Microgrid Testbed

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Leading the 4th Industrial revolution

ICT Innovator

ETRI

IL-WOO, LEE

IoT Convergence Research Department

Hyper-connected Communications Research Lab.

Contents

1. Energy Issue in Korea

-Demand side: 『Energy Saving』 / -Supply side: 『Decarbonization, Decentralization』

The facts

x2

Energy Demand by 2050
continuously growing

VS

The needs

÷2

Carbon emission by 2050

[source: IEA2007, IPCC2007]

“積塵成山”

“Many a mickle makes a muckle”

“泰山不讓土壤”

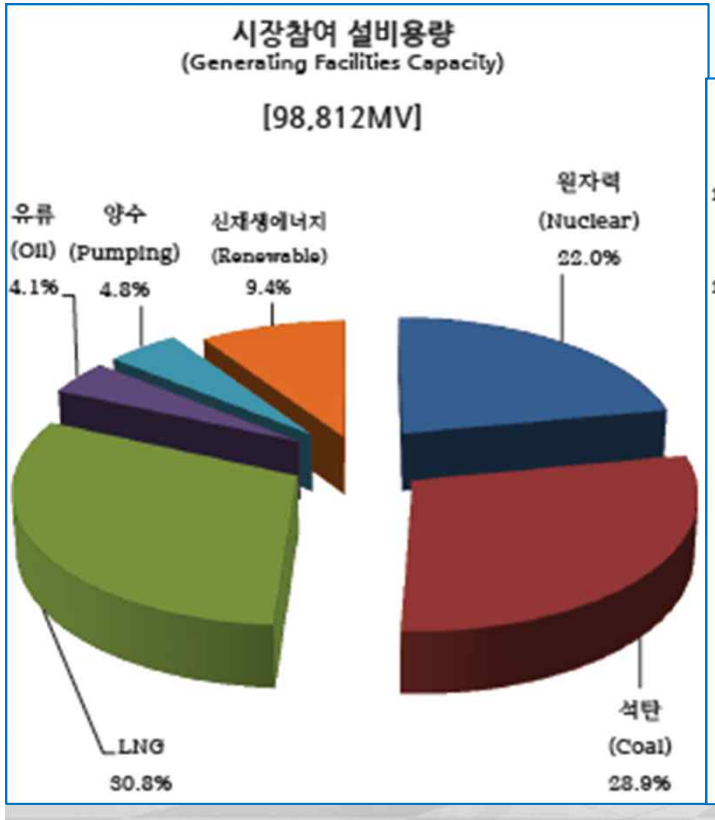
“Little drops of water make the mighty ocean”

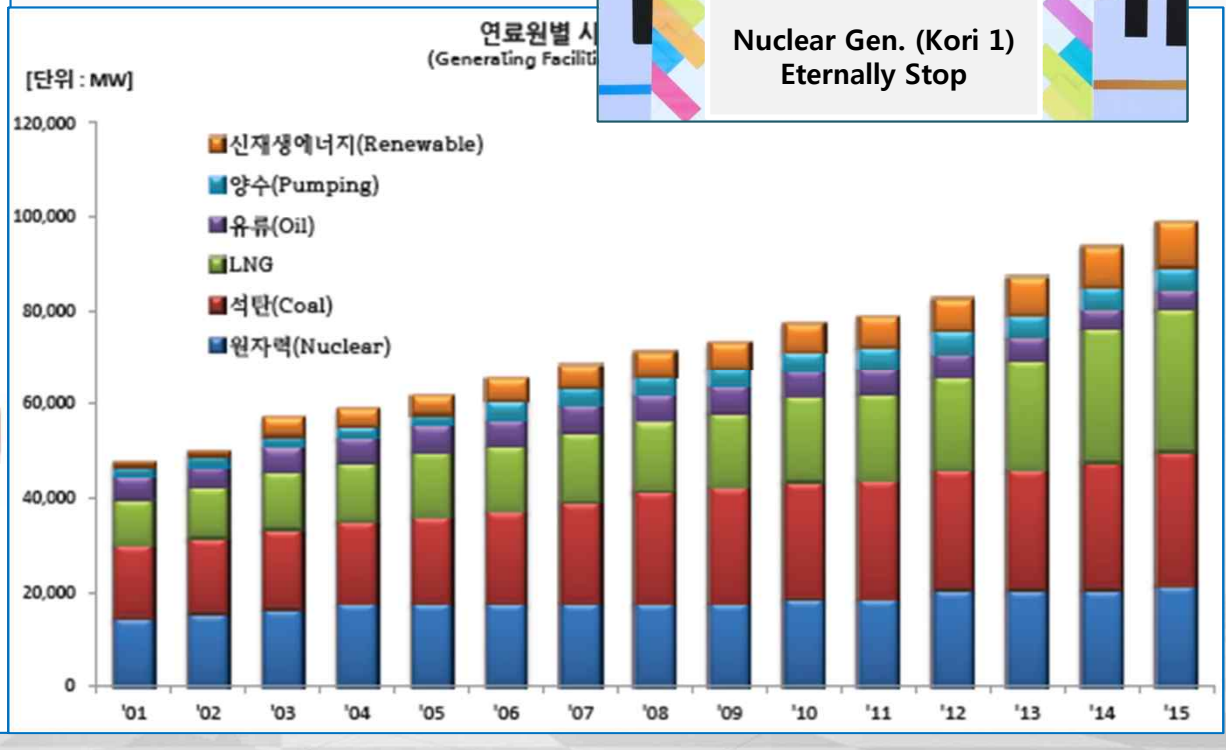
Energy efficiency, Reasonable consumption

