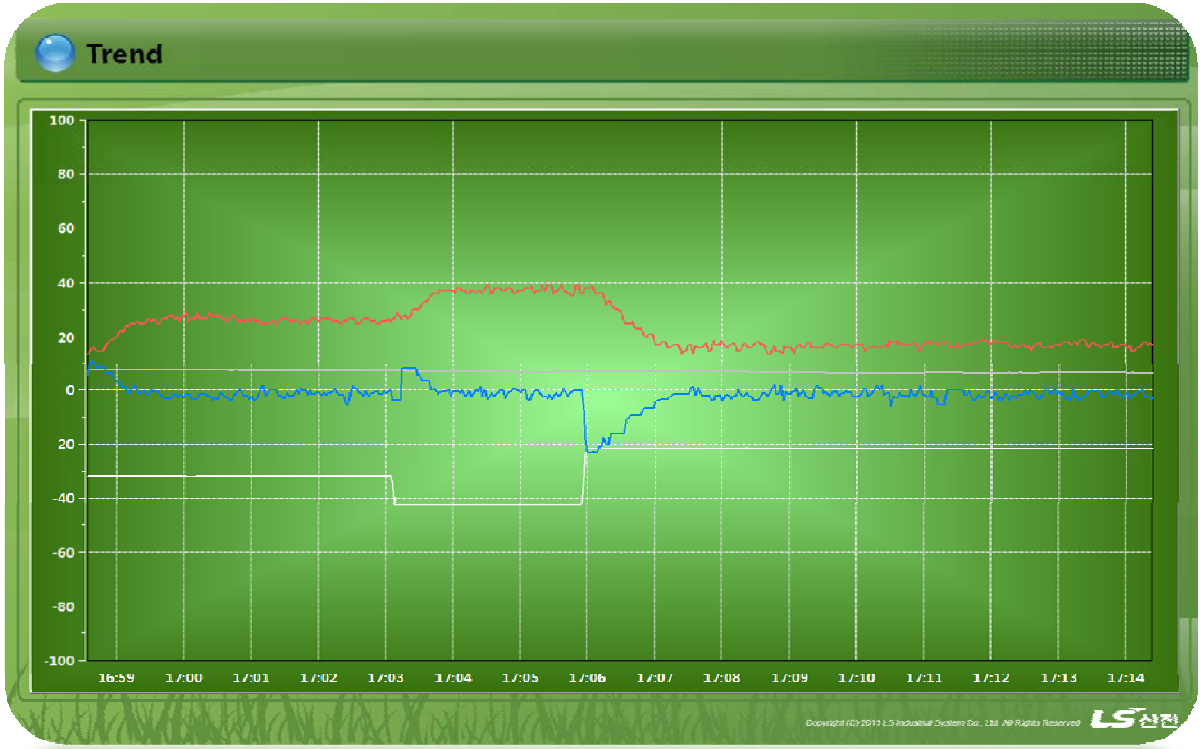
- Select one load source and multi tariff
- Compare total cost each tariff

Load Shedding

- Decide to order of priority for load shedding in advance
- Set load shedding reference curve
- Monitor real time load
- Over the reference amount, load will be shedded

