Environmental Change in Electric Power Industry & KEPCO's Business Promotion for Industry 4.0

2017.6.26

KEPCO-RI

Lecturer

President for KEPCO Research Institute, Dr. Sung Hwan Bae

☐ Main Career

- ○ Current : President for KEPCO RI
- ○ '16. 07 : Executive Vice President & Chief Technology Officer
- ○ '15. 12 : Executive Vice President & Chief Operating Officer
- ○ '12. 02 : Vice President for Seoul District Division
- ○ '09. 06 : Vice President for Technology Policy & Planning Department
- ○ '79. 12 : Employment for KEPCO

☐ Education & Qualification

- ○ BS. in electric engineering, Konkuk Univ.
- ○ MS. in electric & computer science, Union Univ. USA
- ○ Dr. in IT Policy Graduate School, Seoul National Univ. of Science & Technology
- ○ Professional Engineer Electric Safety, Professional Engineer Generation Transmission and Distribution,

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I. Environmental Change in Electric Power Industry

II. Present Status in KEPCO

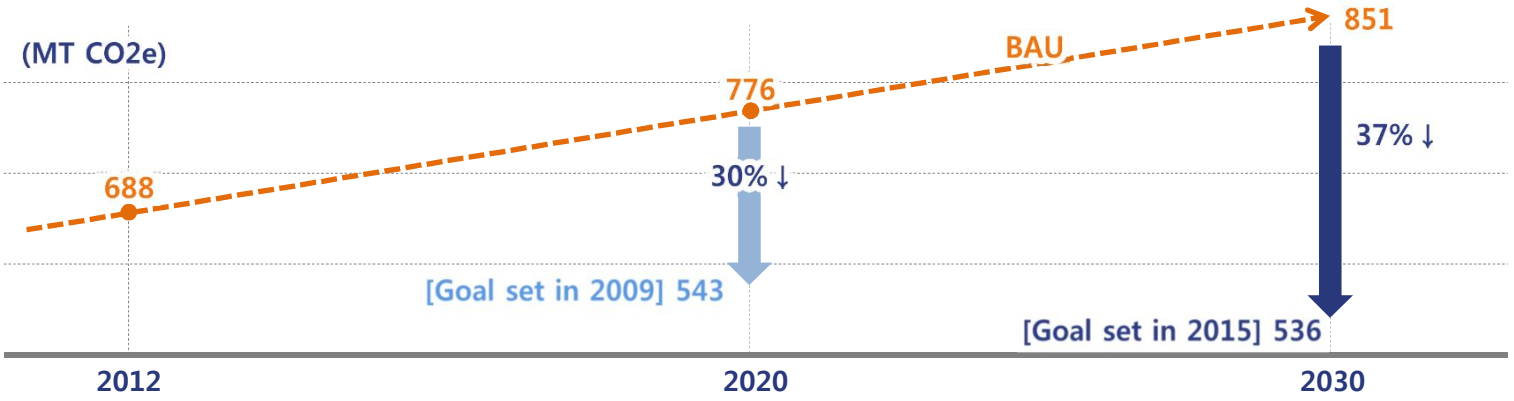
III. Future Strategies of KEPCO

Ⅰ. Environmental Change in Electric Power Industry

1. Carbon Emission Reduction from Paris Agreement

National Goal

• **37% from BAU(2030)** (Reduction Goal)