Expand DER (Distributed energy resources)

1. Energy Issue in Korea

Energy source change : Nuclear/Coal → Renewable with ESS





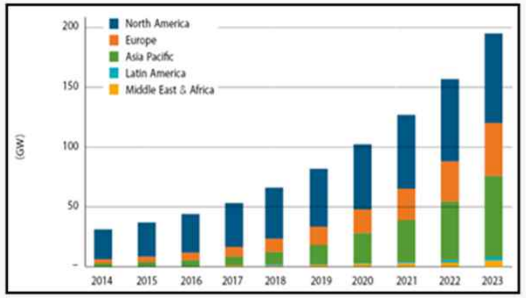
[Generating Facilities Capacity by Fuel Type, '15. Korea]

2. Wind of Change/Requirement

Energy ICT Platform based on ICBMS (IoT/Cloud/Big Data/Mobile/Security)

Social Factors

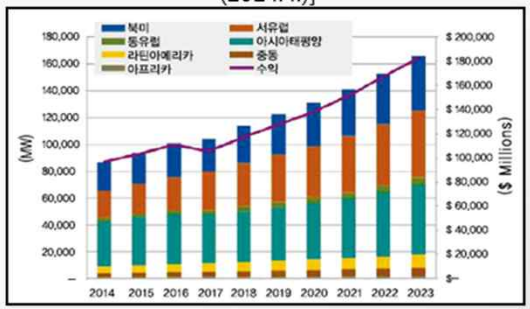
- Improving the QoL ➔ increase energy demand, require high quality
- Decarbonized Power plant ➔ difficulty in supply-oriented supply & demand planning and deployment
- Increasing energy efficiency ➔ need to optimal energy supply & demand planning/Demand side management



[Demand Response Market Forecast, Navigant (2014.4.)]

Environmental Factor

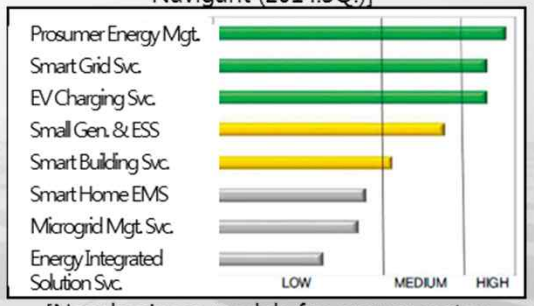
- Global action to reduce greenhouse gas emission ➔ increase electric vehicle (EV), Distributed Energy Resources (DERs)
- Continuous increase of energy demand ➔ demand for consumer, building energy efficiency
- Centralized power generation ➔ distributed generation, energy service based on hyper-connectivity/intelligence



[Distributed Energy Resources Global Forecast, Navigant (2014.3Q.)]

Technical Factors

- Difficulty in demand forecasting & increase in DERs ➔ need to deal with uncertainty, system instability
- Interconnect with DERs ➔ need to integrate various energy resources/optimal operation
- Passive consumer ➔ Active consumer, Transformed into Market Participants, E-Prosumer



[New business models for energy sector, IDC (2015.10.)]

