

KOREA Smart Grid Program and SKA Power System

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1. KOREA Smart Grid Program

Korea's New Vision : Green Growth !

Declared Low Carbon, Green Growth as Korea's New Vision

(August 15, 2008)



Last Generation

**Industrialization
(Quantity Growth)**



Next Generation

**Low Carbon,
Green Growth
(Quality Growth)**



President Lee said that
Green Growth is not a option but a must-do.

Smart Grid Lead Country

In 2009, MEF Leaders announced
10 low-carbon and climate friendly technologies.



Smart Grid
(Lead Country :
Korea, Italy)

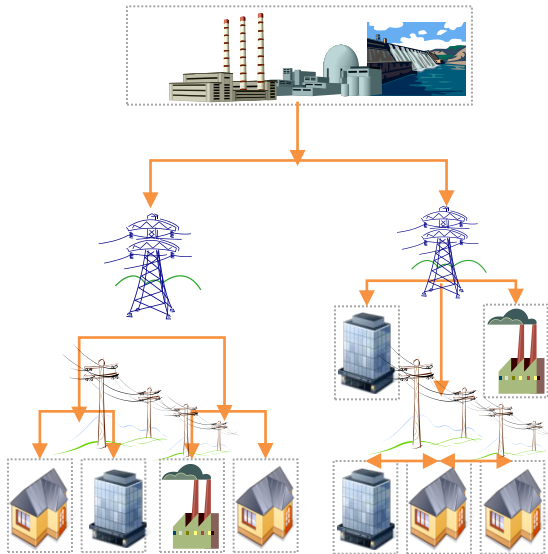


**Smart Grid
Technology
Action Plan**

Created and
Released in Dec, 2009

Paradigm Shift in Power Industry

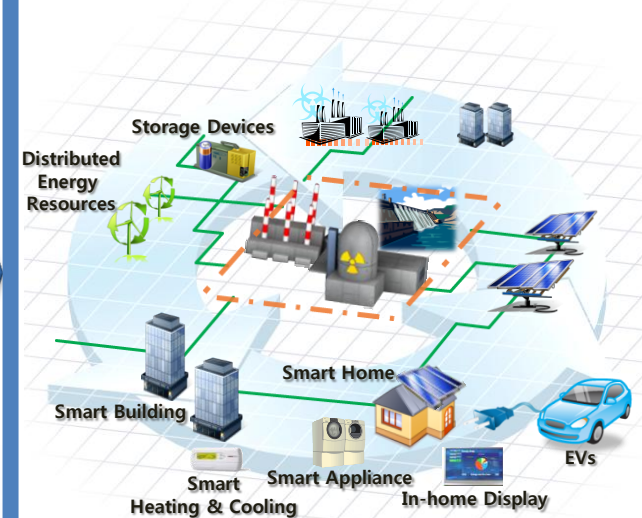
Present



Smart Grid

- Self-healing
- Grid Automation
- Customer participation
- Optimization
- Outage prevention
- Integrated network
- Information security

Future

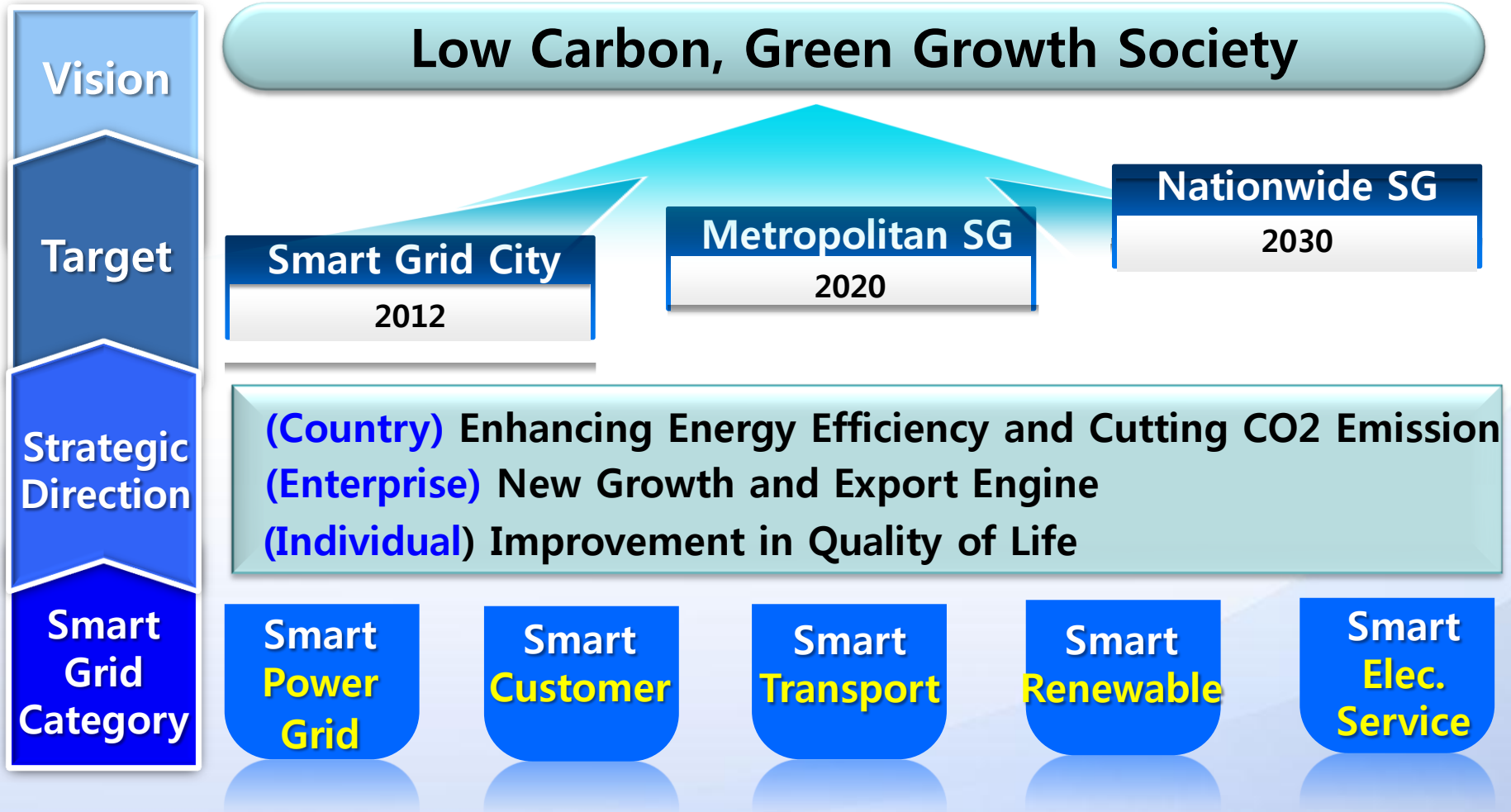


- **Centralized** generation
(Large-scale Generation using **fossil fuel**)
- **One-way** power & information flow
- **Supplier-oriented** facility operation