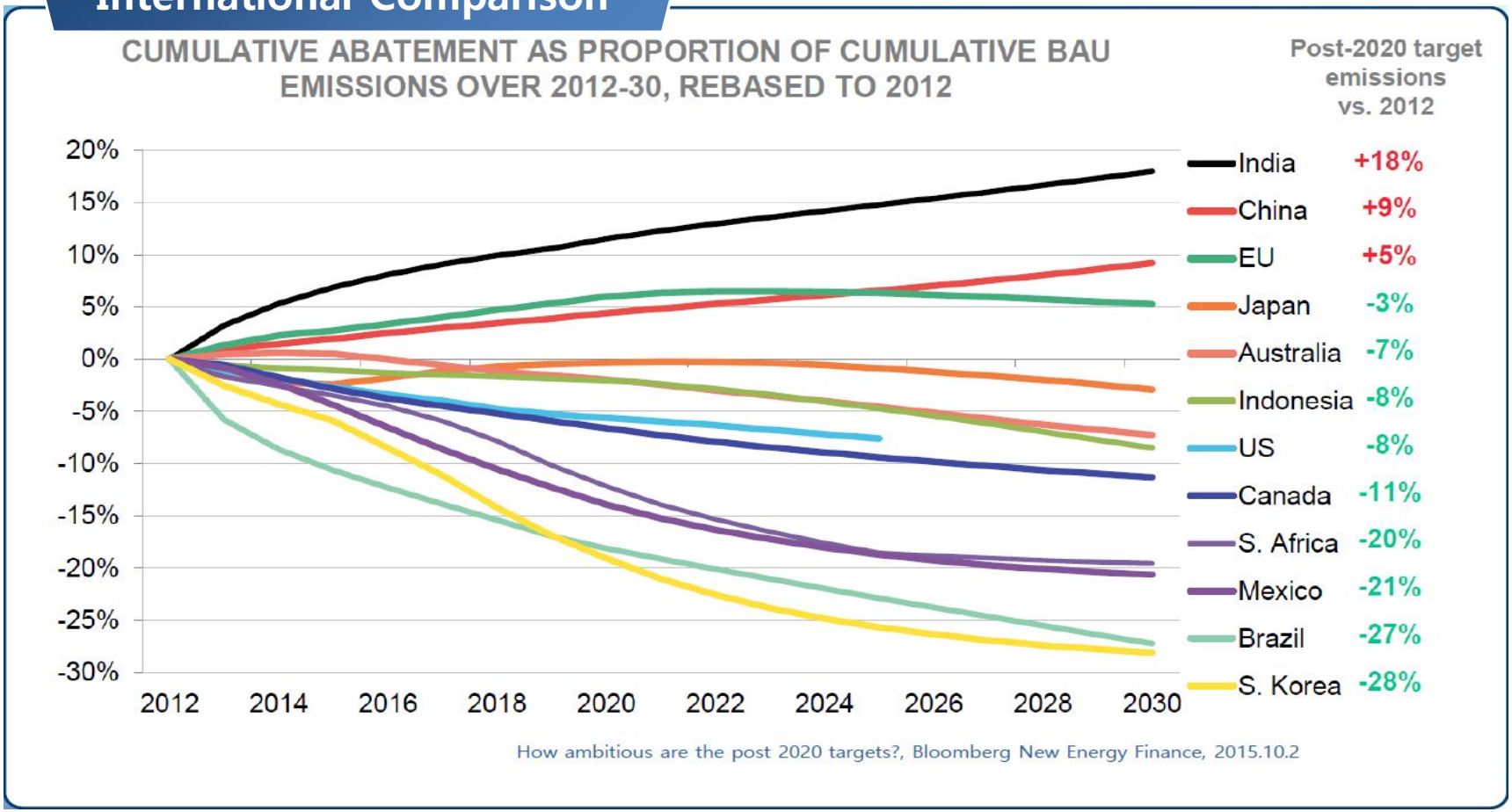


Existing	+	Adding	=	COP21
25.7% from BAU		Overseas 11.3%		37% from BAU

* BAU : Business As Usual

1. Carbon Emission Reduction from Paris Agreement

International Comparison

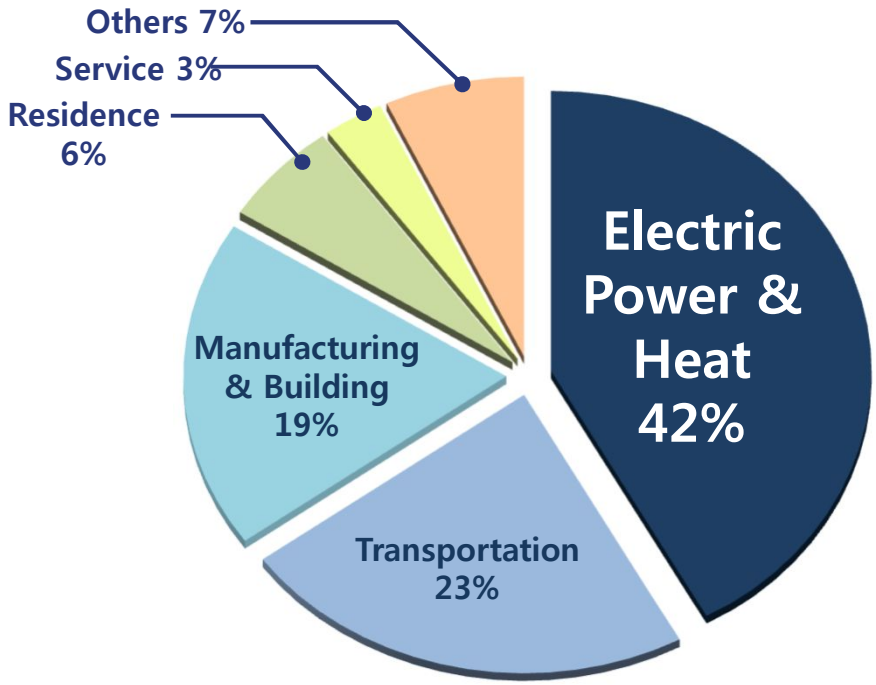


* BAU : Business As Usual

1. Carbon Emission Reduction from Paris Agreement

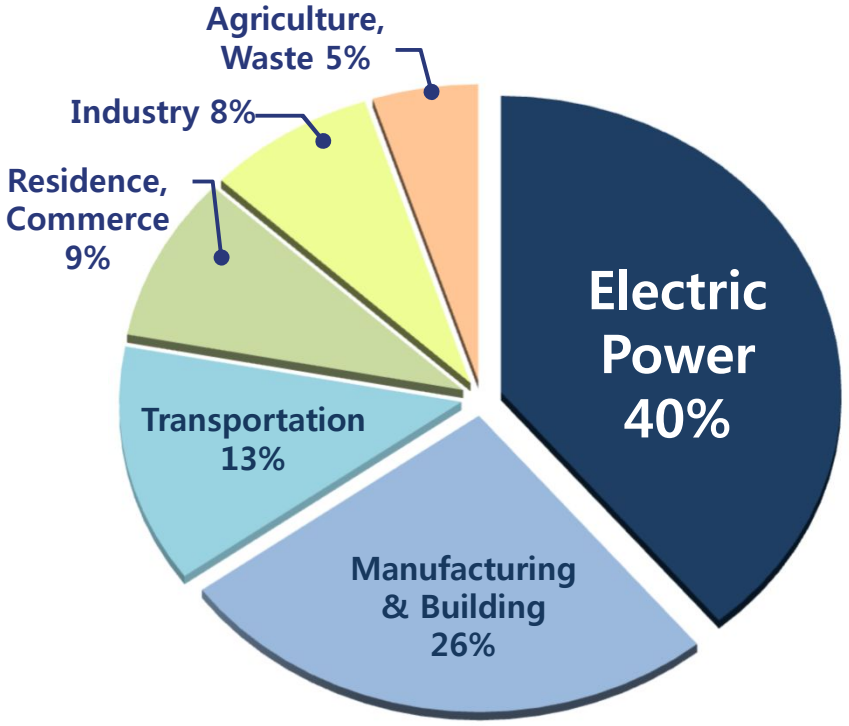
Weights of CO_2 emission per industry(%)

World(2013) 32.2 BT (56% ↑ from 1990)



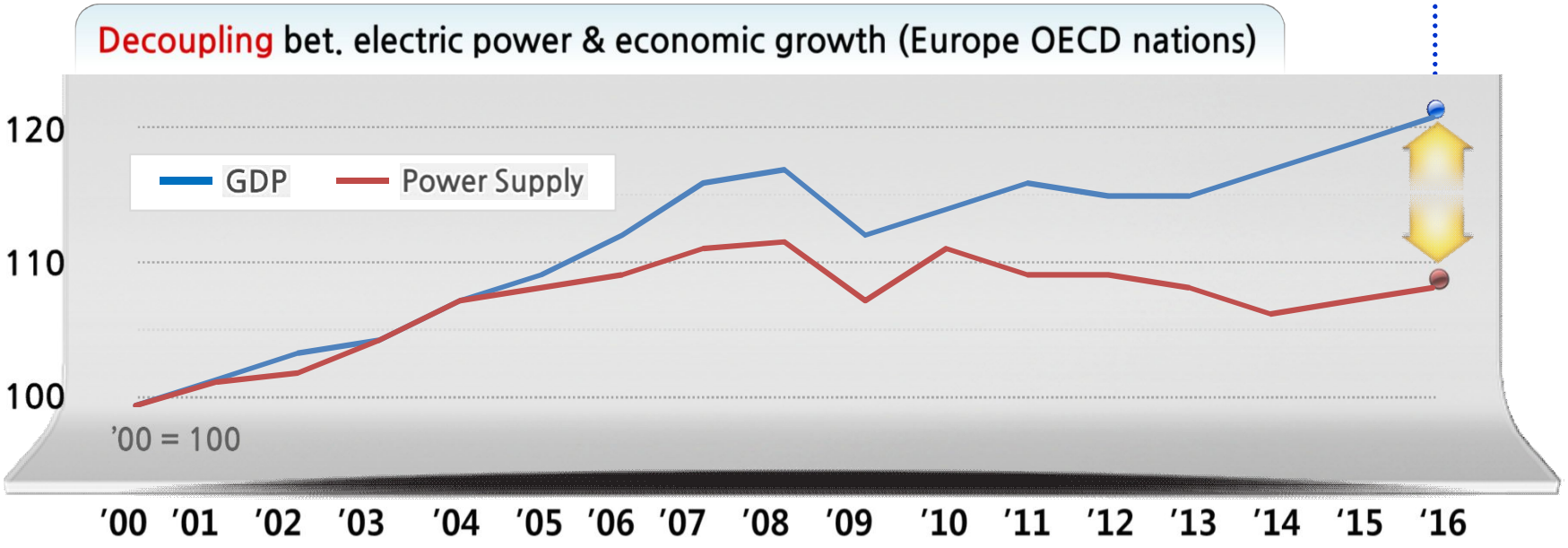
* Source : IEA, CO_2 Emission from Fuel Combustion

Korea(2013) 6.9 BT (138% ↑ from 1990)



* Source : Greenhouse Info. Center, "National greenhouse inventory report in 2015"

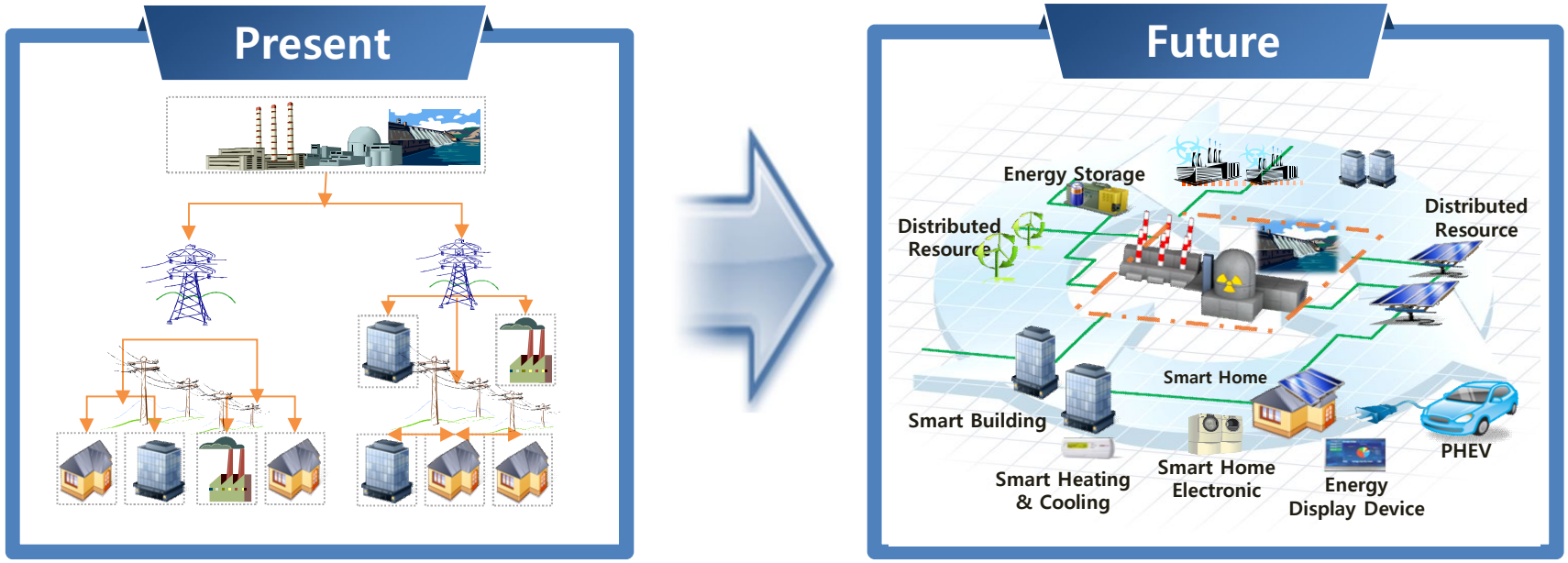
2. Electric Power Demand Decrease



Source : International Energy Outlook 2016 (IEA)