3. Energy ICT R&D

ETRI Approach

『I(Produce Energy)–My(Own Energy)–Me(Energy Saving) & You(Broakerage/Trading)』 **Smart Energy Platform**

[I] Connectivity Technology

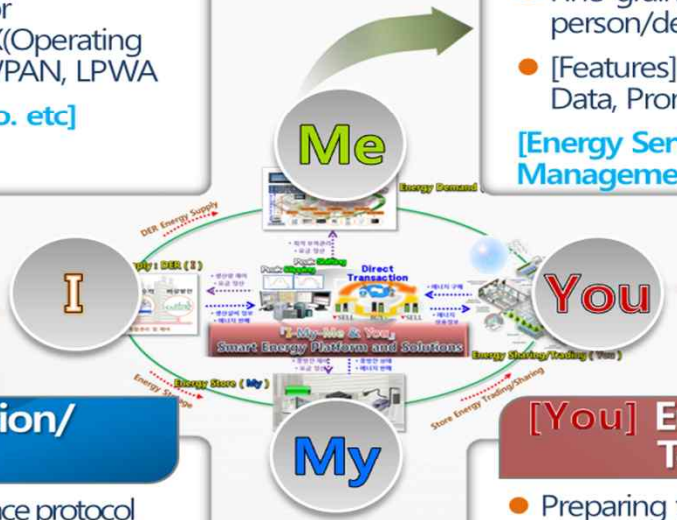
- Energy IoT Platform & QoS assurance Networking Technology
- Trust communication infra. for Various DERs
- [Features] Hyper-connectivity for CAPEX(Capital Expense) / OPEX(Operating Expenses) based on DC-PLC, WPAN, LPWA

[Renewable/DER providers, Telco. etc]

[Me] Energy-saving Technology

- Provides intelligent and convenient energy-saving service (with Bluetooth Low Energy beacon, Smart Plug etc.)
- Fine-grained measurement of energy use per person/device
- [Features] Hyper-personal connectivity, Big Data, Promoting consumer participation

[Energy Service Company, Demand Management Service Provider, etc.]



『Generate/Store』

『Saving/Trade』

[My] Intelligent operation/ Optimization

- Solving the heterogeneous interface protocol problem
- Providing Real-time information gathering/ Control Standard technology
- [Features] IEC 61850 Data Modeling, Internet of Energy (Message Queuing Telemetry Transport ..)

[Virtual Power Plant/ Micro Grid Provider, Electricity Broker, etc.]