- **Centralized & distributed** generation
(Expansion of **renewable** energy)
- **Two-way** power & information flow
- **Customer participation** in facility operation

Korea's Smart Grid Vision

Korea's Smart Grid Roadmap



KEPCO's Smart Grid Vision

KEPCO's Smart Grid Master Plan

Vision

Global Smart Grid Leader

Target

Renewable Energy : 10%, Cost Reduction : 31billion dollars,
Overseas Sales : 40 billion dollars

Strategic
Direction

Peak Reduction
& Load Leveling

Intelligent
Power Grid

Expansion of
Renewable Energy

Standardization &
Security for SG

Creating
New Growth
Engine for Future

Strategic
Item

1 Energy efficiency on the basis of AMI, DR

2 Peak shaving using large-scale battery

3 Intelligent power grid (T & D)

4 Integrated SG operation system

5 Stabilization of renewable energy output

6 Power generation forecasting system

7 Global Smart Grid Standardization

8 SG security infrastructure

9 Embracing EV, electric energy house

10 Global market penetration strategy

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2. Jeju Smart Grid Test-bed

Overview(1)

Goal

To Develop Smart Grid into the Business Model and the Export-Oriented Industry

Period

Dec, 2009 ~ May, 2013 (42 months)

Budget

About 240 million dollars

Scale

**2 substations, 4 distribution lines,
Around 6,000 households**



5 sub-projects of Smart Grid

Smart Power Grid

- Real-time monitoring & control for intelligent T&D power system

Smart Place

- Enhancing energy efficiency through demand response
- Two-way information exchange between consumers and suppliers

Smart Transportation

- EV charging infrastructure
- Control center for charging infrastructure

Smart Renewable

- Connection of renewable energy to the grid
- Power quality compensation & stabilization of output

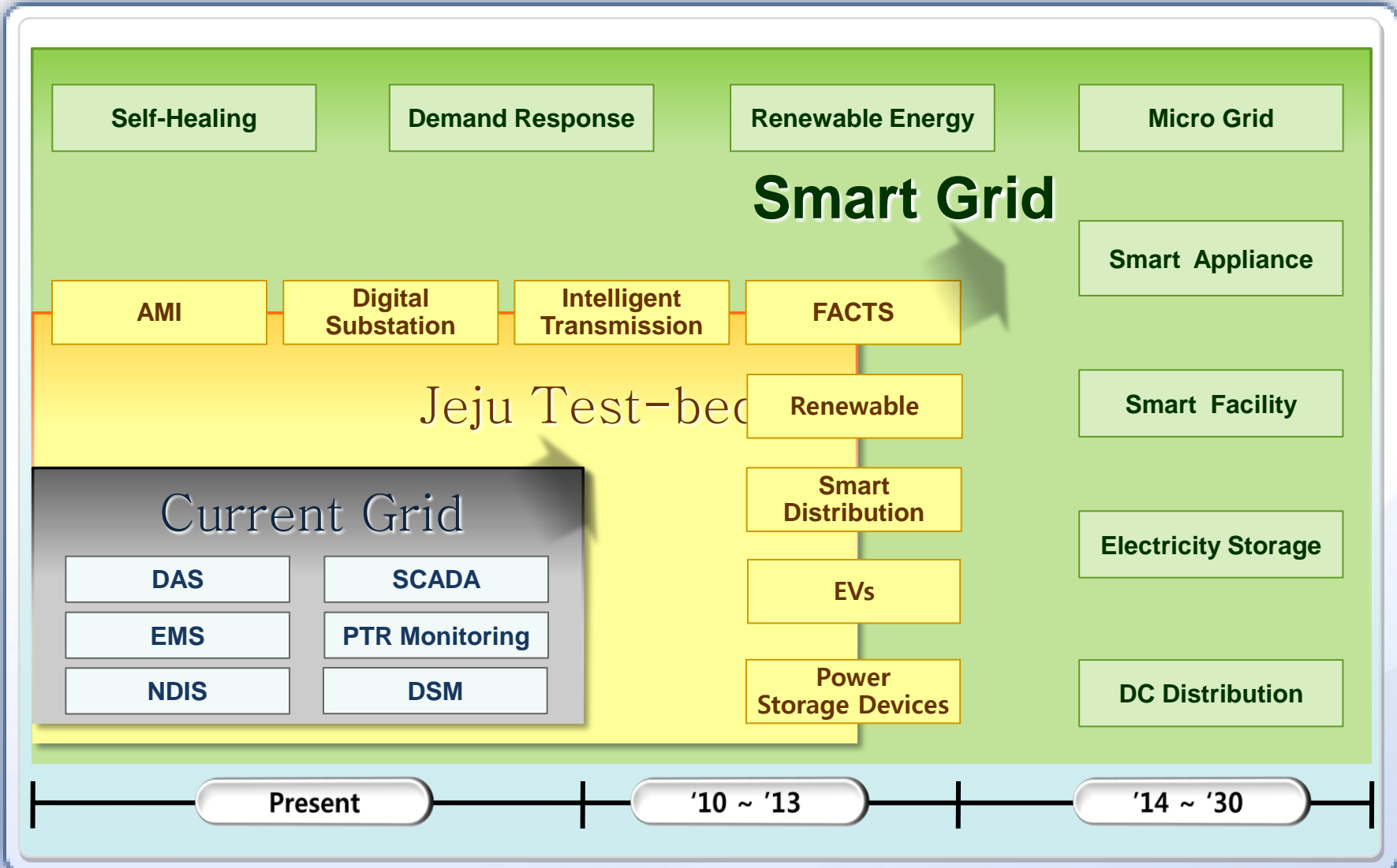
Smart Elec. Service

- Development of various tariffs and service models

Bird 's-eye View



Test-bed's Role



Smart Grid Information Center





3. SKA Power System Infra

KEPCO can do in relation the SKA

- 1. Activity EOI(Expression of Interest)**
- 2. Participate review of SKA Stage 1 work package consortium**
- 3. SKA power supply system in the domestic research and development prior project review**
- 4. Korea's Jeju Smart Grid introduction experimental results**
- 5. The ultimate goal SKA project power supply system**