3. Difficulty in New Nuclear Power Plant Construction

4. Move into Distributed Resources



- ❖ Centralized Generation (Large Scale Generation Using Fossil Fuel) → Decentralized Generation (Renewable Energy) Expansion
- ❖ Unidirectional Flow of Power & Information → Bidirectional Flow of Power & Information(Real Time)
- ❖ Supply Side Facility Operation → Demander Participating Operation Peak Demand Reduction(Move to EV)

5. Boundary Destruction & New Industry Appearance

SoftBank

Renewable Generation

Google

'Nest' (Energy Management)

'Supercharger' (EV Charge)

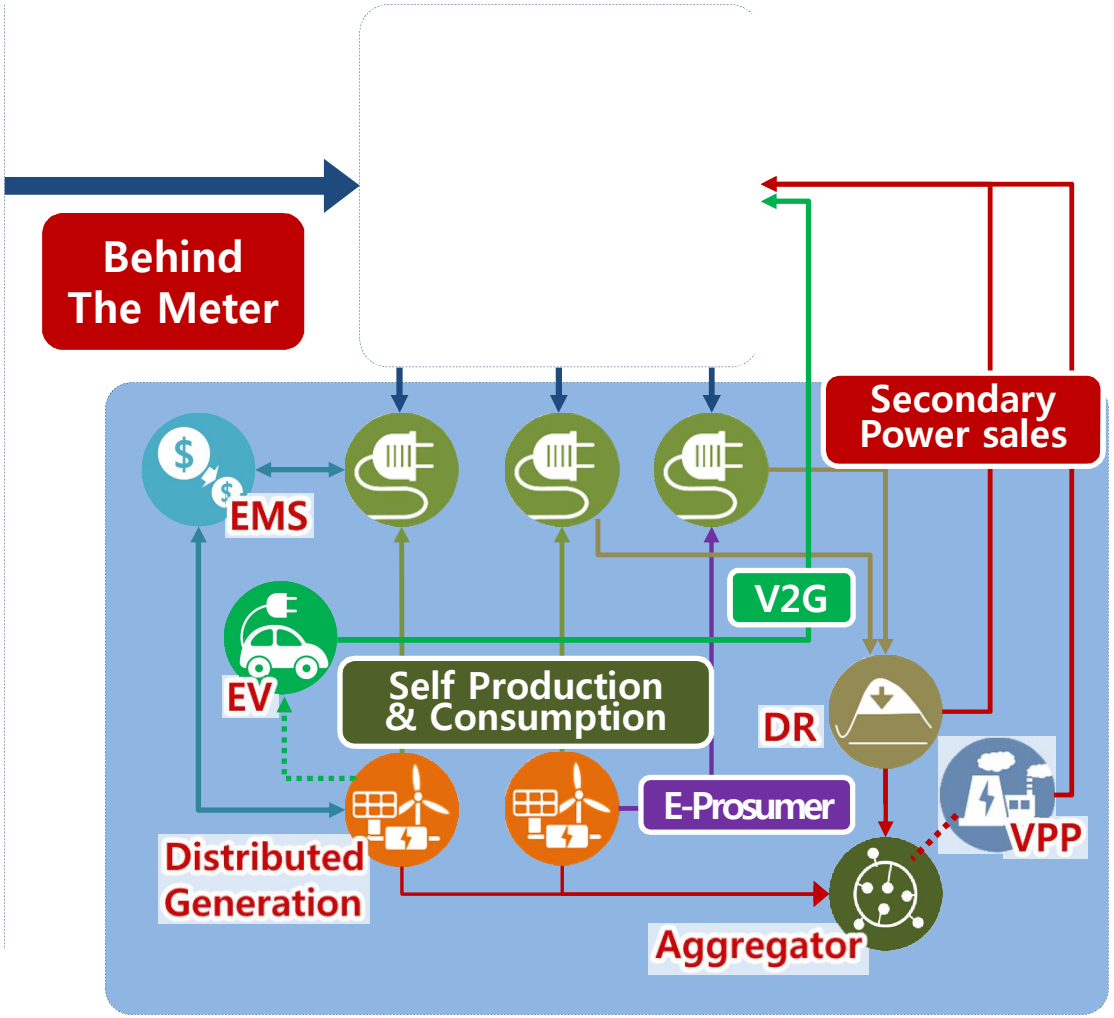
TESLA

'Power Wall' (House ESS)

'i-Home' (Energy Management)

5. Boundary Destruction & New Industry Appearance

Regulation Era	Competition Era	Extreme Innovation Era
Generation		
Transmission		
Distribution		
Sales		
Customer		



6. Energy Trade Legislation for Environment & Safety

Change of Power Purchase Priority

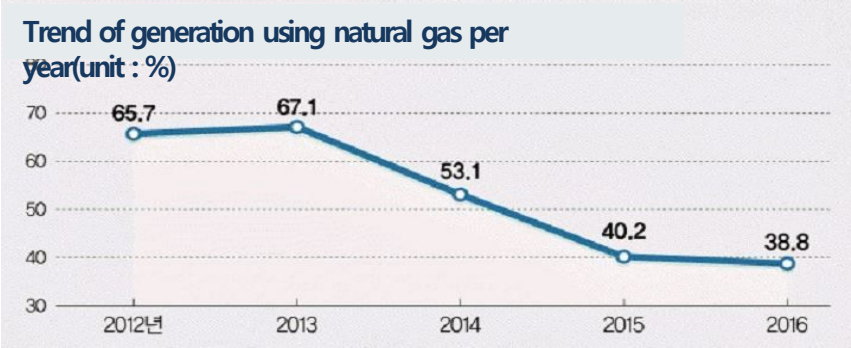
❖ *Promote "Commerce, Industry & Energy Committee" (National Assembly)*

○ *'Revision of Electric Utility Act' passed in Plenary Session ('17.3.2)*

○ *Applied from '8th General Demand Supply Program (2017)'*

- *Review 'economics', 'environment', 'national safety' totally when deciding priority of power purchase in KEPCO*

○ *Renewable energy expansion & mixed energy expected (Renewable, LNG generation rate↑)*



I 7. Long – term Profit Guarantee for Renewable Energy

Secure Return On Investment

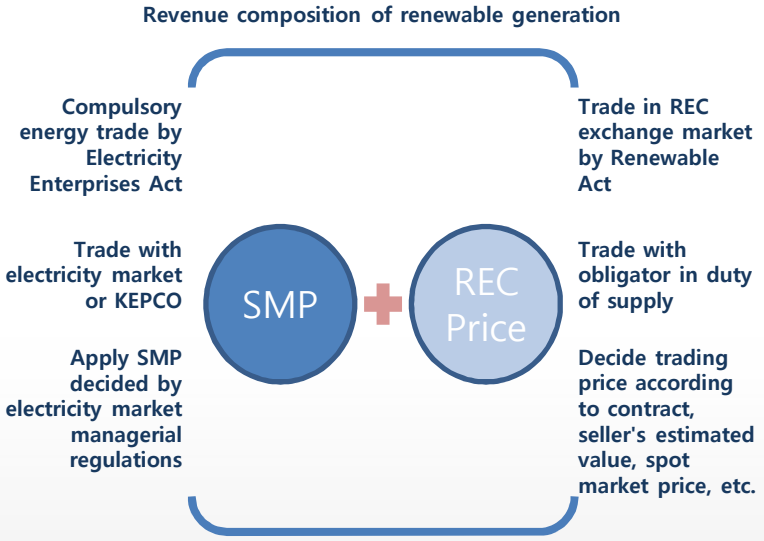
❖ *Government – power generation companies guarantee SMP + REC when purchasing renewable energy. Preserve stable income with long-term guarantee of 'contract unit cost' at the point of construction*

❖ *Mitigate return volatility risk that main restriction for renewable generation*