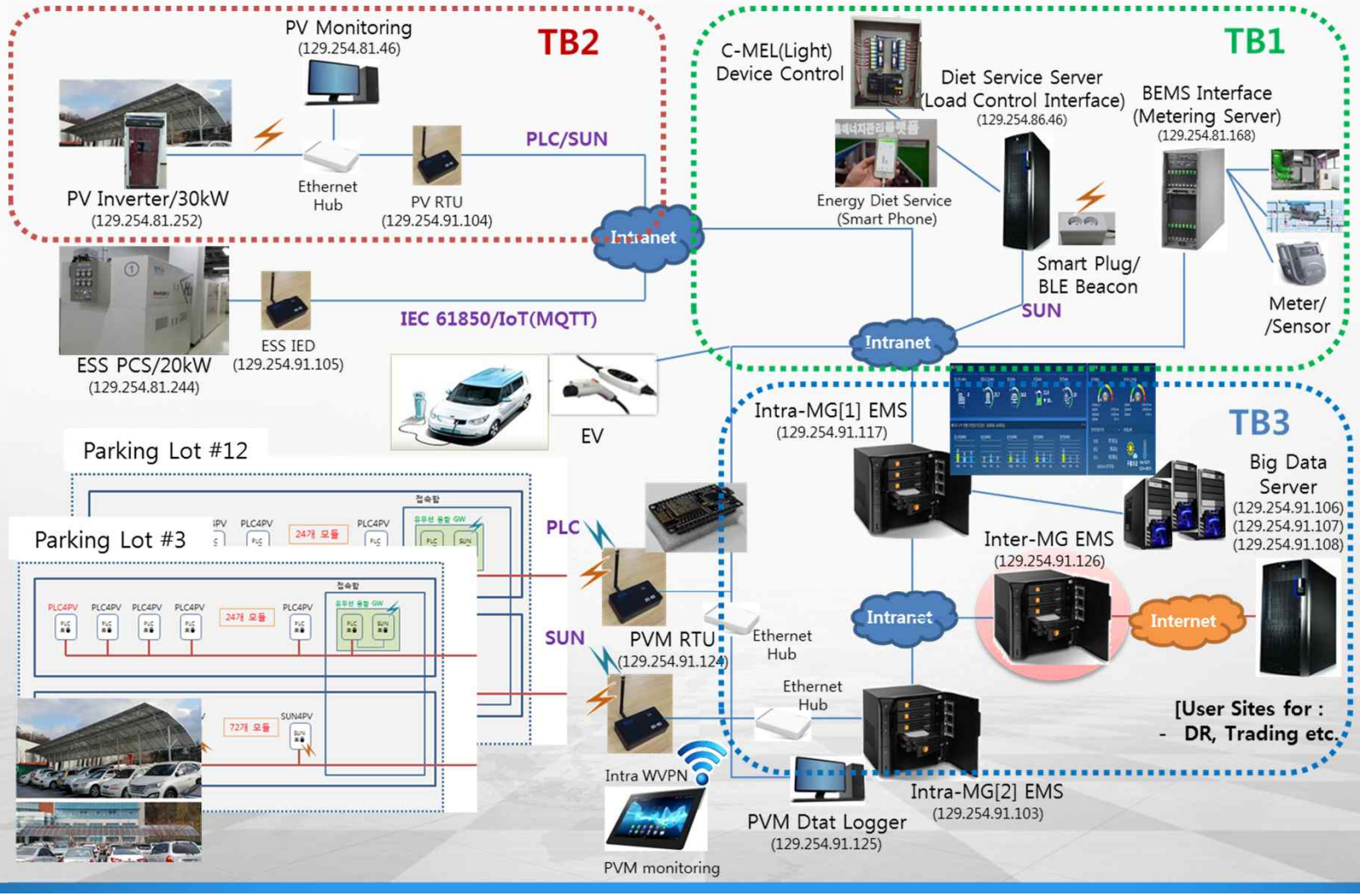
[You] Energy Sharing/Trading Technology

- Preparing the Transactive/Trading Energy market in Korea
- [Features] Market(Electricity brokerage market) linkage and P2P(peer to peer) energy sharing/trading between Energy-prosumers

[Electricity Broker/ Energy Management System Provider, etc.]

4. Microgrid Testbed : ETRI

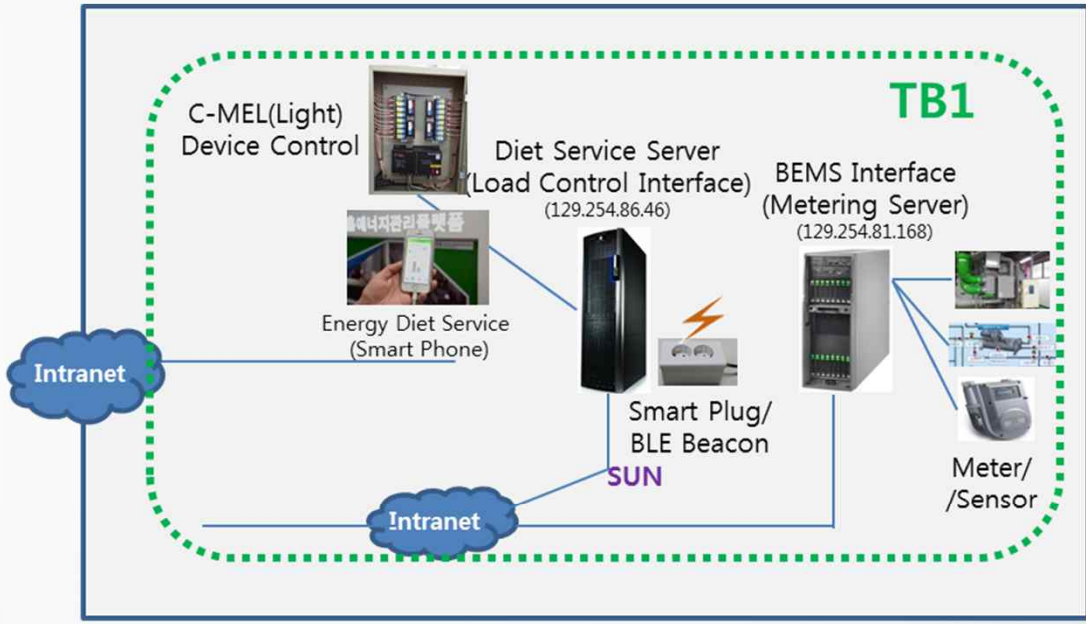
Microgrid : a small network of electricity users with a local source (DER) of supply that is usually attached to a centralized national grid