KEPCO an EOI to Activity

3 SKA.TEL.PWR – Power

4 SKA.TEL.PWR.SUP – Power Supply to SKA

4 SKA.TEL.PWR.EMM – RFI and other low emission investigations

4 SKA.TEL.PWR.GRID – SKA Grid and Distribution Network

4 SKA.TEL.PWR.LOC – Locally Powered Remote Station Power Block

4 SKA.TEL.PWR.PMC - Power Monitoring and Control

4 SKA.TEL.PWR.ENV – Environmental / Ecological Impact of Power Provision

4 SKA.TEL.PWR.ENV – Power Infrastructure Requirements

KEPCO an EOL to Participate

Power (PWR)

52 Respondents

(* Lead = Expression of interest to lead Element; Full = full coverage of the work within the Element; Cons = Consortium; Y = Yes; N = No; P = Participate)

- ABB Australia (Lead: Y; Full: N; Cons: N)*
- Alberta Centre for Advanced Micro&Nanotech Products
- ANSYS Limited (Lead: Y; Full: N; Cons: N)*
- ARC Centre of Excellence for All-sky Astrophysics
- ARIYA Project Managers
- Arup (Lead: Y; Full: Y; Cons: N)*
- Aurecon (Lead: Y; Full: N; Cons: N)*
- BCF Solutions
- Bigen Africa Services
- Canadian SKA Industry Consortium (NRC led) (Lead: Y; Full: Y; Cons: Y)*
- CCD Design & Ergonomics
- Circadian Solar
- Cisco International Limited
- Cobham Technical Services
- CTAER and IAA-CSIC (Lead: Y; Full: N; Cons: Y)*
- Dihlase Consulting Engineers
- Fluor Ltd (Lead: Y; Full: Y; Cons: N)*
- GE Intelligent Platforms (Lead: Y; Full: Y; Cons: N)*
- GHD (Lead: Y; Full: Y; Cons: N)*
- GHD Pty Ltd
- Hatch Associates (Lead: Y; Full: N; Cons: N)*
- Hitachi Data Systems
- INAF - Istituto Nazionale di Astrofisica
- KEPCO KDN
- Lockheed Martin Australia
- METHODE ELECTRONICS
- Mott MacDonald Ltd (Lead: Y; Full: N; Cons: N)*
- National Instruments
- National Physical Laboratory
- National Research Council of Canada
- NCRA-TIFR
- Nexeya Systems
- Norsat International Inc
- Nova Systems
- Omnisys Instruments AB
- Parsons Brinckerhoff (Lead: Y; Full: Y; Cons: N)*
- Prudent Energy Corporation
- Rapallo Consulting & Contracting Engineers (Lead: Y; Full: Y; Cons: N)*
- Reutech Radar Systems
- ROXTEC AUSTRALIA
- Sanyati Holdings (Lead: Y; Full: N; Cons: N)*
- Siemens Industry
- Siemens Nederland
- SKA South Africa (Telescope manager)
- SKA South Africa (Power, Site and Infrastructure) (Lead: Y; Full: N; Cons: N)*
- SSI Engineers and Environmental consultants
- STFC – Technology Department
- Tata Consultancy Services
- Telespazio VEGA UK Ltd
- The Boeing Company
- Tronicon Industries Inc.
- WorleyParsons Europe Limited (Lead: Y; Full: Y; Cons: N)*

Operation System for SKA Power EMS

Operation System

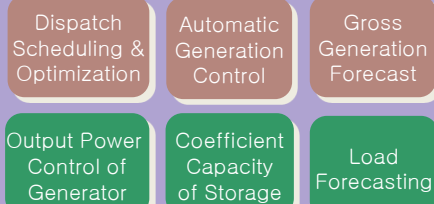
Remote Monitoring



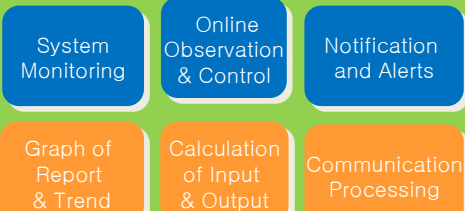
HMI of Control Center



Generation Control Application



Real Time Power Grid & Single Line Diagram



S-IDB(Smart Data Integration Bus)/IEC61850,IEC60870,DNP3.0



PV(100Kw)