- Contract system to sum up SMP + REC for long-term profit creation

❖ *Public Generation enterprise purchase pv or wind power*

- long-term & fixed price to sum up 'SMP+REC' by force



* SMP : System Marginal Price, REC : Renewable Energy Certificate

8. Kick out Coal & Sale Restriction in Market

Restriction of low price coal generation

❖ *Stop old coal and no more new coal to reduce fine dust*

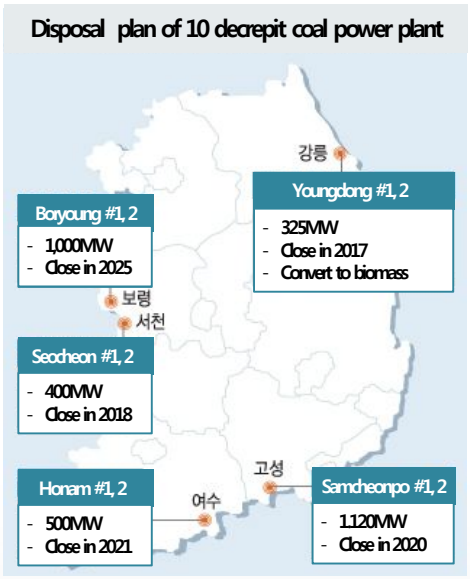
Restrict to sell self coal generation in market except for approved ones

(Electric Utility Act revised '17. 3. 2)

➢ *Permit existing generated power (surplus) to be sold up to 50%(now)*

→ *Overall prohibition in the future*

※ *National self coal generation (POSCO, etc.) : about 66MW*

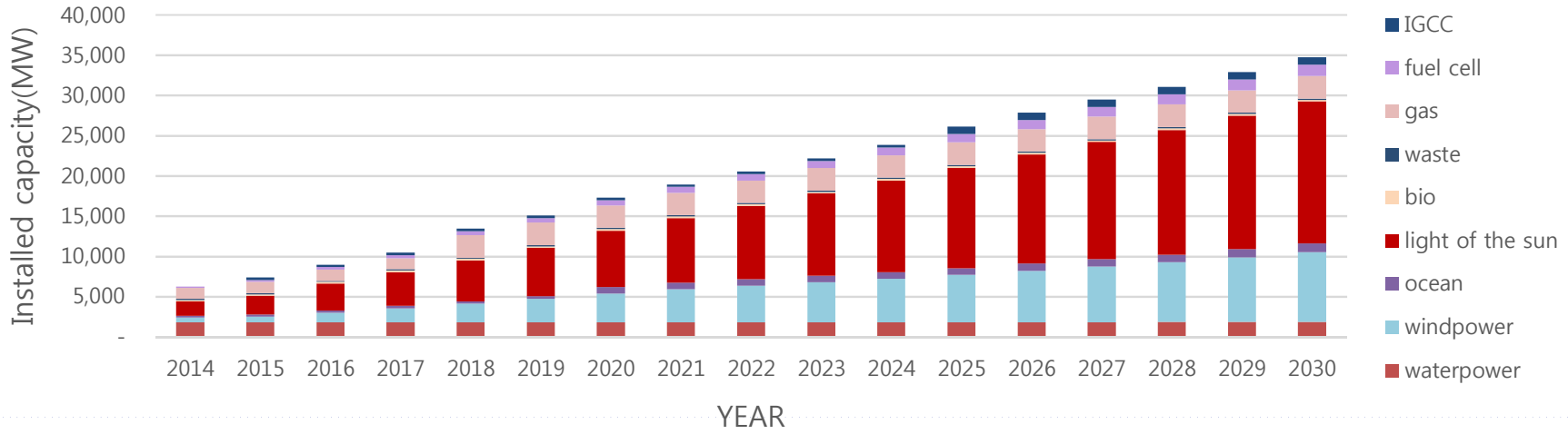


Fine dust reduction → stop national coal generation & block new one

9. Unlimited Renewables into PowerGrid

- **Capacity of main transformer in Substation : 25MW → 60MW**
- **Powerline capacity of distribution system**
  - **up to margin(current condition) → unlimited(reinforcement)**
- **Renewable source expansion : 60GW(2030)**
  - **KEPCO : 20%, 12GW**

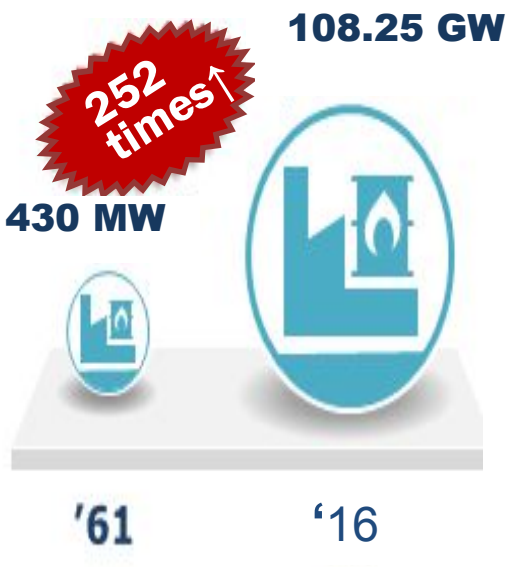
<7th Demand Supply Program>



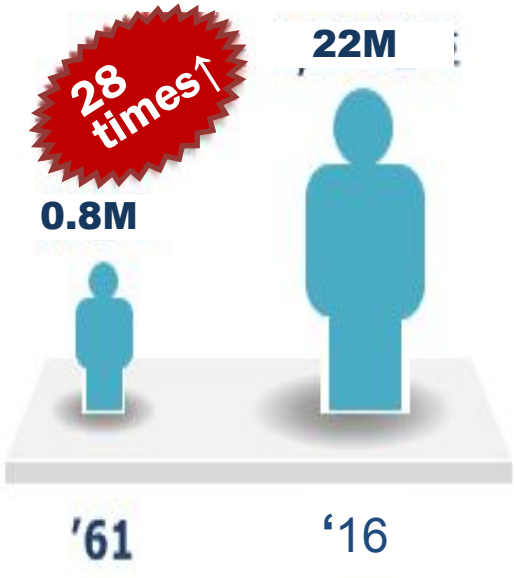
Ⅱ. Present Status in KEPCO

1. Present Status in KEPCO

Capacity of generating plant



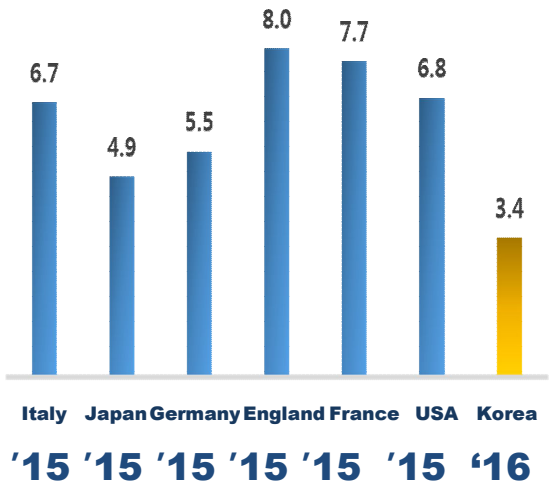
Number of customers



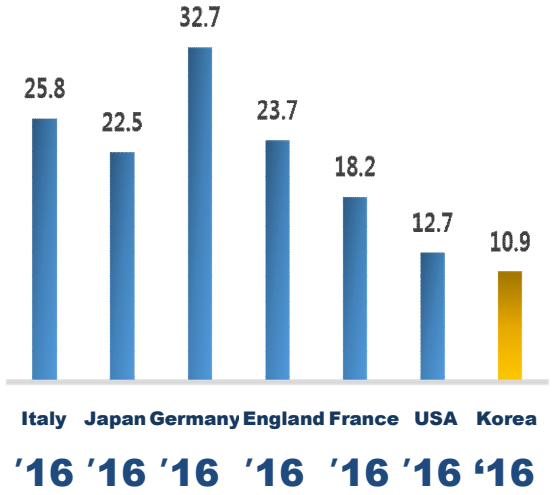
Sales volume of electricity

2. Present Status in KEPCO

Transmission & Distribution loss rate(%)



Residential Electric Charge(cent/kWh)



Outage per Customer (Min)

III. Future Strategies of KEPCO

1. Remote MG (Carbon free island)

Overview

❖ Relatively small power system composed of renewable energy(wind power, solar photovoltaic, etc.) and Energy Storage System(ESS) for remote areas

KEPCO R&D

❖ Demonstration and commercial operation in domestic islands : Gasa-island(2014), Geocha-island(2017), etc.