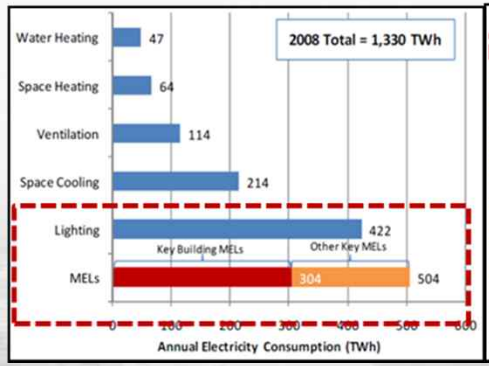


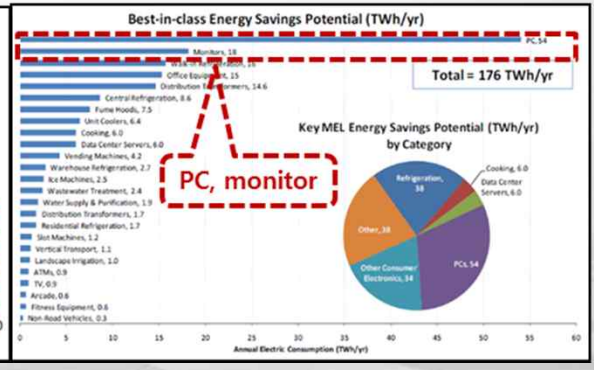
4-1. Testbed 1 : Energy Diet with Smart Plug

『Energy Diet Service with Smart Plug』

- Backgrounds
  - Relatively high energy-use intensity of commercial building
  - Highest energy savings potential of PCs, monitors, and lights in office
  - People' mindset: conserving energy is inconvenient and requires a sacrifice without a reward.
- Energy Diet Service with Smart Plug
  - Focuses on energy savings of PC, monitor, and light in office
  - Provides intelligent and convenient energy-saving service without user intervention
  - Provides fine-grained energy management service
  - Provides automated reward management service to motivates users to save energy







[DOE Technical report D498: 224; 2010.]

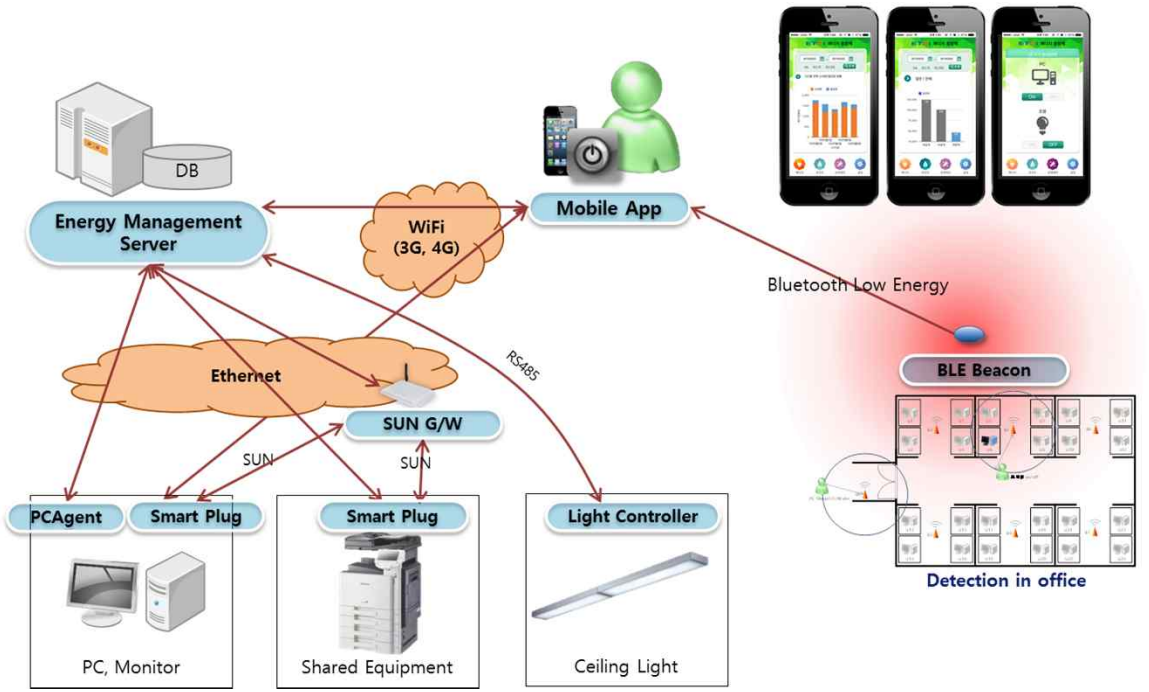
4-1. Testbed 1 : Energy Diet with Smart Plug

『Energy Diet Service with Smart Plug』

Goal

- To manage and reduce energy consumption in a convenient and fine-grained manner in an office environment
- To promote energy savings through automated reward management

Config.