EMS



TOC

SW

STATCOM,AVC

PCS

BMS

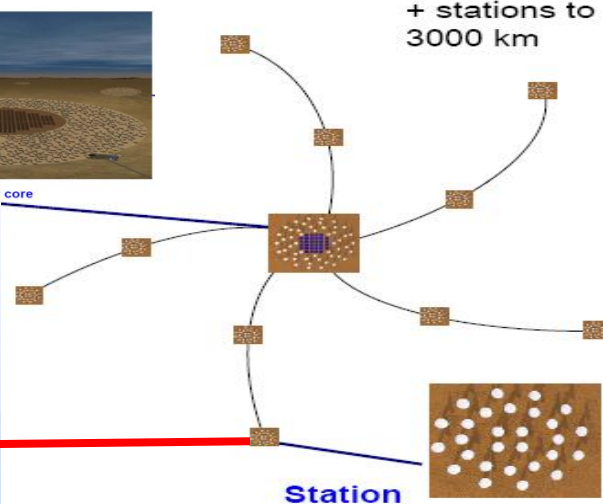
Battery

Load Bank



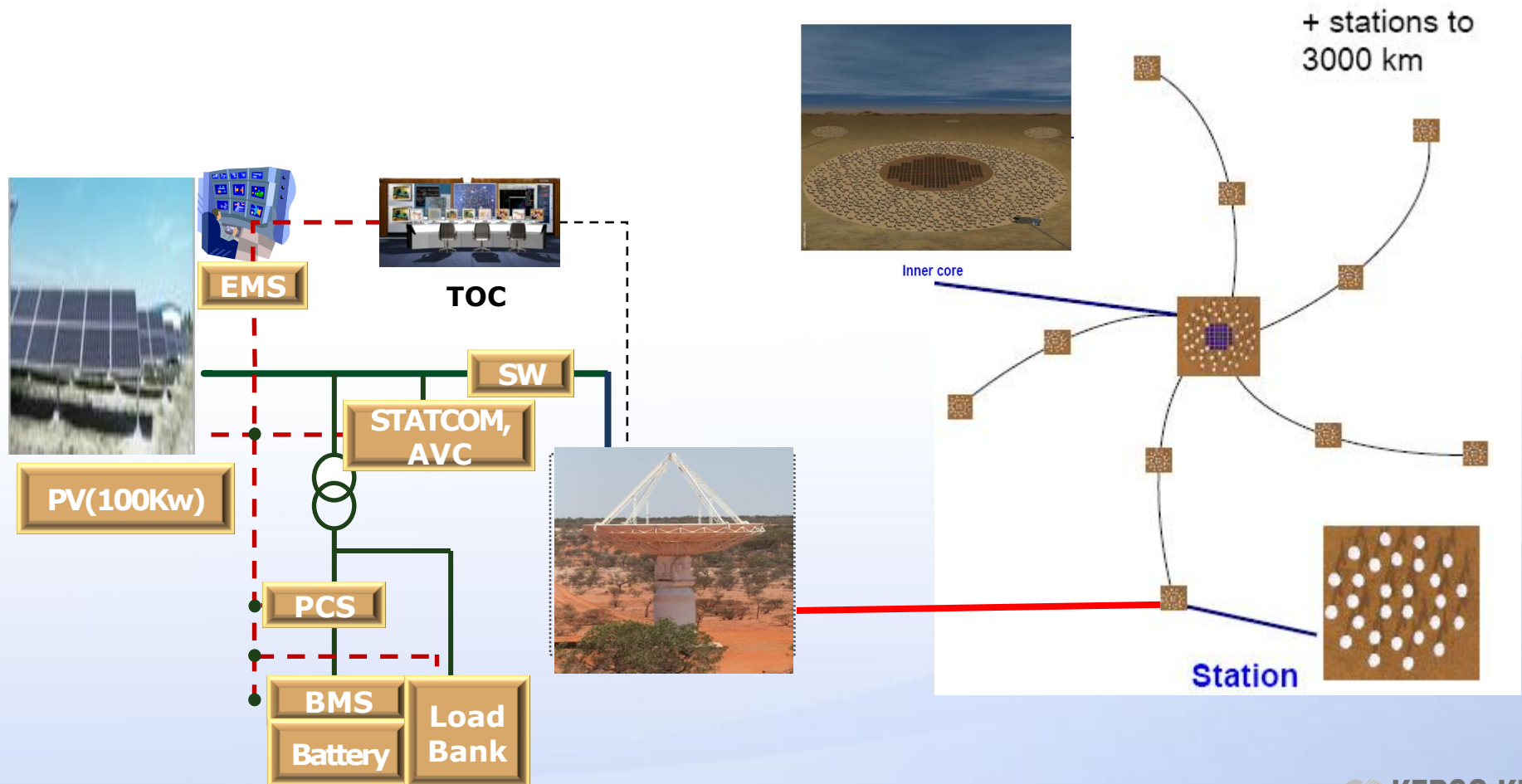
Inner core

+ stations to 3000 km



Target System Diagram for Station

Power System Design (PV 100Kw) for SKA.



Propulsive Strategy

Optimized PV(Photovoltaic) power supply system

- ◆ High technical skill of KEPCO support for SKA Project
- ◆ Maximum use of Smart Grid test-bed in JEJU for PV system

The optimized operational technology development for SKA EMS
The creative development of product for power supply
The utilization of high ICT skill

SKA EMS

- Load management base on Demand Respose(DR)
- AGC(Automatic Generation Control)
- Network Analysis(NA)
- Generation Schedule(GS)
- SCADA system base on IEC-61850

PCS & STATCOM

- High-efficiency PCS
- Battery Energy Storage System(BESS)
- Power Quality Compensation
- Dynamic Voltage Regulator
- Restraint power disturbance
- Voltage Stability Improvement using STATCOM

LiB & BMS

- Developing battery of longevity and large capacity
- Battery model for Hybrid
- Cell control technology
- Measuring battery data
- Insulation skill for High-Volt
- Control technique of charging and discharging

Design

- Design for optimized power supply system
- Design for optimized power generation
- Design for Biz. model
- Design for optimized operational management

Main configuration(PV 100Kw)

PV(Photovoltaic) Power System(100kW)

Function	AC↔DC Converting, Battery charging & discharging and output power control			
Contents	Class.	Companies	Capacities	Main Contents
	POWER SOURCE	Utility	100kW	<ul style="list-style-type: none">• PV POWER SOURCE(100kW)• A MODULE(230W) * 432EA
	PV PCS	IN-TECH FA	100kW	<ul style="list-style-type: none">• DC -> AC CONVERSION of PV POWER• PV OUTPUT POWER and BATTERY CONTROL
	BATTERY	NEXCON ATLAS BX	60kW	<ul style="list-style-type: none">• Chg & Dischg in accordance with PRODUCTION COST• FOR PV : 60kWh(2V*195Ah*150EA)