Grid connected test

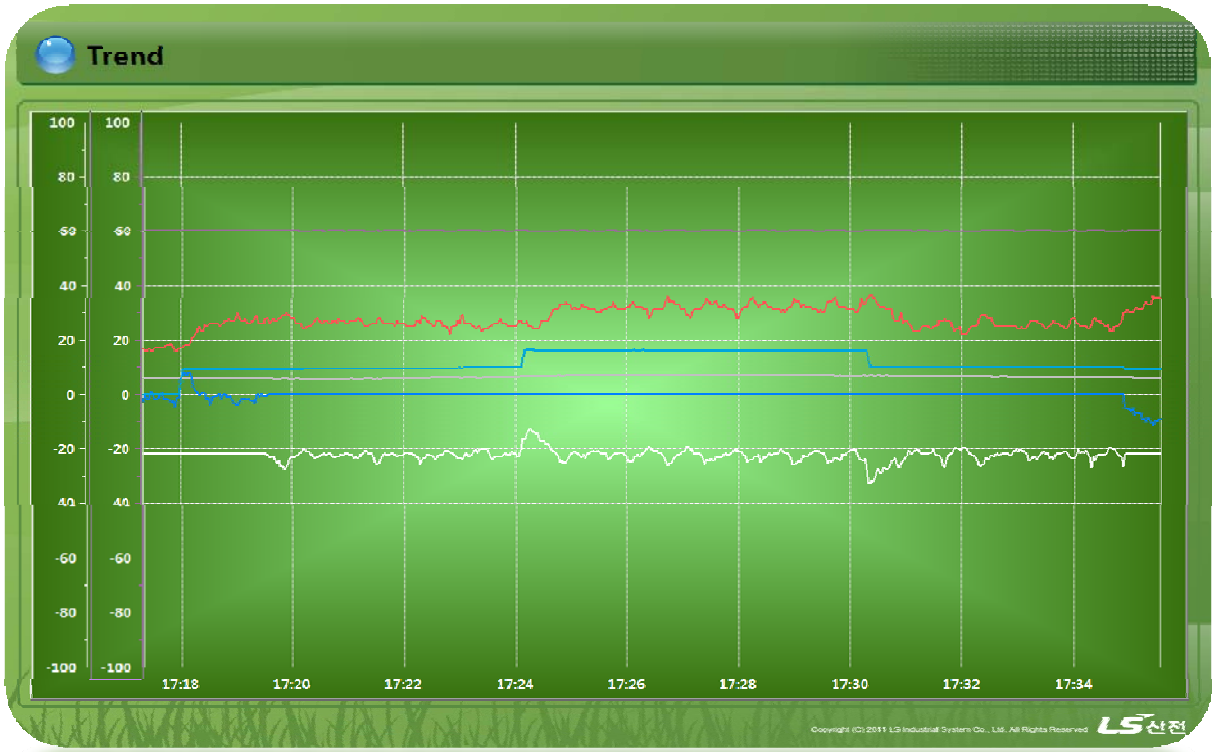
- AGC Mode: Constant Tieline Flow Control
- Set Flow: 0kW
- Control Unit: Diesel Engine
- Change to active power of BESS



PV active power
BESS active power
Diesel active power (AGC Control)
Tieline Flow (AGC Result)

Stand alone test

- AGC Mode: Constant Frequency Control
- Set Frequency: 60Hz
- Control Unit: Diesel Engine
- Change to active load of dispatchable load



- PV active power
- BESS active power
- Diesel active power (AGC Control)
- Tieline Flow
- Load
- Frequency (AGC Result)

✓ The most noticeable plan in South Korea's smart grid project is the construction of a Smart Grid Test-bed on Jeju Island on 2009.

Project Overview

Entity

- Administrator : Korean Government
- Participants : Over 168 Companies in five areas

Goal

- Construction of state-of-the-art Smart Grid reference site
- Early commercialization of Smart Grid technology

Period

- Total 42 Months: '09.12.01 ~'13.05.31
- 1st phase: '09.12.01 ~ '11.05.31
- 2nd phase: '11.06.01 ~ '13.05.31

Funds

- Matching fund between the government and participating companies
- Government contribution: ₩37billions