4-1. Testbed 1 : Energy Diet with Smart Plug

『Energy Diet Service with Smart Plug』

Features

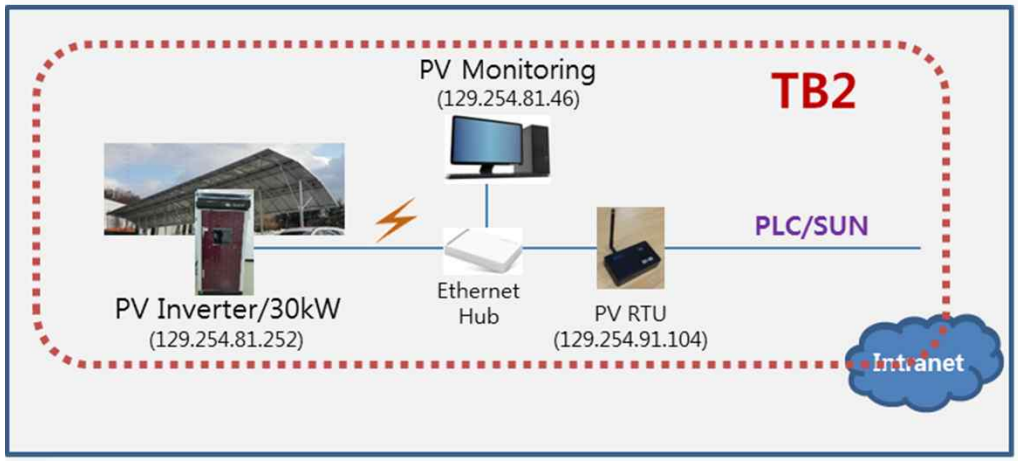
- **Fine-grained Energy Management**
  Smart Plug with Low power/high reliability sub-GHz wireless Network (SUN)
  Energy consumption monitoring of individuals or each device
- **Convenient, Intelligent Energy Saving**
  Energy saving without user intervention
  Automated power control of individual's PC, monitor, shared office equipment and ceiling light according to user's movement
- **Automated Reward Management**
  Estimating user's effort to save energy: turning off PC and monitor, taking stairs

Benefits

- **Low-cost, user-friendly energy saving service**
  Low-cost to build infrastructure, Energy management service for users
- **Positive motivating the behavior of energy saving**
  Mindset modification to save energy in office

4-2. Testbed 2 : Renewable Energy Monitoring

『DC-PLC and Sub-GHz Technologies for Renewable Energy Monitoring』



- System Configuration
  - 30kW Photovoltaic (PV)
  - Low-cost PLC modules covering 4-panels at a time
  - Low-cost wireless Sub-GHz modules for monitoring at panel level
  - RTU for gathering monitoring data
  - Ethernet hub for sending data to cloud
  - PC for displaying the monitoring data

- User-friendly Remote Monitoring
  - Easy monitoring through consumer devices including PC and smart-phone
  - Achieving quick detection of faults of a renewable resource causing energy production reduction
  - Possible to reduce whole-life cost

4-2. Testbed 2 : Renewable Energy Monitoring

『 DC-PLC and Sub-GHz Technologies for Renewable Energy Monitoring 』

Goal

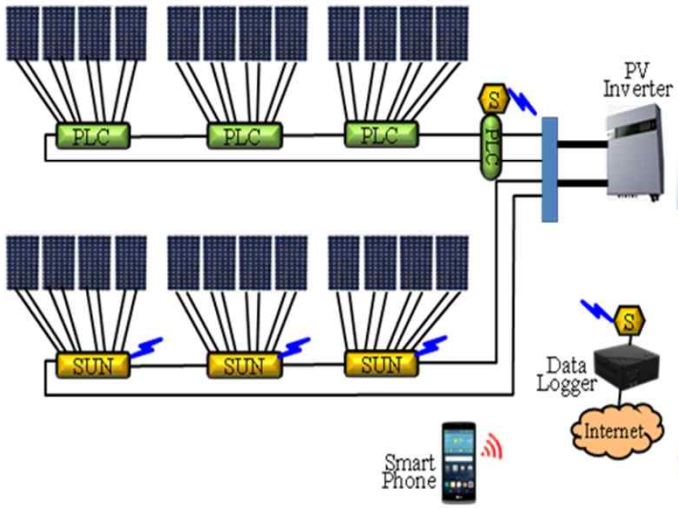
- Renewable Energy Monitoring at Module-level
  Based on Low-Cost DC-PLC and Sub-GHz Technologies
  for Improvement of Maintenance Efficiency

Config.