Photos of product

CELL



PCS



BMS



BATTERY



The Role of Participating Companies

KEPCO

KDN

1) EMS : Prediction of gross PV generation + Demand analysis

= **Reactive power calculation** & **Command of operating mode**

2) PCS : Output control of battery energy by EMS command

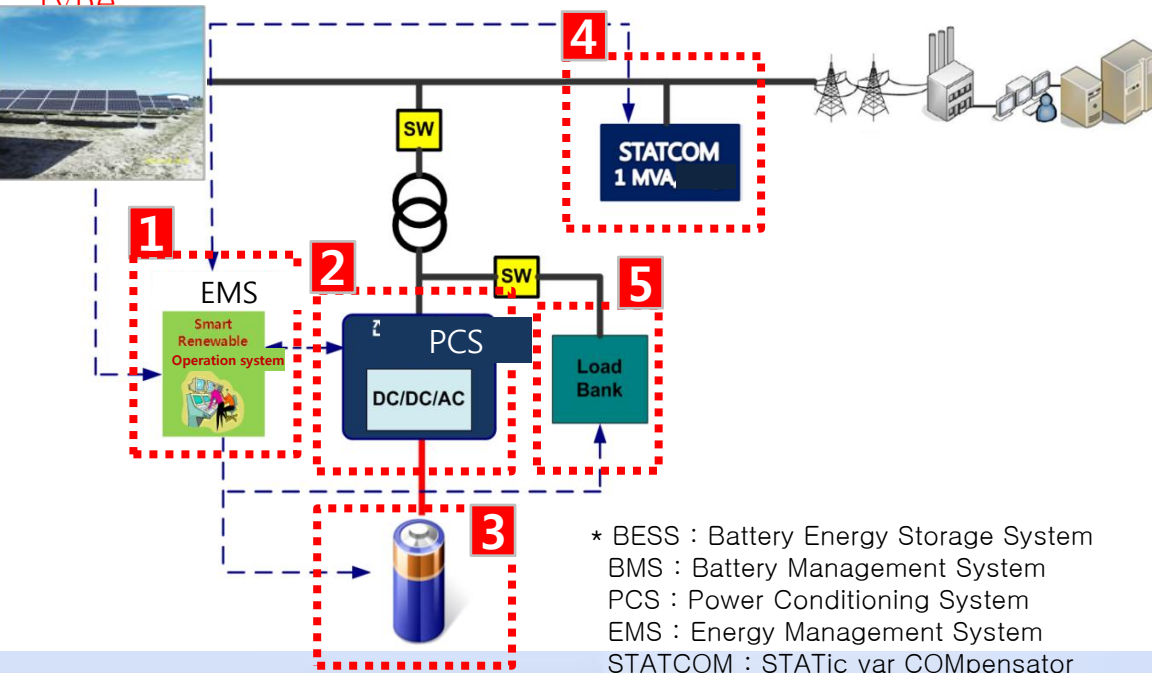
4) STATCOM : **Control of bus voltage and reactive power**

5) BESS/BMS : **Simulation of power generation control**

ATLAS BX / NEXCON

3) BESS(LiB) : Producing **BMS** and **LiB of Hybrid**

type



EMS

- Data collection
- Power generation prediction
- BESS/STATCOM control



PCS

- Smoothing control
- Constant Power control
- Energy shifting control



BESS/BMS

- Charge & Discharge
- Battery management



STATCOM/AVC

- Generating & Absorbing Reactive
- Stabilization of grid frequency
- Voltage stability improvement



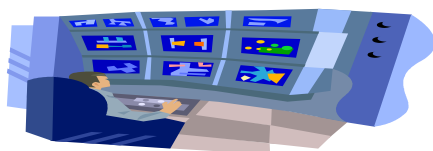
Load Bank

- Simulation of load fluctuation
- Simulation of Power generation control

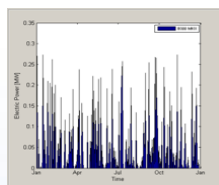
System Overview of SKA EMS

SKA EMS

Unified Operation Centre



CLIMATE



PREDICTION of
Photovoltaic
Sources



Photovoltaic Sources

Environment
Data

Gross Generation
Forecast

EMS Data

Production Cost
Data

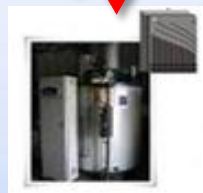
SKA EMS



BESS Data

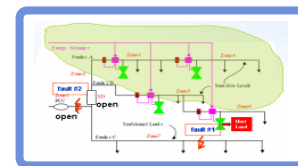
Mode Control

Energy Storage



Grid
Information

Power Grid



Load Data

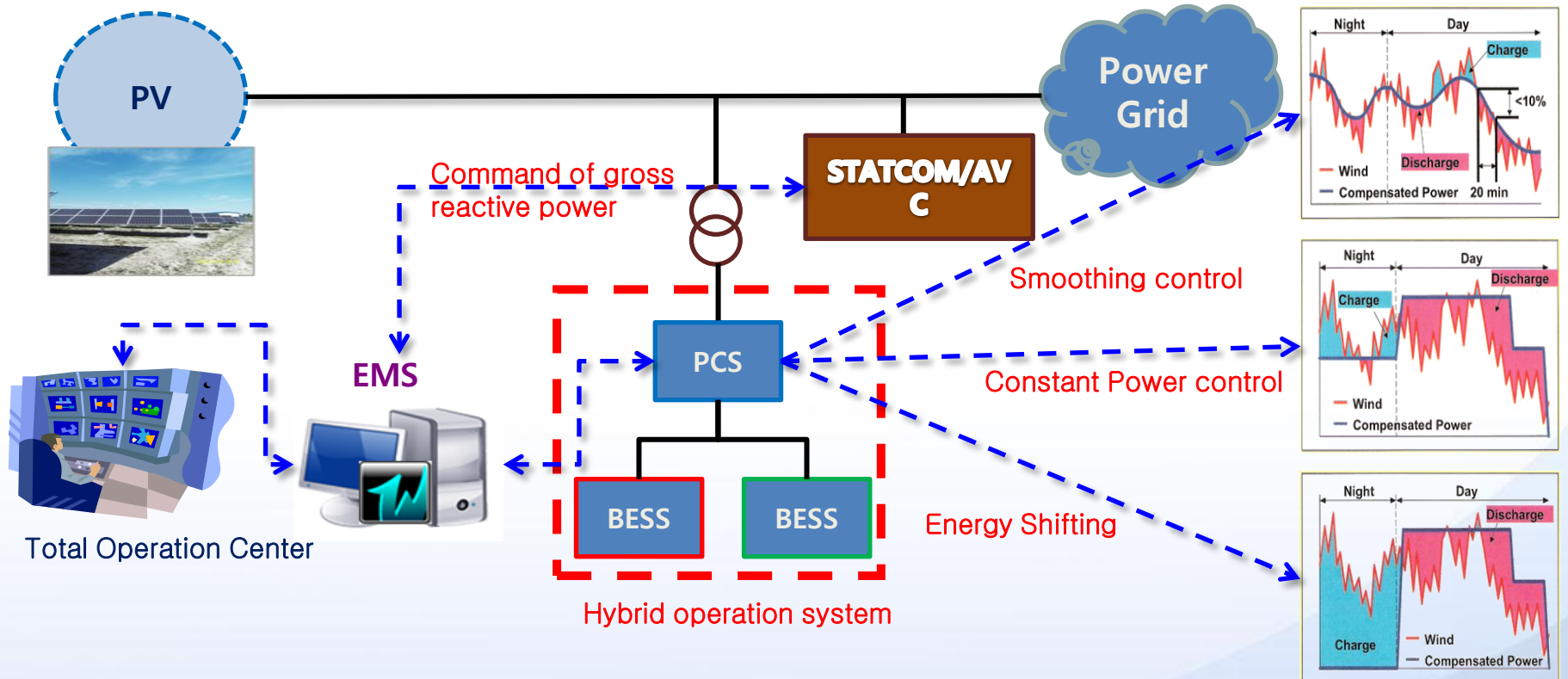
Mode Control
Operation
Data



STATCOM

Main Functions SKA EMS(1)

