Challenges for the Future Energy in Korea

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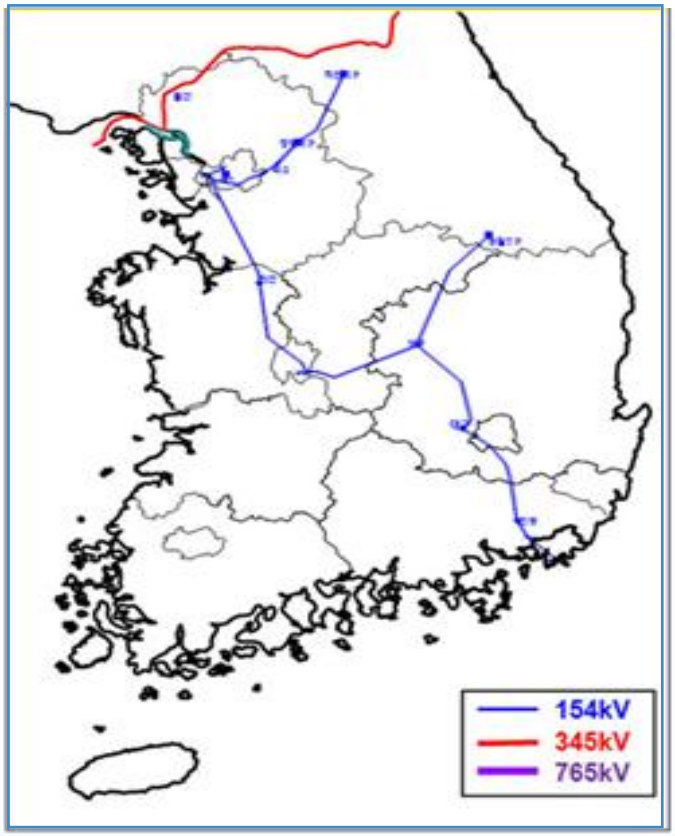
President of KESRI

Instructor Profile

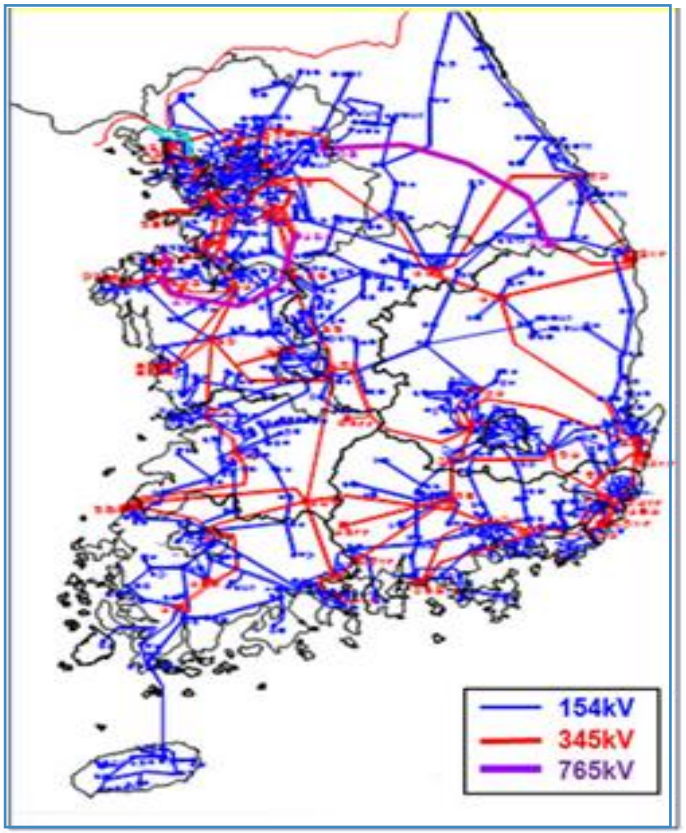
- B.S. Electrical Engineering, SNU
- M.S., Ph.D. Electrical Engineering, OSU
- Professor, SNU EE
- Member, Korea Electrical Safety Corporation-Advisory Committee
- Member, Committee on Green Growth
- Member, National Energy Committee of Korea
- Executive Director, Korea Smart Grid Institute
- Chairman, Electric Power Policy Committee of Korea
- President of KESRI

Development of Korean Power Network

Power System in 1968



Current Power System



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Korea, Now

- Highly Concentrated
- Isolated Power Island

World No.1 Electric Power Quality

	Korea	U.S.A	Japan	Rank
Voltage Maintenance (%)	99.93 ('12)	-	99.9 ('93)	1
Power outage time (min)	10.88 ('14)	120 ('09)	11 ('07)	1
Frequency maintenance (%)	99.97 ('11)	-	99.9 ('94)	2
Transmission loss (%)	3.69 ('11)	5.8 ('11)	4.8 ('11)	1