<Gasa-island Remote MicroGrid (Energy Management System , Wind/Solar farm, operation HMI* from left)>

* Human-Machine Interface

Expected Effects

❖ Reduction of operation cost : 320 million KRW/yr*

❖ Improvement of power quality and abundant supplying

❖ Reduction of carbon emission : 607ton/yr*

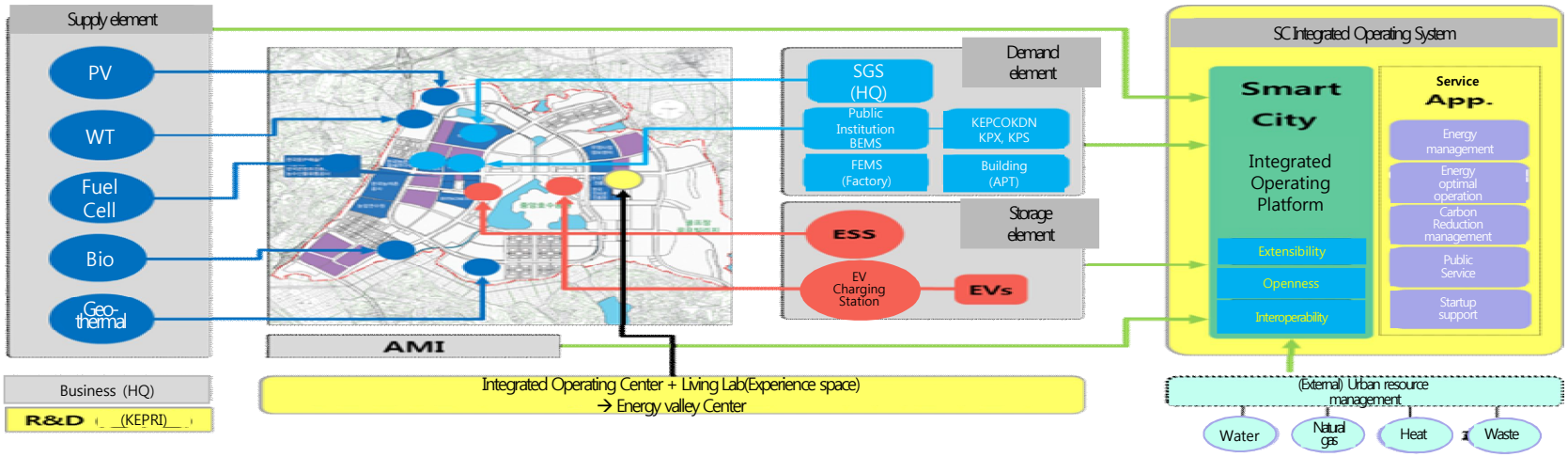
❖ Solution for "Energy New Biz"

* Operation result of Gasa-island

2. Smart City

Smart City

- Integration of urban(energy) resources and provision of advanced services(energy efficiency improvement, security, convenience) based on renewable energy and smart grid, ICT
  → Sustainable low-carbon future city with lower consumption of resources and operating costs



2. ESS(Energy Storage System)-1

Overview

❖ ESS Phase in KEPCO

2011 – 2014	2014 – 2017	2015 – 2018
Demonstration - 4MW/2h ESS (Jocheon S/S in Jeju Island)	F/R ESS Project - Total 500MW at 17 locations by 2017	Flexible ESS (Multi-Function) - 28MW ESS for 80MW offshore wind farm

❖ Frequency Regulation ESS Project in KEPCO

FR ESS	Operational			Planned	Total
	2015	2016	2017	2017	
Rating(MW)	52	184	140*	124	500
No. of Sites	2	7	4*	4	17

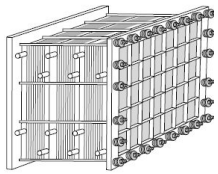
* Note : these sites are currently under construction

* Distributed · ESS : HV 6site 4.1MW, LV 63site 5.8MW

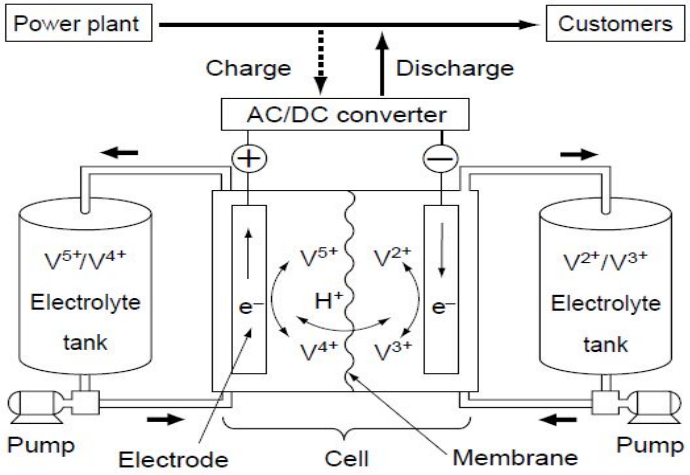
2. New ESS -2

Vanadium Redox Flow Battery

- Energy and power out-put can be designed independently
- ESS for long-term application
- Low-cost, long cycle life
- Capacity : 1MWh, Output : 100kWh



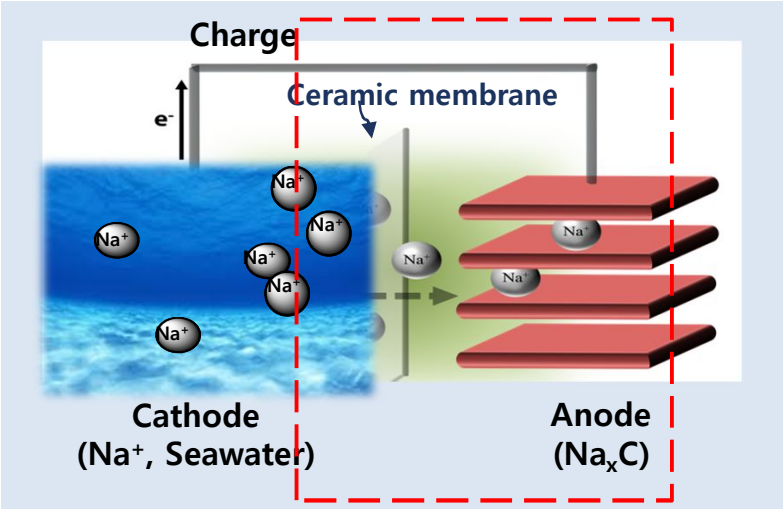
<Schematic diagram of VRFB>



Battery using Sea-Water

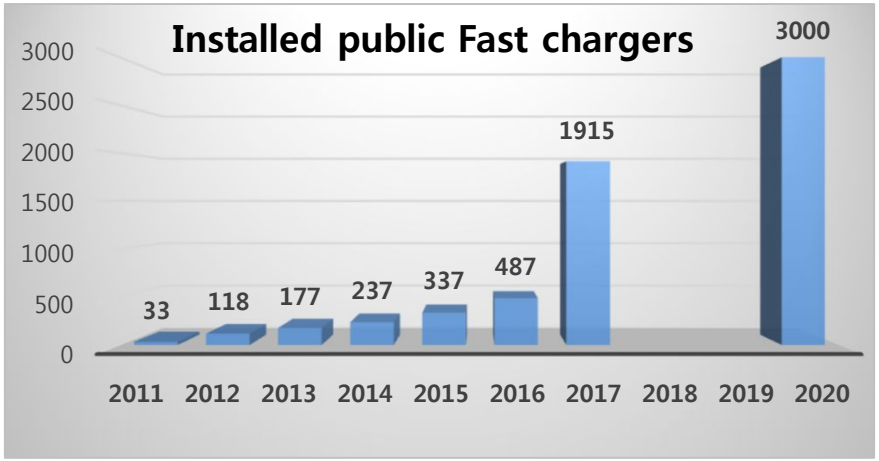
- Advanced Na ion battery using sea-water as Na source
- Na is cheaper and more abundant than Li
- Low-cost, high energy density

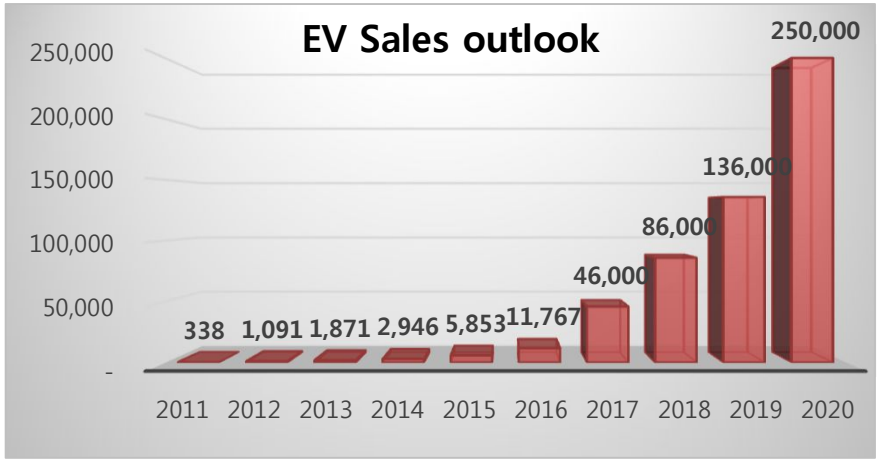
<Schematic diagram of Battery using Sea-Water>