EMS operation plan



- ◆ Changing the operation mode to supply stable power depending on gross power generation and the grid conditions
- ◆ Voltage stability improvement by the control of Static Var Compensator control in power system

Main Functions SKA EMS(2)

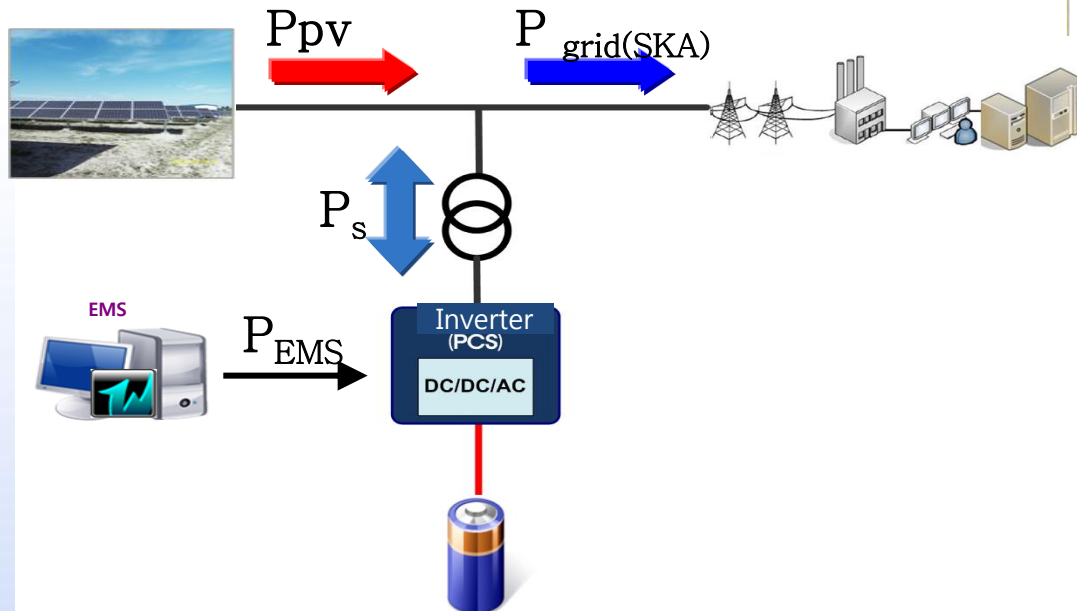
Application effects of EMS

- Improving PQ(Power Quality)

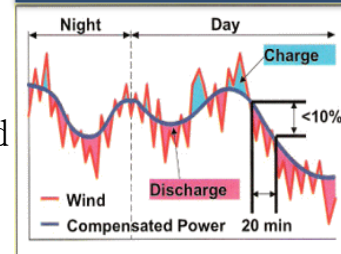
Control of irregular Power → Enhancement of PQ and efficiency

- Improving efficiency of consuming power

Equalization of consuming power → Reduction of investment costs
Using Off-peak Electricity → Curtailment of electricity costs

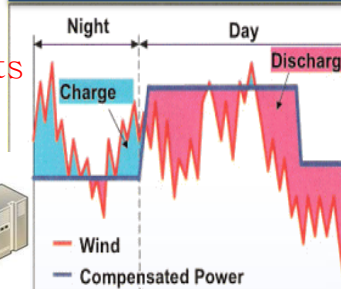


Smoothing Control



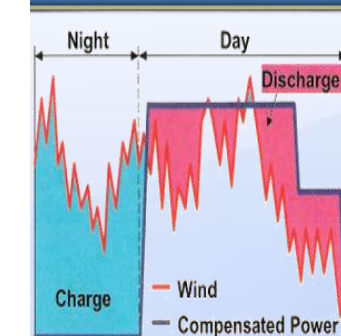
- Long-term & Short-term operational scheduling
- $P_{pv} > P_s$: Battery charge
- $P_{pv} < P_s$: Battery discharge

Constant Power Control



- Supply constant power to the grid
- Automatic Generation Control by EMS command
- $P_{pv} > P_{EMS}$: Battery charge
- $P_{pv} < P_{EMS}$: Battery discharge