Source: KPMG result of evaluation of electrical energy'13

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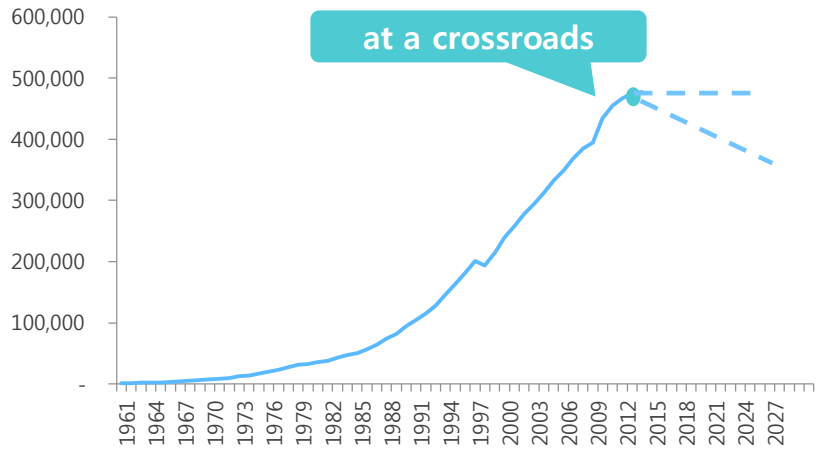
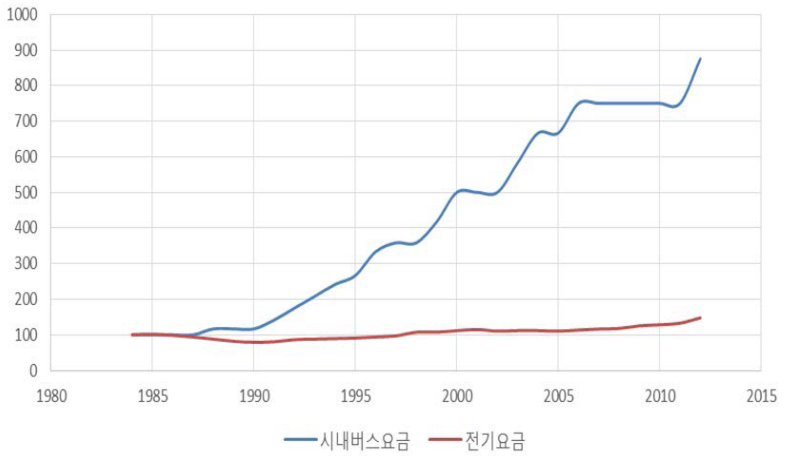
Korean Electric Power Status