3. EV Charging System

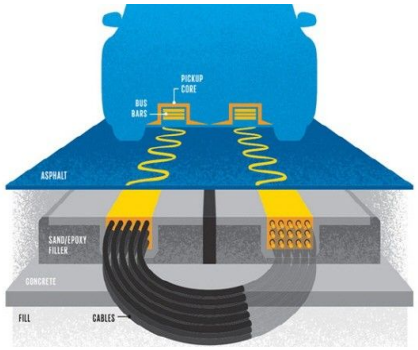
EV and Charging infra outlook





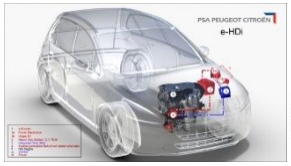
Charging System in the Future

Autonomous EV



Wireless Charge for Moving Vehicle

Graffin Super-Capacitor & Li-Battery Hybrid System



ESS in EV

=

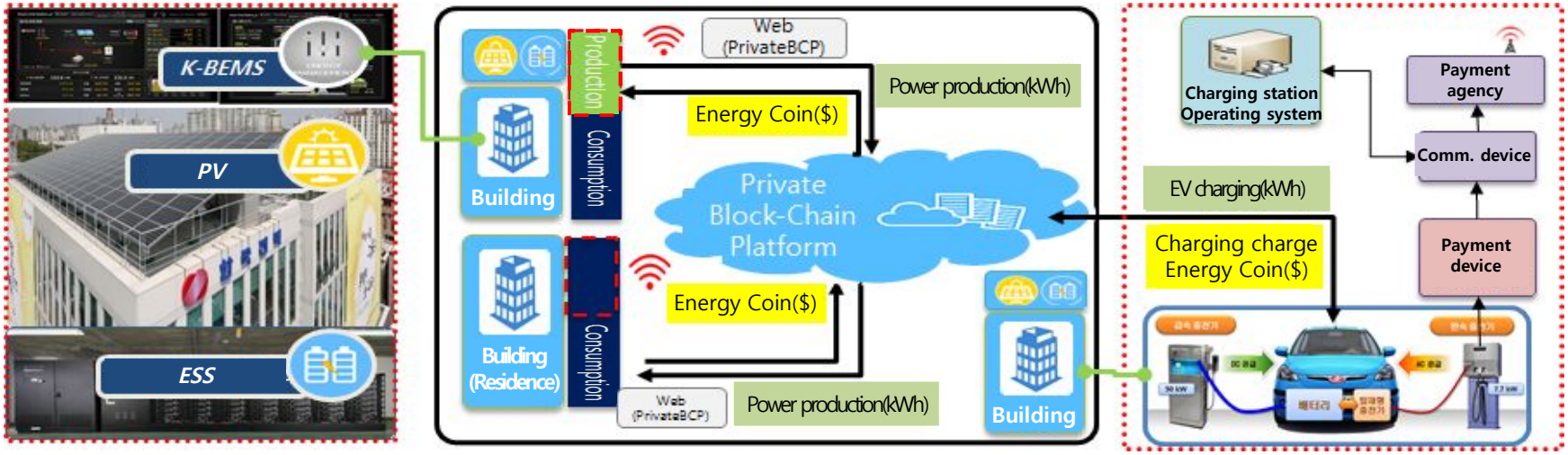
Super-Capacitor

+ Hybrid

Li-Battery

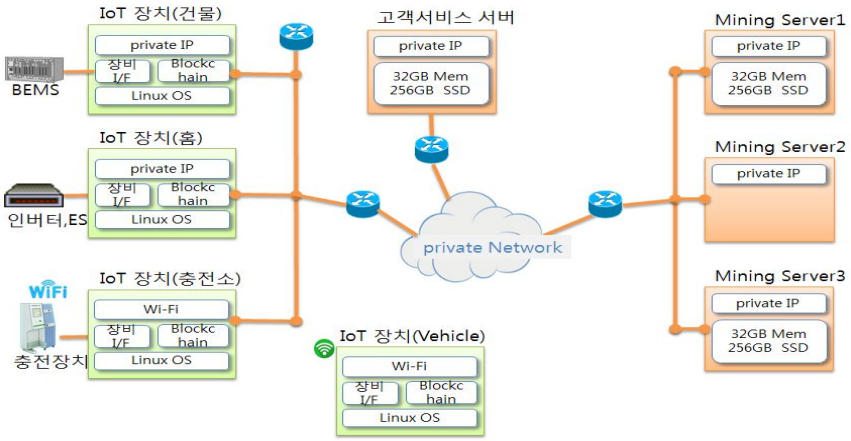
4. BlockChain

Demonstration of transaction with energy prosumer

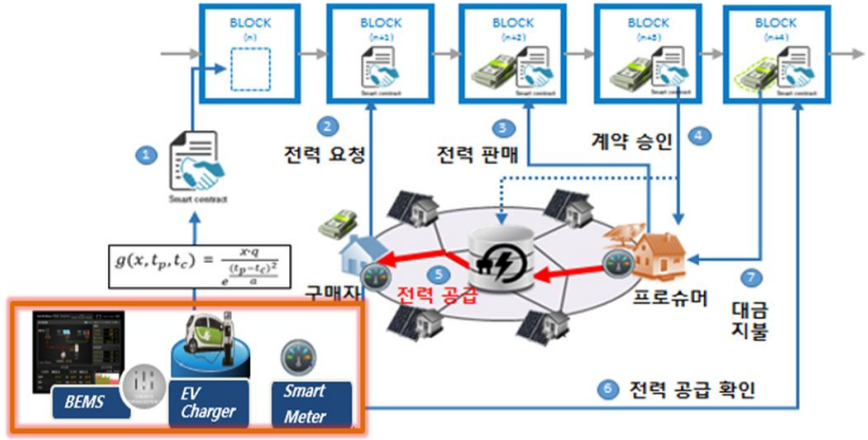


Building energy transaction using blockchain

Charging EV using blockchain



Blockchain-based energy transaction network

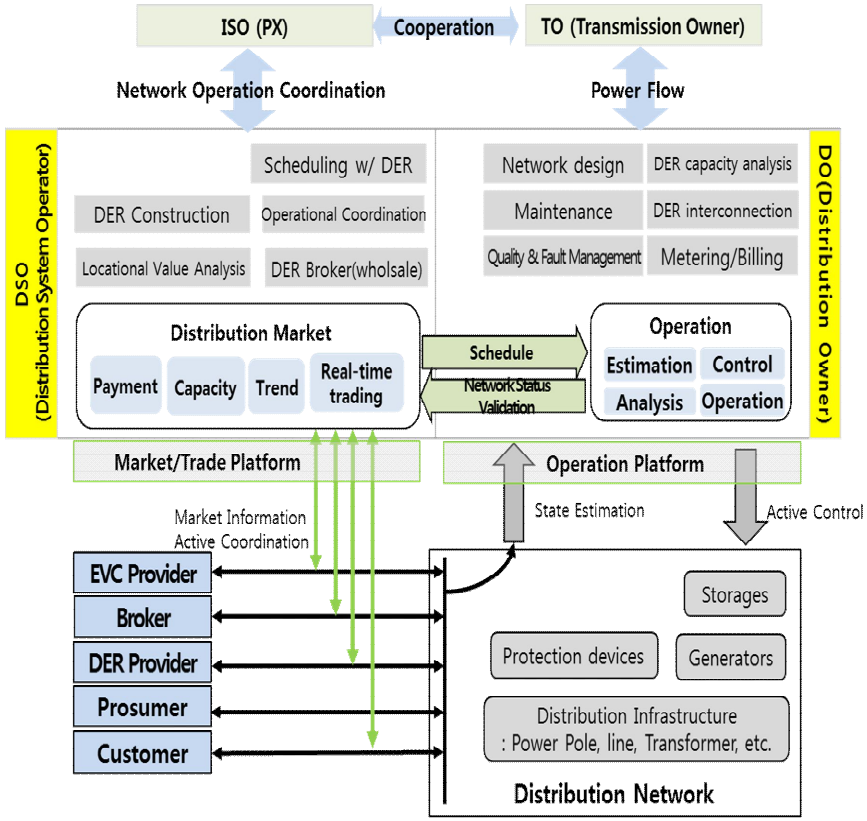


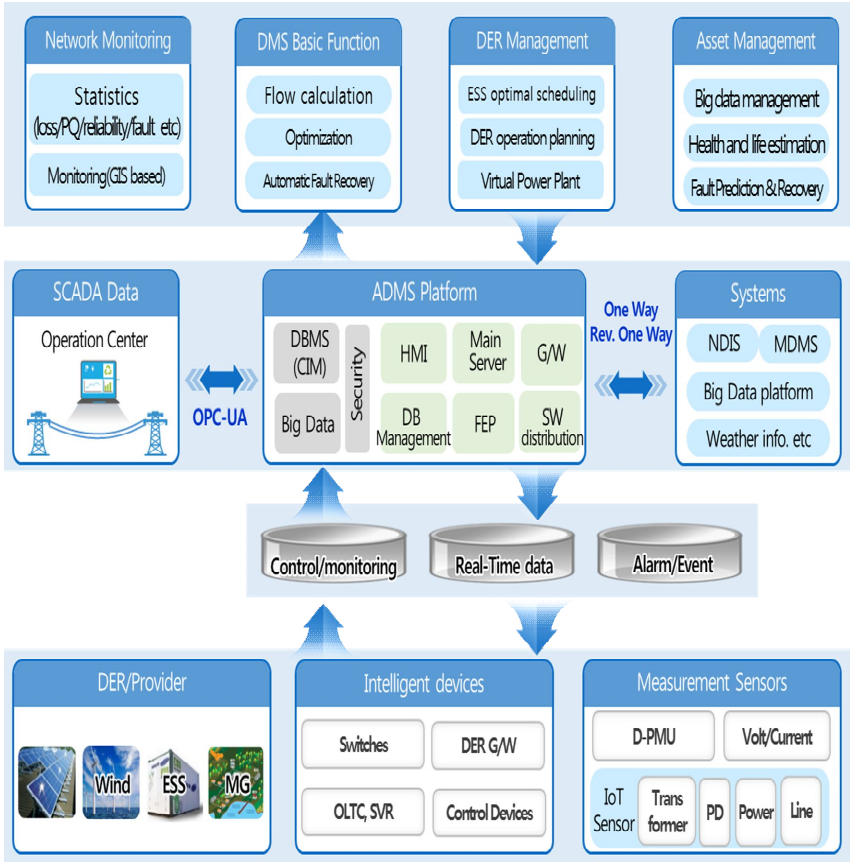
Blockchain-based energy transaction procedure

5. Advanced Distribution Management System

DSO/ADMS

Voltage and stability management / Open and Active management system



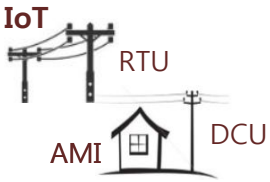


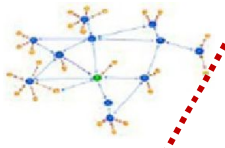
6. Using IoT Fault Prediction System

Big Data, AI Prediction

Intelligent Data Analysis & Fault Prediction using Big Data of MV/LV Grid

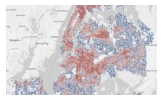
Data Creation (Things) ↔ Acquisition & Network ↔ Collection & Aggregation ↔ Artificial Intelligent (Prediction / Inference) ↔ Visualization Business ↔ Services