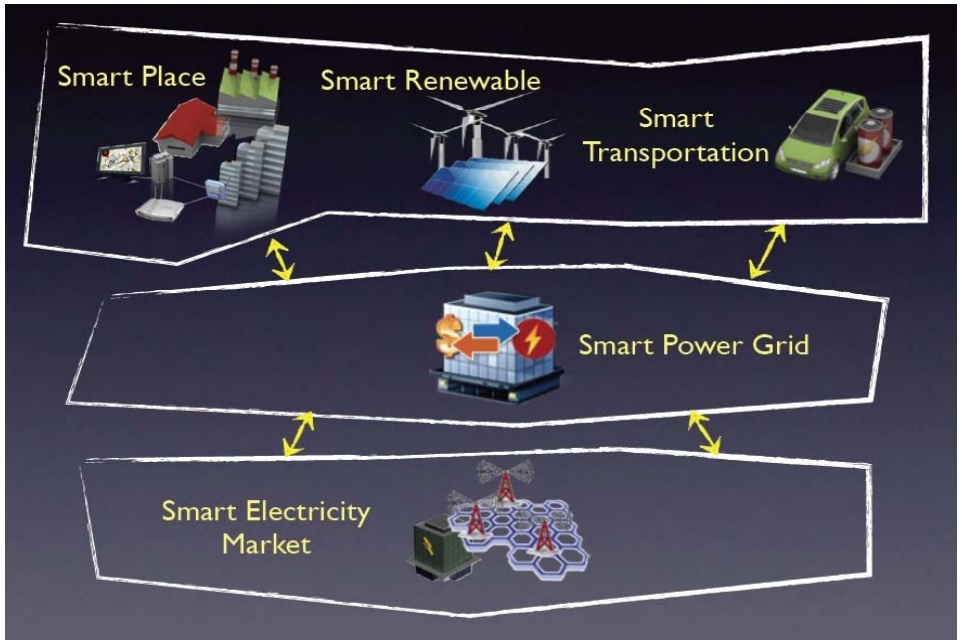
Jeju Test Bed

Location & Size

- Location : Gujwaup, Jeju Island
- Size : Total Number of Test Bed households about 3000
- D/L : 2 Substations and 4 Distribution lines
- Note : Utilizes existing wind farm for the Test Bed Project

- ✓ Smart Place, Transportation, Renewable, PowerGird, and Electricity Service
- ✓ LSIS is leading and participating in all areas

Test Bed Areas



Key Tasks in each area

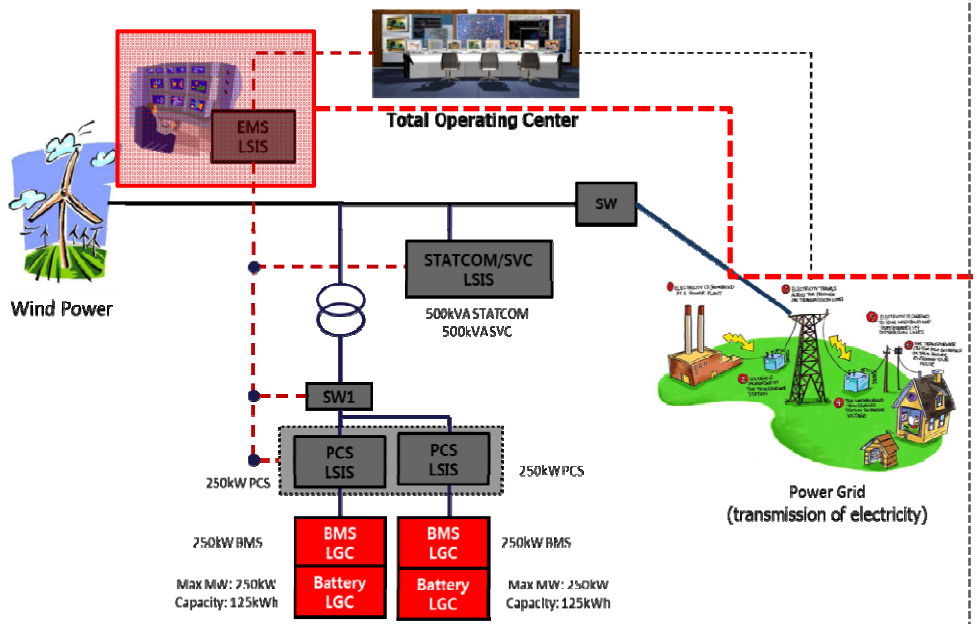
Smart Place	▪ Improve energy consumption efficiency - Development of AMI - Development of DR mechanism
Smart Trans-portation	▪ Enhance EV and charging infrastructure - Establish & upgrade of charging infra - Network based monitoring and control of EV operation information
Smart Renewable	▪ Experiment renewable energy technology - Regarding renewable energy sources - Including energy storage, PCS, EMS , SATCOM, Stabilizer for renewable generation
Smart PowerGrid	▪ Upgrade T&D System - Intelligent distribution, digitalized substation - T&D real-time monitoring for wide area
Smart Electricity Service	▪ Operate energy trading market - Various bi-directional power trading service - Total Operating Center(TOC) in test bed

Smart Renewable

- Experiment renewable energy technology
  - Regarding renewable energy sources
  - Including energy storage, PCS, EMS , SATCOM, Stabilizer for renewable generation

Operating Center

System Configuration



Smart Rnewable EMS

same as

Microgrid EMS

BESS Schedule

- Automatic system
- Optimize battery charging/discharging schedule using wind power and electricity price forecasting information
- Generate bidding data combining wind power and battery schedule

PCS Control

- Operate mode: smoothing, unit power control, feed flow control
- Stop if battery SOC is over than 95% or under than 5%
- FFC is a powerful function for power stabilization