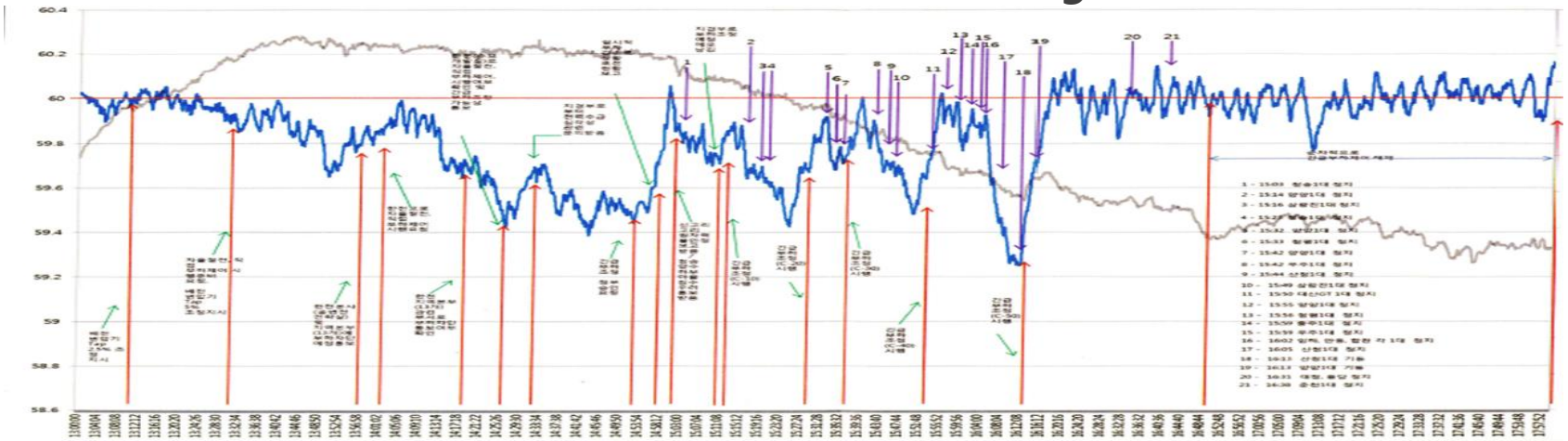
Annual Power Consumption per capita



Bus Fare vs Electricity Cost



9.15 Circulative Power Outage



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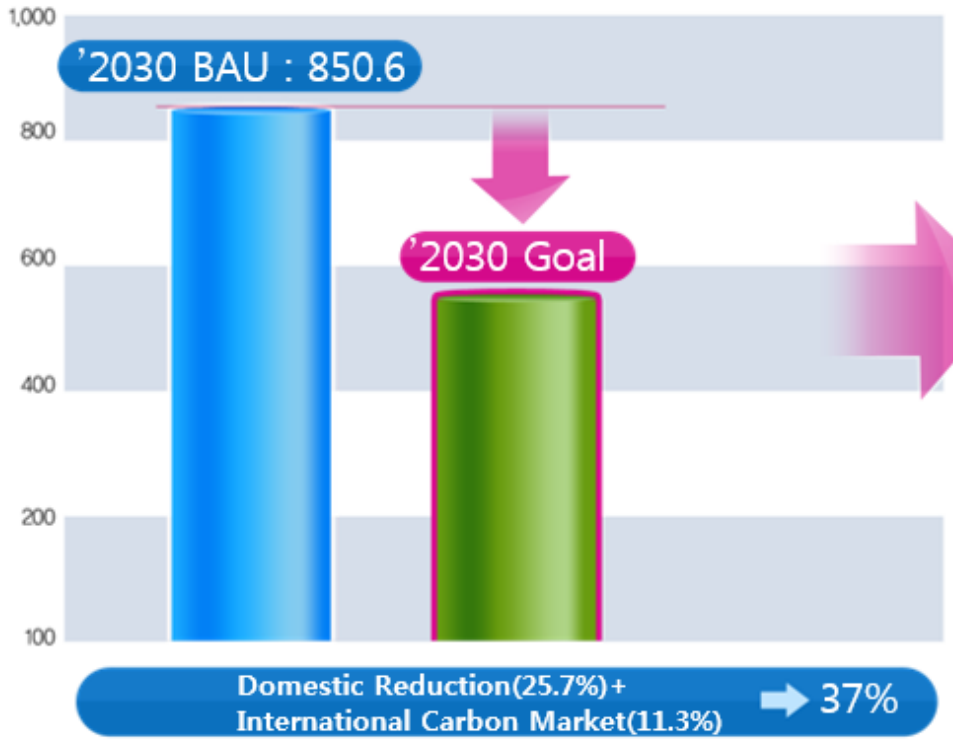
International Trend – New Climate Regime



'2030 Goal
"37% Reduction of Expected emission"

* Domestic Reduction 11.3%,
International Carbon Market 25.7%

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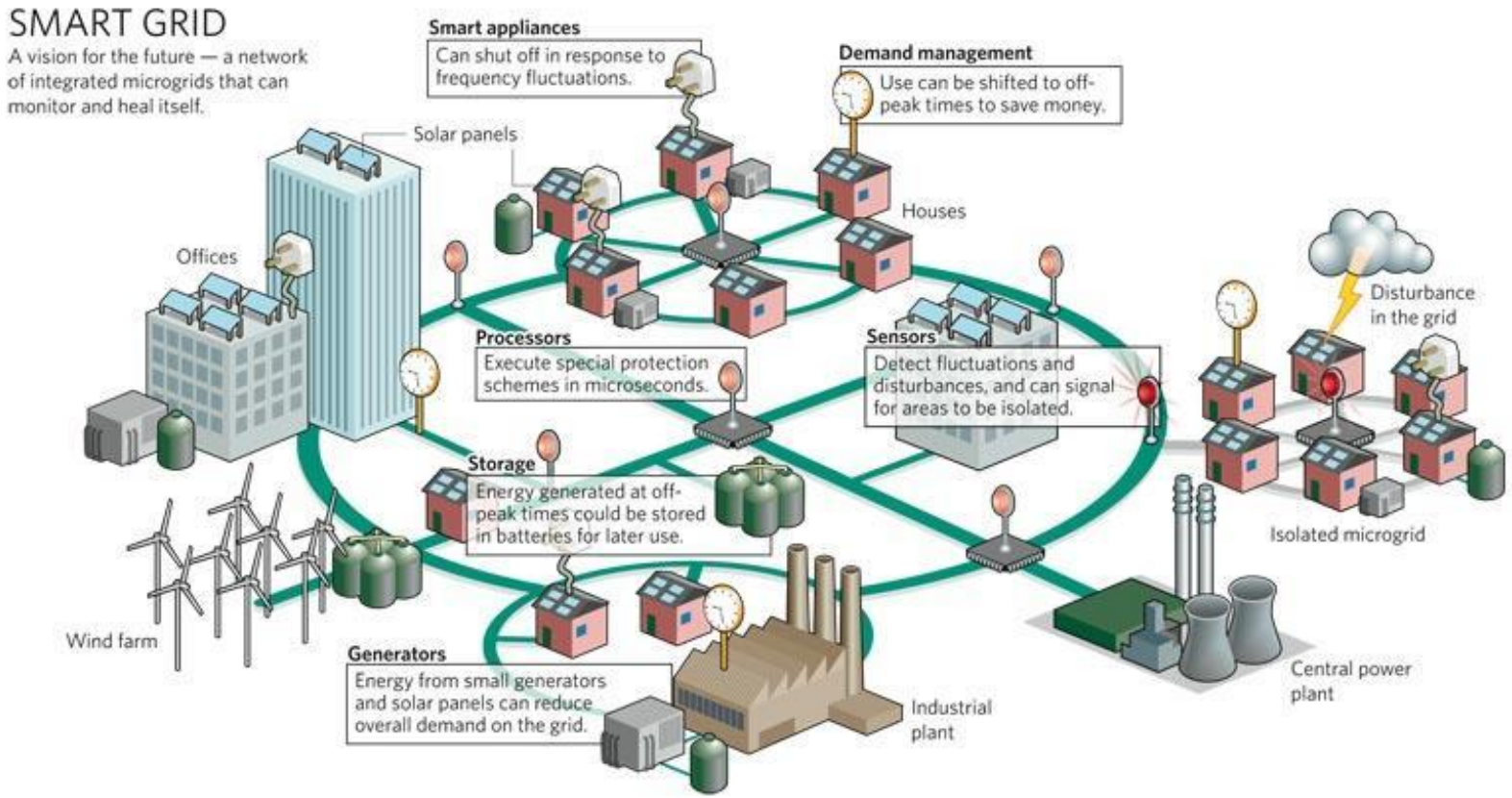
Solution for Challenges : Smart Grid