- Big data platform
- Data preparation
- Rule-based engine

- Machine learning
- Context awareness
- Pattern recognition

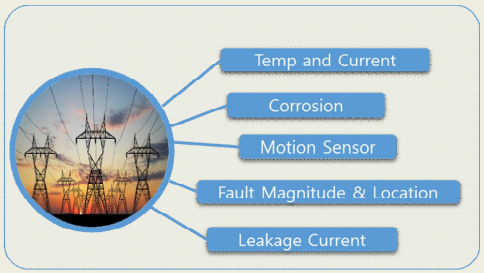


VR / AR

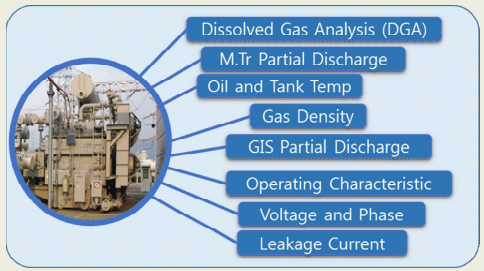
T&S Fault Prediction

Designing Comprehensive Diagnosis and Prediction System based on IoT Sensor

Data mining based on IoT Sensor
(Overhead Transmission System, Substation System, etc.)



Transmission System

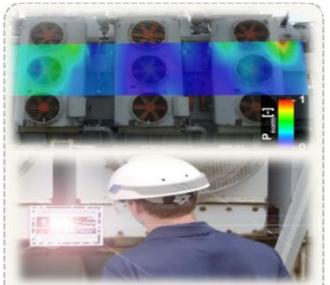


Substation System

Big Data & AI
(Comprehensive Diagnosis System)

Fault Prediction

VR / AR
(Visualization)

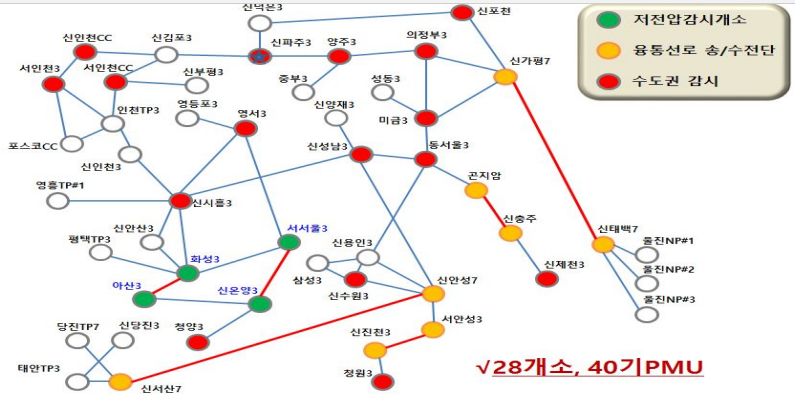


Fault Prevention

7. WAMPAC – Intelligent power system operation system

KEPCO WAMAC status

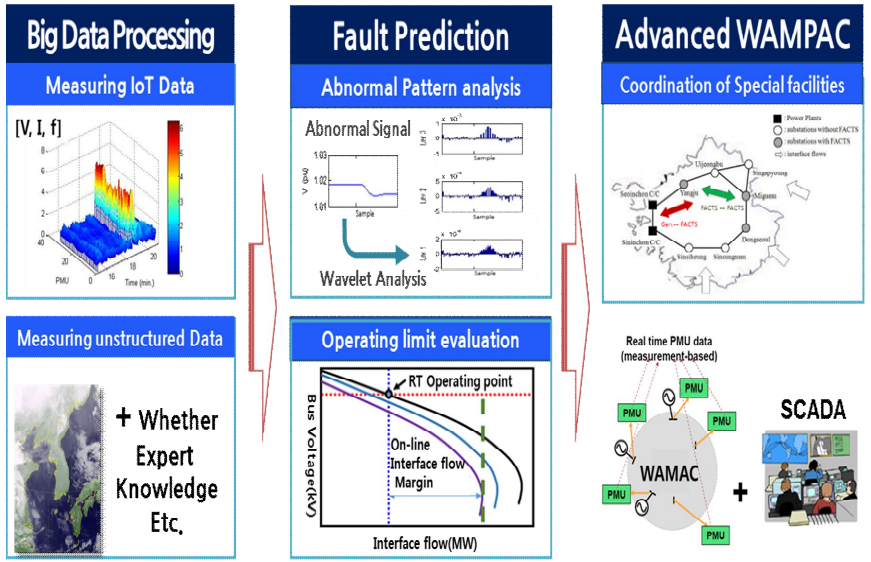
- **PMU Installation**
  → 40 PMUs installation at 345kV 28 S/S



- **Monitoring main interface line & S/S**
  → Installation at system operating center of KEPCO

Development Plan of WAMPAC

- Synchrophasor + Unstructured Data
  ➔ **Big Data processing technology**
- Pattern Analysis using Big Data
  ➔ **Fault Prediction & Operating limit Evaluation**
- HVDC, FACTS, Renewable Energy Coordination
  ➔ **Advanced WAMPAC Technology**