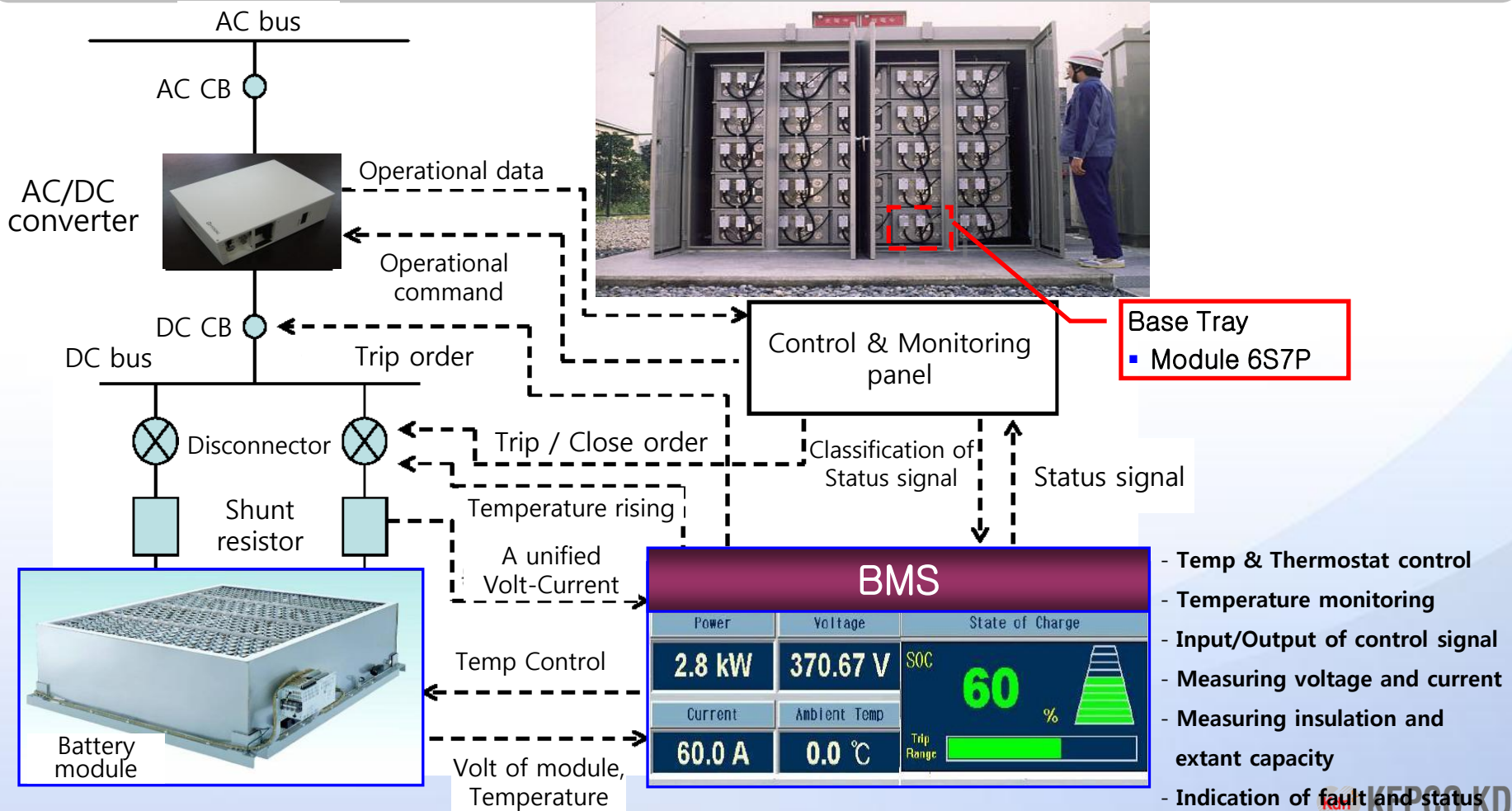
Energy Shifting Control



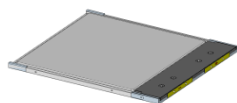
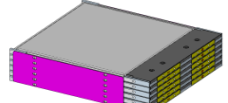
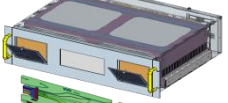

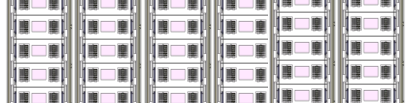
- Supply max power in peak demand Improving economic dispatch
- At night : Battery charge
- At day : $P_{pv} > P_{EMS}$ (Charge)
 $P_{pv} < P_{EMS}$ (Discharge)

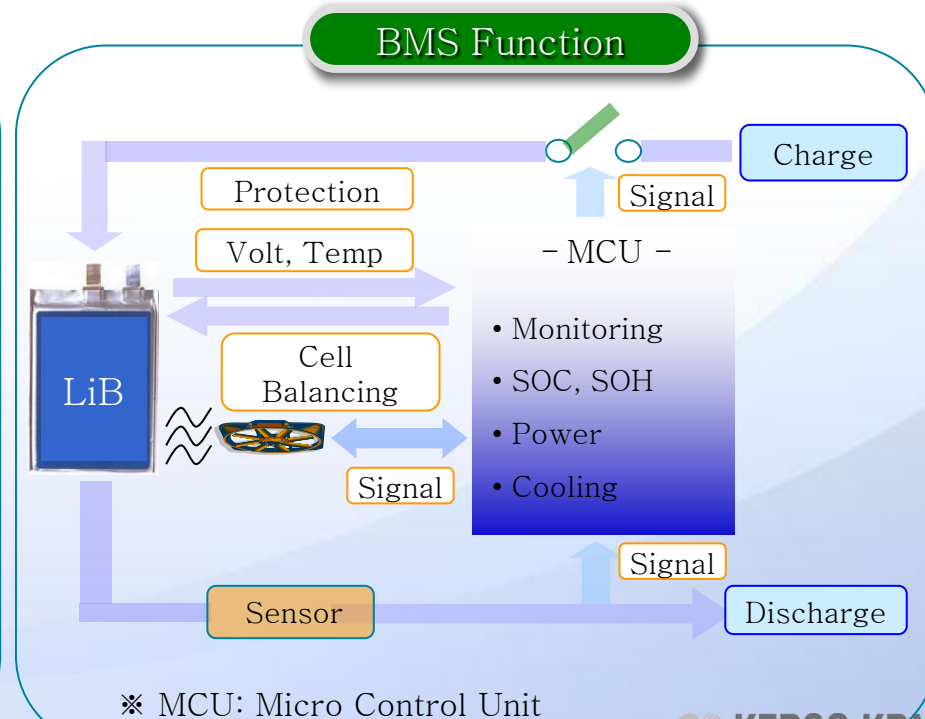
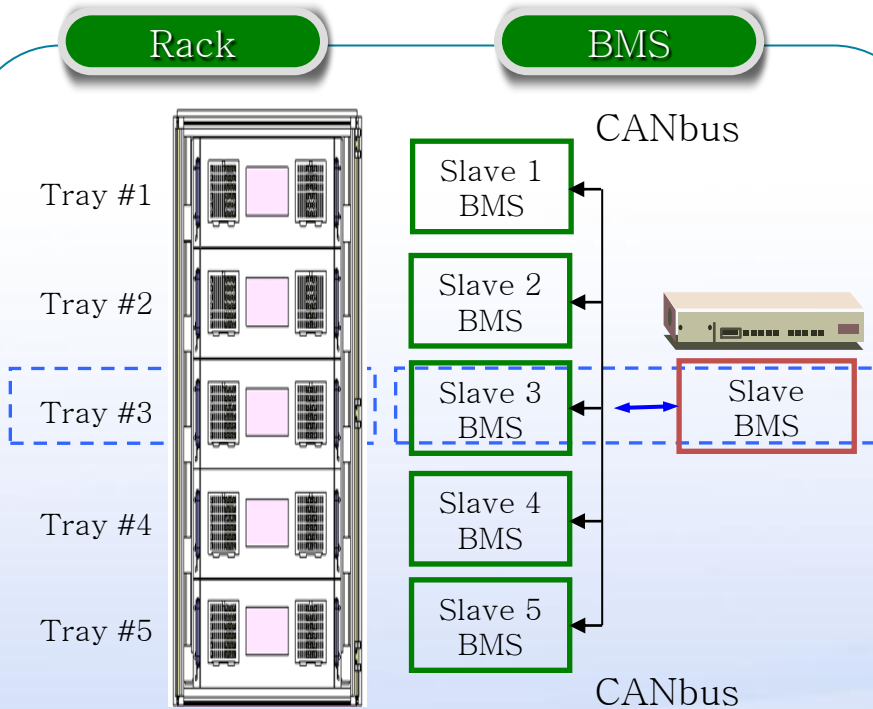
Main Functions SKA EMS(LiB/BMS)