- **Next Generation Power Grid**
- **Power Grid + ICT**
- **Nationwide Smart Grid by 2030**



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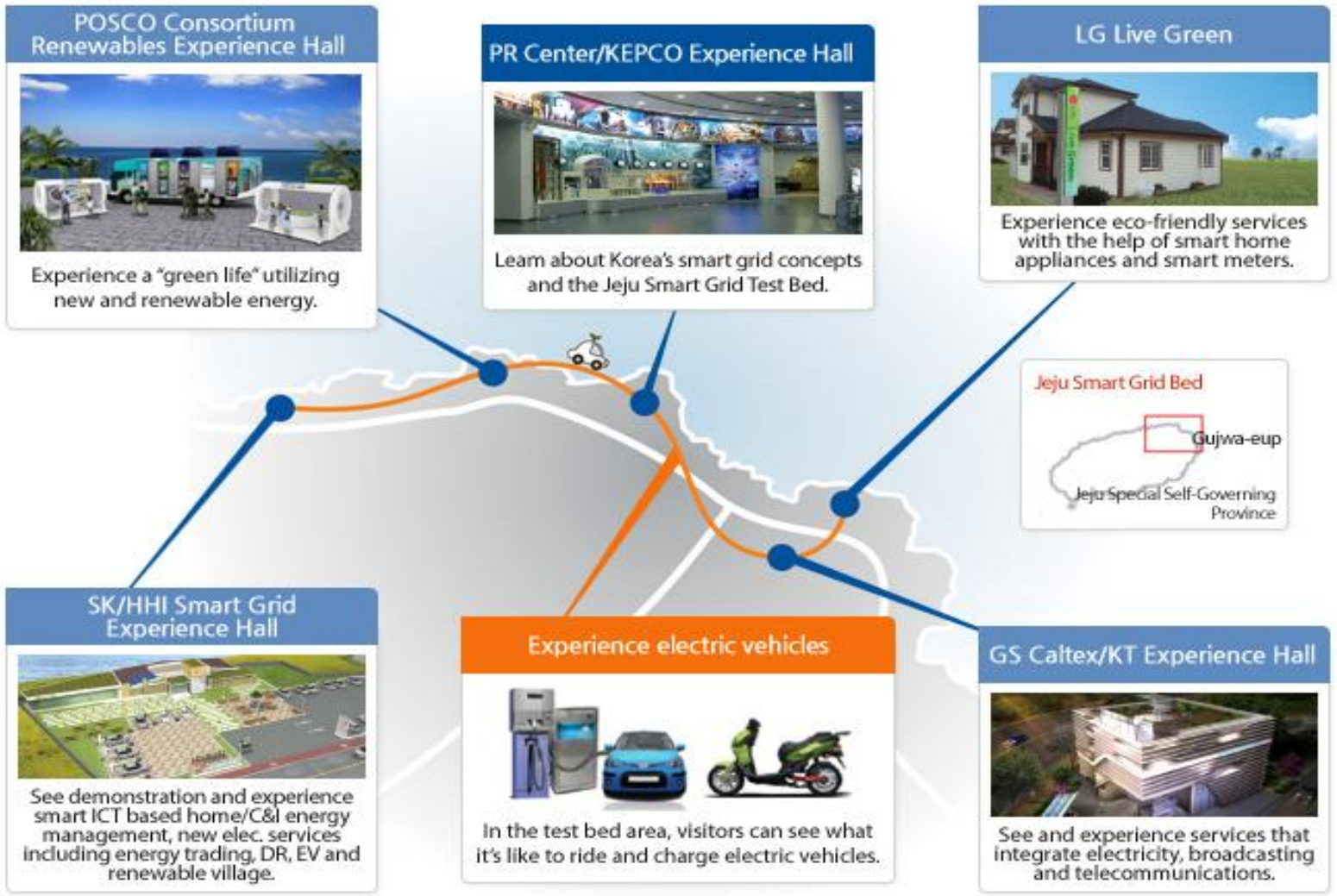
Jeju Smart Grid Test Bed Project