8. Power Plant Fault Prediction System

Fault Prognostics

Operation/Maintenance Optimization through Intelligent Digital Power Plant

Connectivity

Monitoring

Plant A

Plant B

Big Data Platform

Service (Synergy)

Convergence

Big Data | IoT | AI | Service

Platform (Connection)

HUB-POP

Resource

KEPCO Cloud Infrastructure

Infra (Cloud)

IDPP

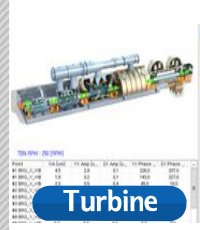
Tech. Center — Monitoring for Equipment

Expert DB — Diganositics&Prognotics

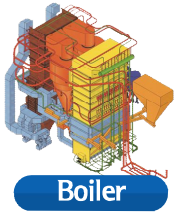
VR/AR — Remote Tech. Support

Asset Center — Decision Support

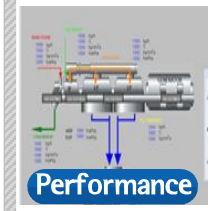
Remote Diagnostics



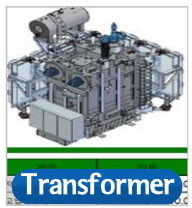
Turbine



Boiler



Performance

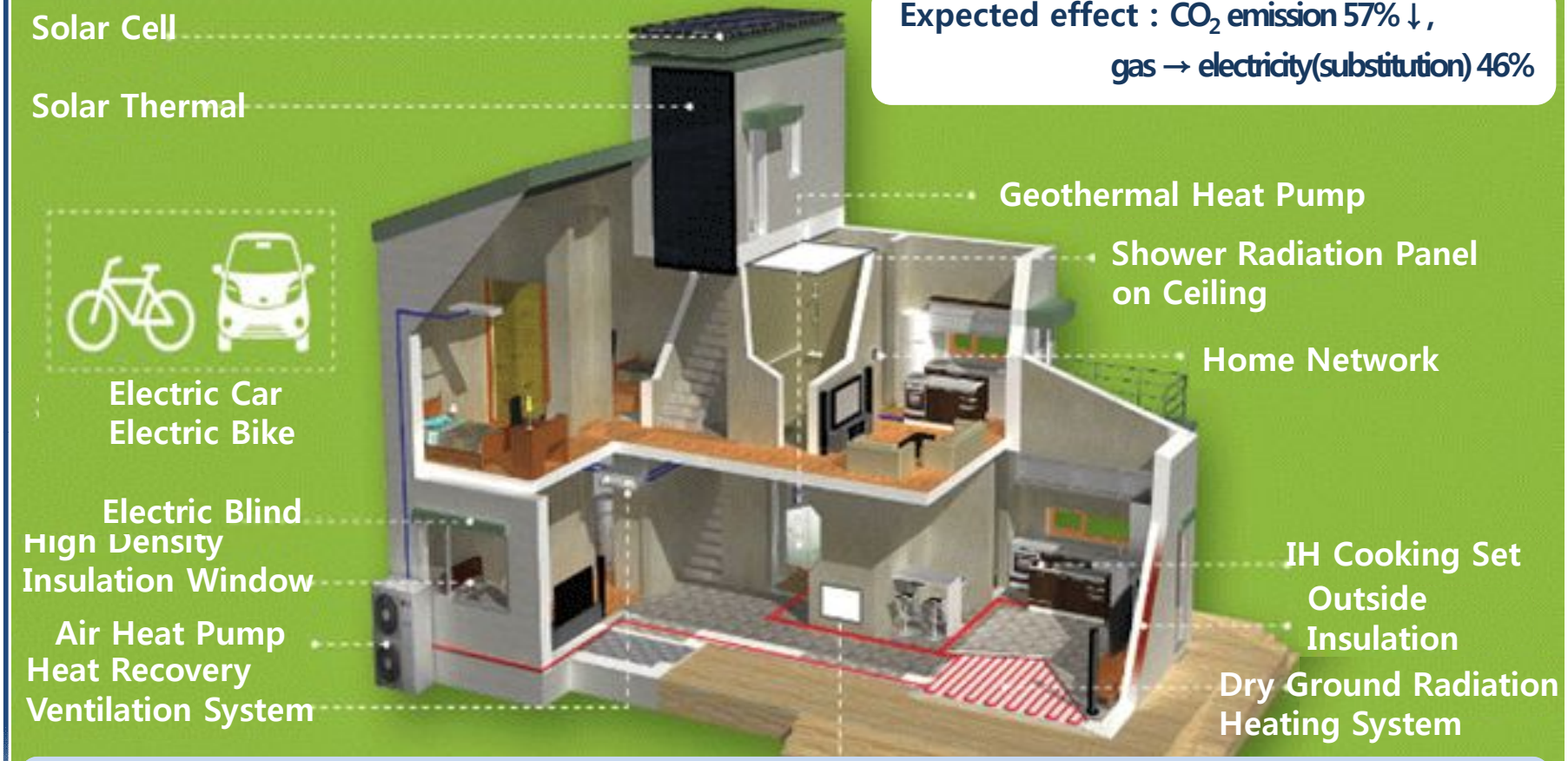


Transformer

Realtime DB | Big Data Processing | Intelligence Operation | Reliability Improvement

9. Energy Passive House

E-Smart House



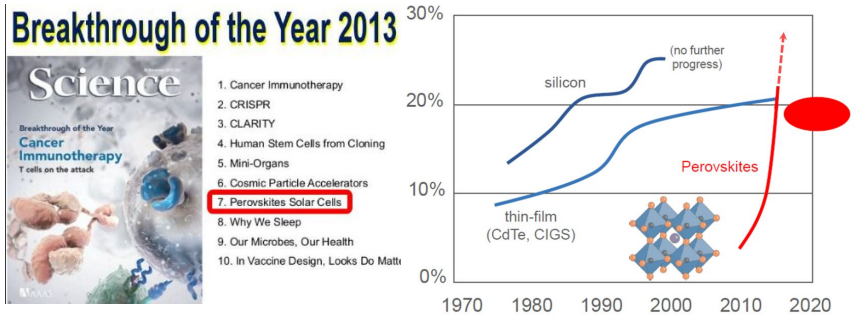
- ❖ (Passive House) High Insulation/Efficiency, Self-energy production
- ❖ (Efficiency) Geothermal Heat Pump, IH Stove, LED
- ❖ (Smart Home) Optimized energy usage based on EMS
- ❖ (Thermal Loss) High Insulation Construction
- ❖ (Renewable energy) PV, Geotherm, ESS

10. New Solar Energy

Perovskite Solar Cells

Inorganic-organic hybrid perovskite solar cell for BIPV(Building Integrated Photovoltaic System)

- ☞ **Achieved solar power conversion efficiency (PCE) exceeding 22% (2016).**
- ☞ **Top 10 Breakthrough Technology ('13, Science).**

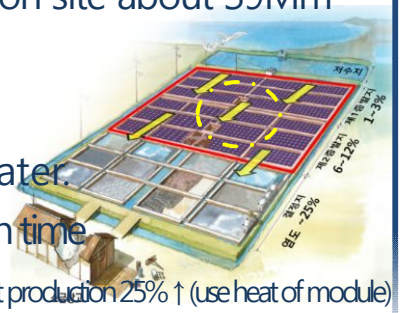


※ **Utilization** : Tile, Roof, Curtain, Facade etc.

Underwater PV Systems for Salt Farms

The world firstly, salt & electricity co-production by installing underwater PV system in salt farm.

- ☞ Domestic salt evaporation site about 39Mm^2
  → Securing 4GW-PV Site
- ☞ PV module's heat
  → evaporation of seawater.
  → Reduce salt production time

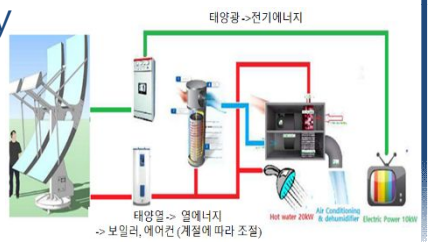


※ Module efficiency 5% ↑ (water cooling), Salt production 25% ↑ (use heat of module)

Concentrated Photovoltaic + Thermal

Hybrid Solar energy generation system providing electric energy(3㎾) and thermal energy(5Mcal/h) at one household in 20㎡

- ☞ power conversion efficiency (solar cell efficiency) 30% ↑
- ☞ Solar heat collection efficiency 50% ↑



KEPCO KOREA ELECTRIC POWER CORPORATION

With Future Technology, Save KEPCO

Thanks !