- ◆ LiB system is manufactured for large capacity on the basis of Tray combined with basic modules
- ◆ System is composed of battery module, remote monitoring panel, PCS and BMS(Battery Management System)
 - BMS protect batteries and operate system effectively



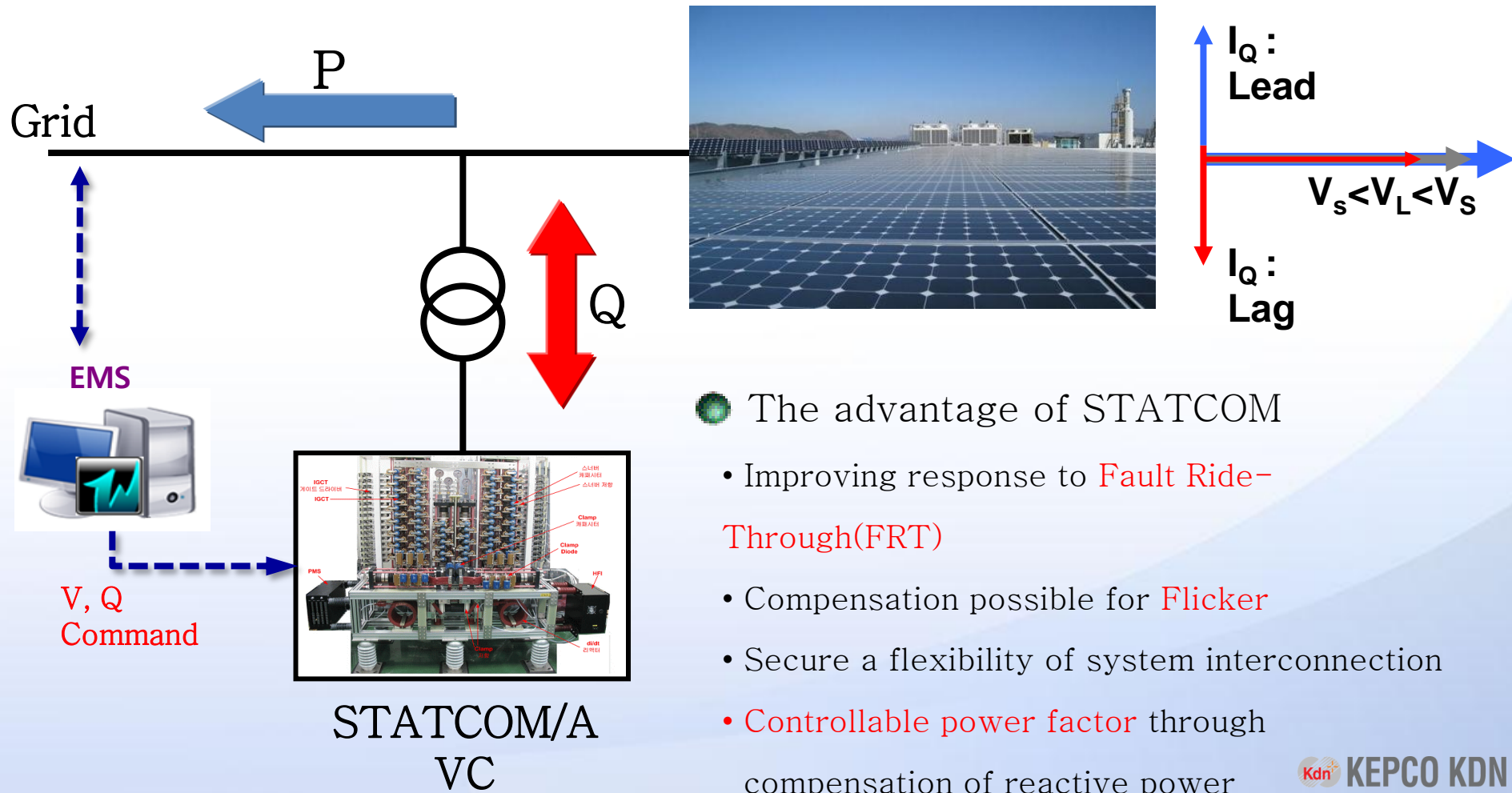
Main Functions SKA EMS(Lib/BMS)

200KWh Platform				
Cell	Module	Tray	Rack	System
				
50Ah	Cell 1S7P Link	Module 6S7P Link	Tray 5S Link	Rack 6S Link



Main Functions SKA EMS(STACOM/AVC)

STATCOM/AVC in The PV System



The advantage of STATCOM

- Improving response to **Fault Ride-Through(FRT)**
- Compensation possible for **Flicker**
- Secure a flexibility of system interconnection
- **Controllable power factor** through compensation of reactive power

Considering Korea power systems

Strength of Korea Electricity

Korea Electricity Industry

- One of the biggest energy-consuming countries in the World
- Relatively new power infrastructure & Superior ability of operation
- "World Best" power qualities
 - Outage hour in Korea : Just 14.29min/year
(France : 57min/year, UK : 68min/year, USA 122min/year)
 - Loss rate of transmission/distribution in Korea : about 4%
(UK : 9%, USA: 7%, JAPAN : 5%)
- Power IT Infra : Young and already SMART

Related IT Convergence Industry

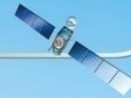
- "World Best" of Korea IT infra → "IT KOREA"
 - Broadband internet deployment ratio : World's #1(95.9%, OECD 2009)
- Builds the world's first nationwide Smart Grid system currently
 - Jeju Smart Grid Test-bed : World's largest Smart Grid community
- "World Best" smart home appliance, automobile, EV, construction, and shipbuilding



Global Top 5 Energy & Engineering Company

KEPCO Way

Global Excellence 세계최고 • Customer Respect 고객존중 • Performance Driven 성과추구
Challenge & Innovation 도전혁신 • Social Responsibility 사회적 책임



전기에너지 주택