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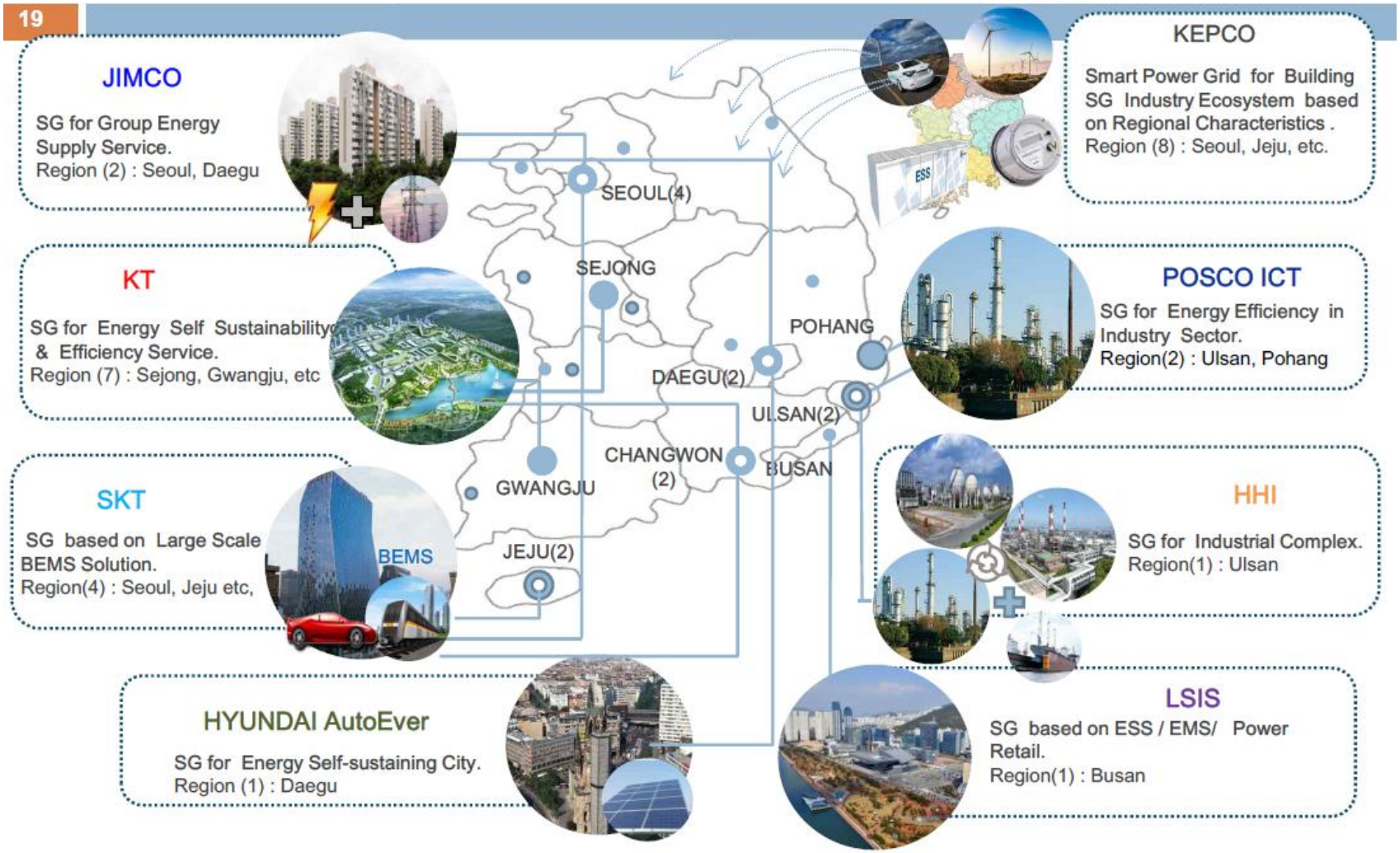
Smart Grid Hub Cities



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Energy New Industry in KOREA

Electric Vehicle

Eco-Friendly Energy Town

Resource Trading Market

Zero Energy Building

Energy Independent Island

Waste Water Utilization

ESS

PV Rental

Source : Committee of Green Growth

ESS for Frequency Regulation

❑ Current State of KEPCO FR Business

- ❑ Accumulation installation amount of 500MW by 2017
- ❑ 625 billion(KRW) budget (KEPCO)
- ❑ Expected effect
  - Reduce in annual average power purchase cost of KEPCO by $0.35bn
  - Improve the power quality & efficiency by FR

❑ Business plan

	2014	2015	2016	2017	Total
Capacity(MW)	52	184	140	124	500
Budget (100 million)	570	1,900	1,890	1,890	2014

EV Charging Star-Network by KEPCO

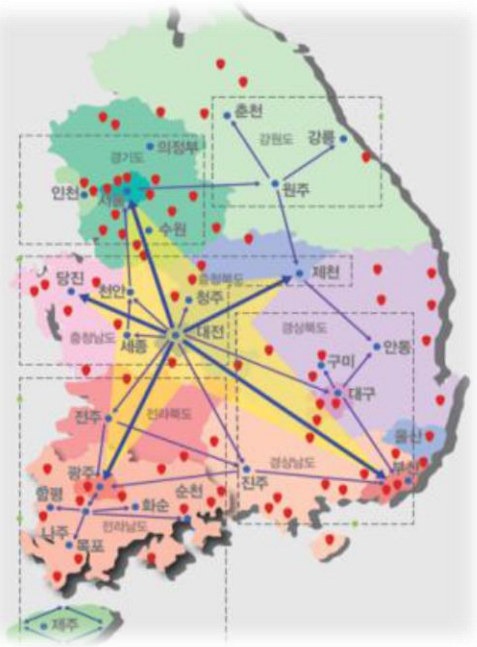
❑ Star-Network Plan & Fee-charging

❑ Cut the distance between charging infra

	'15	'16
Interval	100km	50km
Sites	40	50

❑ Star-Network Plan

	'15	'16	Total
Fast-charging	23	100	123
Slow-charging	105	400	505
Total	128	500	628



❑ Fee-charging

- ❑ Step 1: Charging fee
- ❑ Step 2: Charging fee + Service fee

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EV & Charging Station Plan in Korea