Great Expansion of Renewable Resources → Massive Installation at Module-level

Low-Cost DC-PLC and Sub-GHz → Suitable for Monitoring at Module(Panel)-level

User-friendly Monitoring at Module-level → Obtaining Efficient Maintenance



4-2. Testbed 2 : Renewable Energy Monitoring

『DC-PLC and Sub-GHz Technologies for Renewable Energy Monitoring』

Features

- **Based on DC-PLC and Sub-GHz Communications**
  Requiring no additional communication-line ➔ Easy to apply to conventional renewable resources
- **Using Low-Cost Techniques and Covering 4 Modules at a Time**
  Obtaining high cost-efficiency suitable for renewable resources with rapid growth
- **Supporting Module-level Monitoring**
  Detecting quickly faults reducing energy production ➔ Improving maintenance efficiency

Benefits

- **Providing Infrastructure for Hyper Connectivity and Energy Information through Wired/Wireless Communication Convergence Technology**
  Providing monitoring technology based on wired/wireless communication for various environment such as region/property/scope/QoS
- **Enhancement of Maintenance of Distributed Energy Resources and Upgrading of Added-Value Creation**
  Providing maintenance upgrade by achieving efficient upkeep through module-level monitoring
  Building a premium (value-added) renewable energy infrastructure for Chinese low-priced PV system

4-3. Testbed 3 : DER Optimal Operation

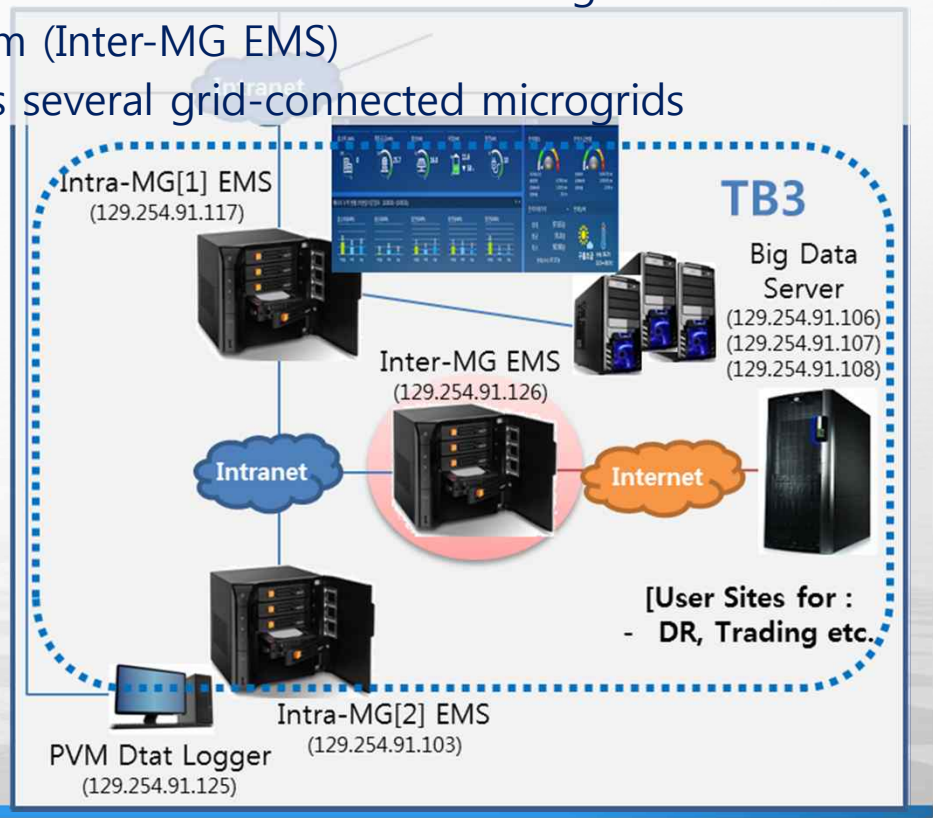
『Energy Storage System (ESS) Optimal-Economic Scheduling』

- Microgrid Energy Management System (MG EMS)
  - Objective: Data Collection, Visualization, Analysis, and Management

- Individual Microgrid Energy Management System (Intra-MG EMS)
  - Energy management system that manages DERs in the individual microgrid
- Multi Microgrid Energy Management System (Inter-MG EMS)
  - Energy management system that manages several grid-connected microgrids

- Energy Storage System (ESS)
  - Enables load shifting based on its energy storing capability
  - Helps to reduce power usage cost of the grid-connected microgrid under the time-of-use (TOU) price plan

- ESS Optimal-Economic Scheduling
  - Minimizing the electricity bill by controlling the ESS optimally