❑ EV and Charging Station Roadmap

(unit : ea)

		2014	2015	2016	2017	2018	2019	2020
EV	per year	1,000	3,000	10,000	30,000	40,000	50,000	64,000
	Total	3,000	6,000	16,000	46,000	86,000	136,000	200,000
Fast Charging	per year	60	100	150	150	193	170	400
	Total	237	337	487	637	830	1,000	1,400
Slow Charging		1,170	2,940	9,800				

❑ 1 million EV's by 2030

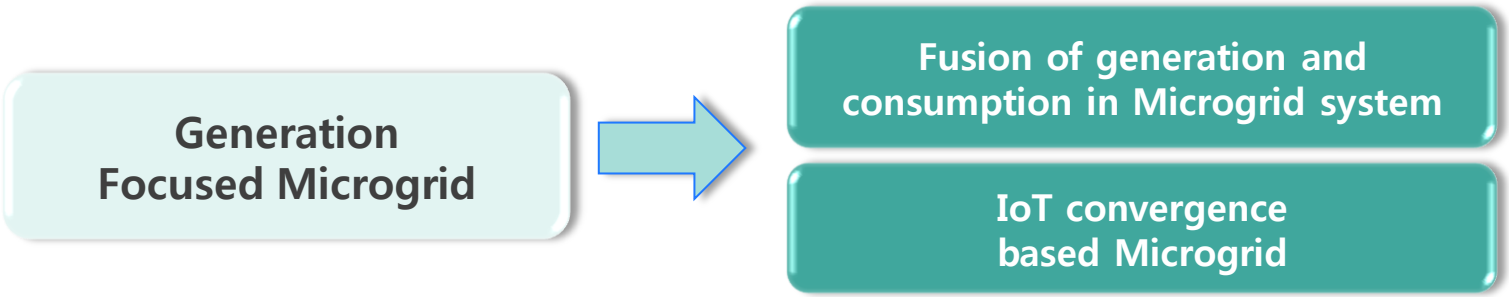
Seoul National University Campus Microgrid

❑ SNU Campus MG Demonstration Project Overview

- ❑ Project Budget: 15.7 million USD (Gov. 10.3M, Private 5.4M)
- ❑ Project Period: 2015. 06 ~ 2019. 05 (for 4 years)

❑ Project Goal

- ❑ Development of a customized SNU Campus MG model
  - 4 hours islanding operation
  - 20% peak load reduction and energy cost saving
  - Consumer participative energy-saving services



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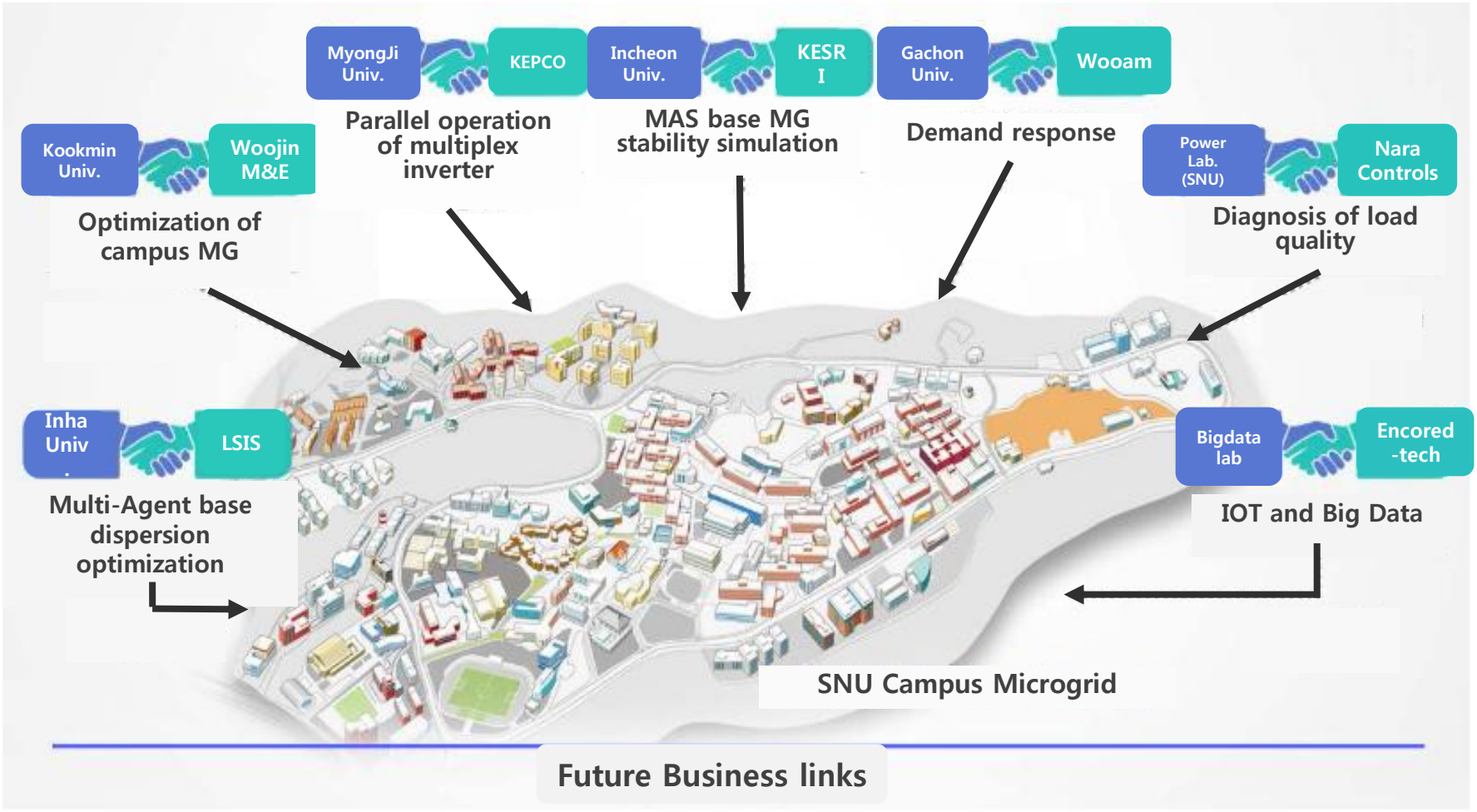
Seoul National University Campus Microgrid

❑ Convergence of Industry and Academic Cooperation



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Roles of the Connected Vehicles

- Smart Transportation
- Smart Energy System
- Smart ICT Platform

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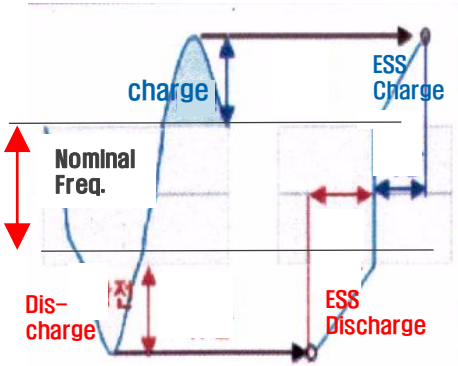
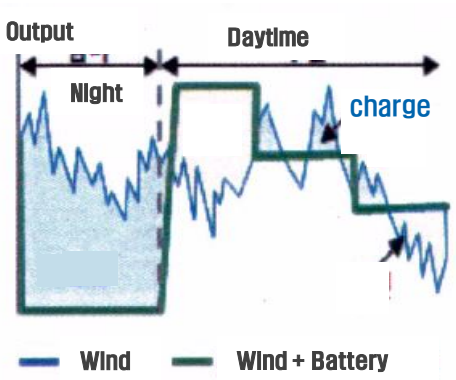
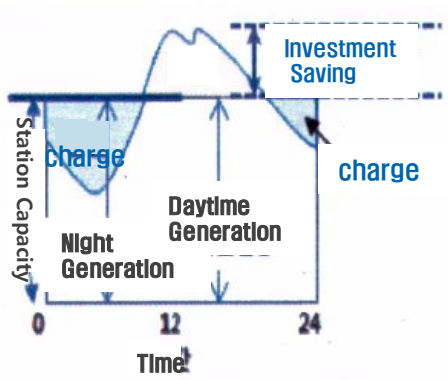
Roles of EV Connected to Power Network

	Frequency Regulation	Renewable Energy Stabilization	Peak Reduction
Application Method	Over rating : charge Under rating : discharge	Flattening by compensating for unstable output	Light-load : charge Heavy-load : discharge
Content			

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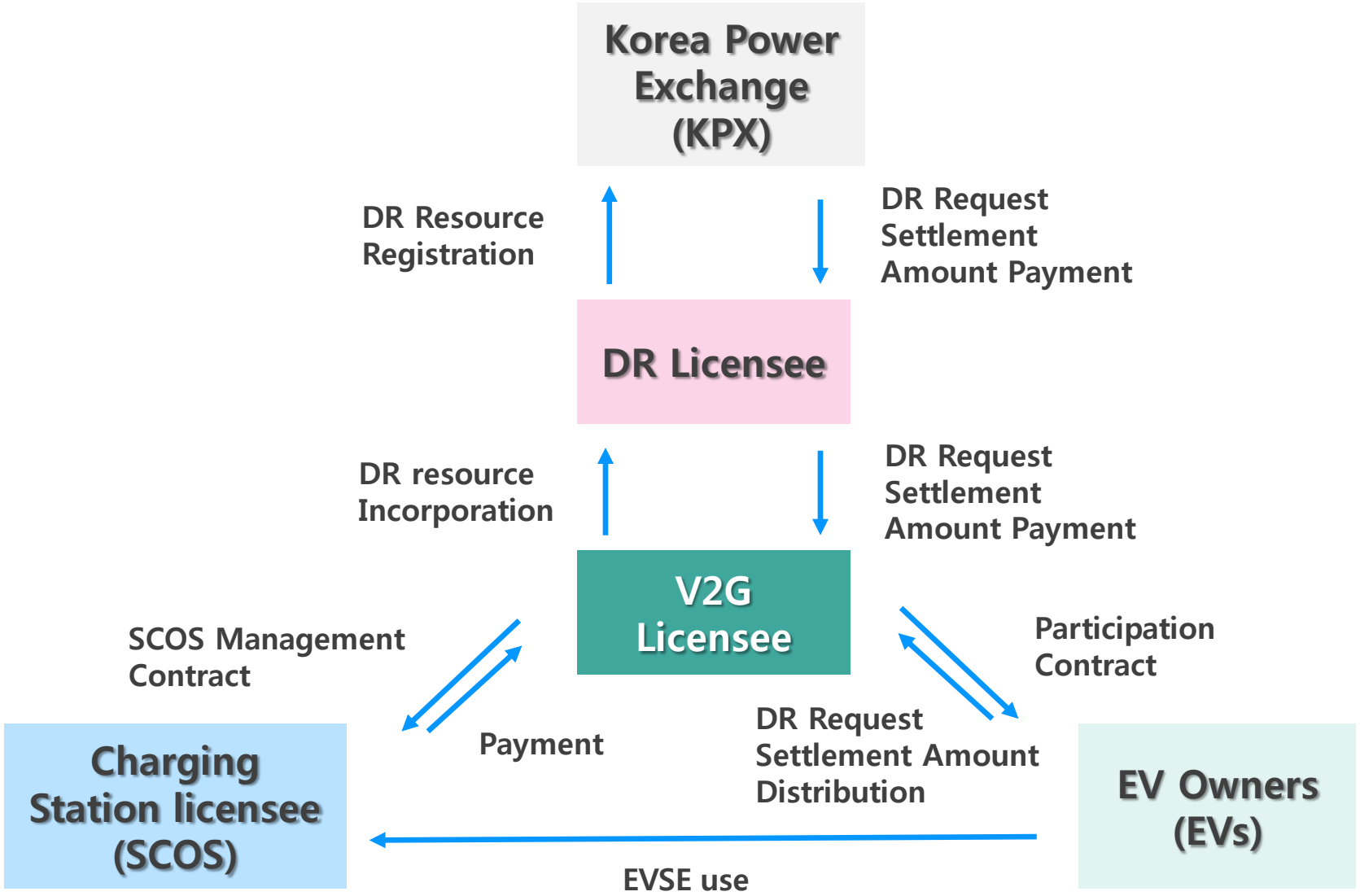
New Business with EV's