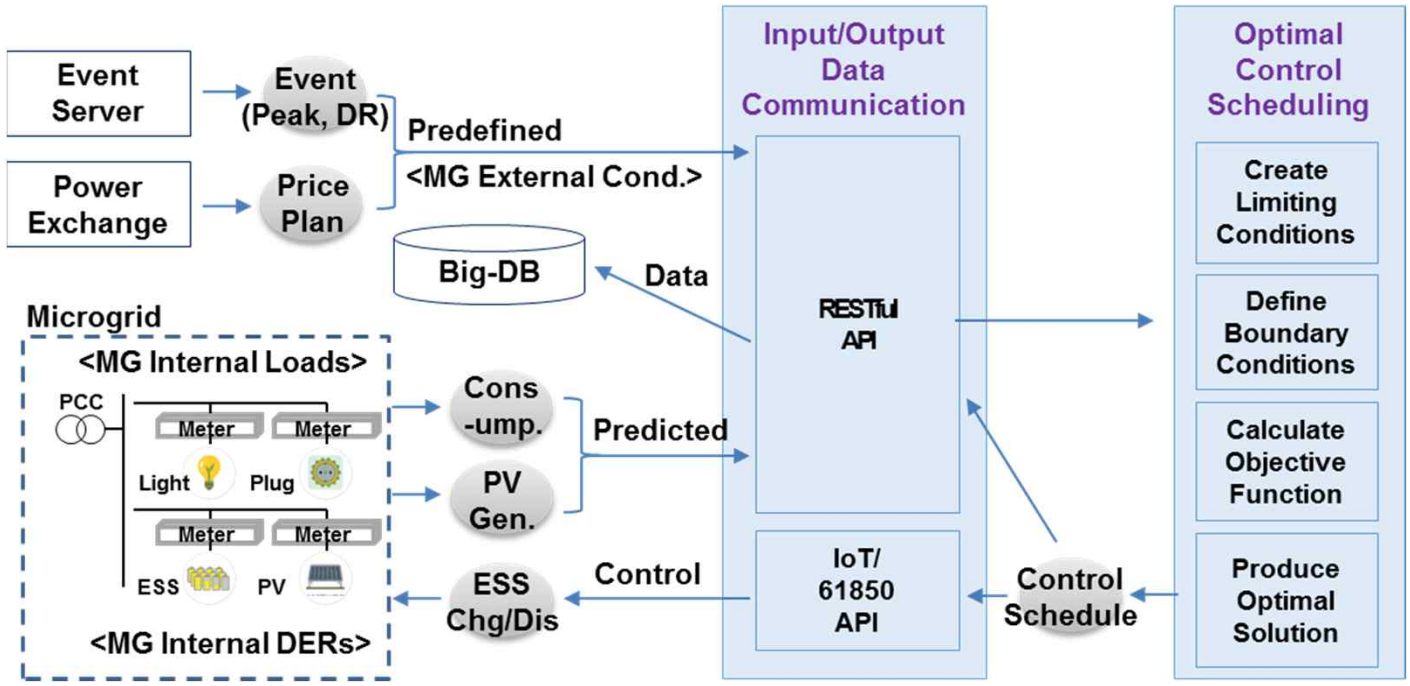
4-3. Testbed 3 : DER Optimal Operation

『Energy Storage System (ESS) Optimal-Economic Scheduling』

Goal

- DER Optimal Control Scheduling Technology
  that improves the DER power usage and reduces the grid power usage cost
  through the optimal control for DERs in the grid-connected microgrid

Config.



4-3. Testbed 3 : DER Optimal Operation

『Energy Storage System (ESS) Optimal-Economic Scheduling』

Features

- **DER Optimal-Economic Control**
  Optimal control scheduling for the ESS within the grid-connected microgrid to maximize its economic profit
- **Considering the Internal Conditions of the Grid-Connected MG**
  Optimal control scheduling that is subject to the internal conditions of the microgrid such as the load power consumption. PV power generation, and ESS energy/power capacity
- **Considering the External Conditions of the Grid-Connected MG**
  Optimal control scheduling that is subject to the external conditions of the microgrid such as the price plan, peak control event, and DR event

Benefits

- **Microgrid Side: Improved DER Usage**
  Maximized DER power usage as a result of the optimal control
- **Microgrid Side: Cost Reduction**
  Reduced grid power usage cost through the optimal control of DERs
- **Grid Side: Power Demand Reduction during Peak Hours**
  Reduced power demand during peak hours as a result of the microgrid economic scheduling

Young Forty, Let's Move!

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