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Concept of V2G

Consumption

Generation

Electrical Gird

V2G SYSTEM

Charging

Discharging

EV

Power Technology
EV Technology

+

ICT

=

New
Power Plant

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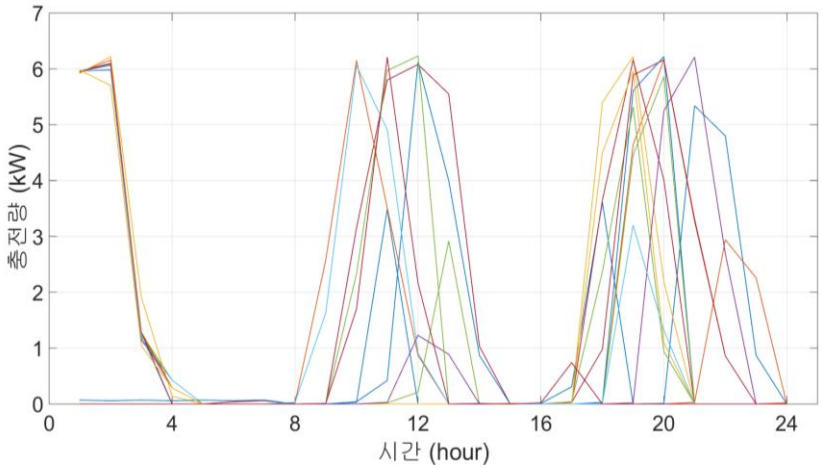
Seoul National University V2G

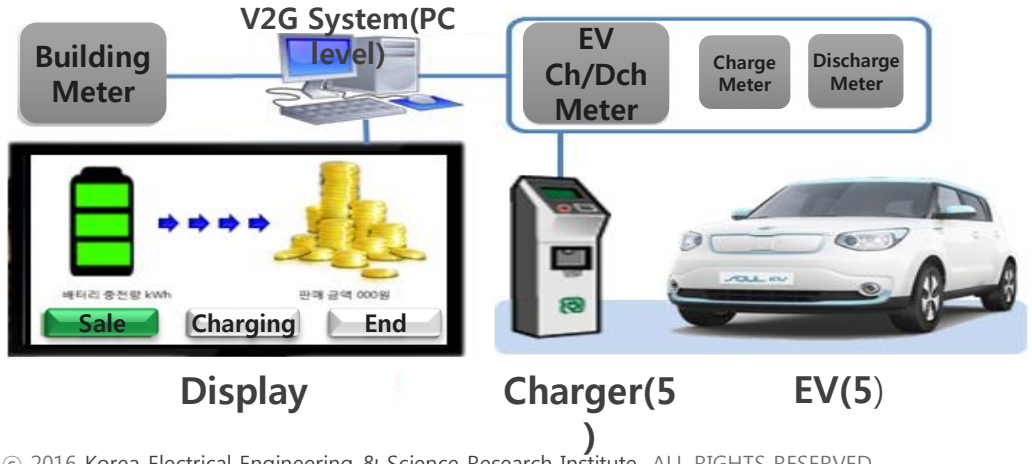
❑ V2G Test Bed in SNU

❑ Automatic Charge/Discharge System

- ❑ 13:00~17:00 → Discharge
- ❑ 23:00~06:00 → Charge
- ❑ SOC limit : 50%



❑ Local control is possible and prior to automatic control



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Seoul National University V2G

① Electricity Cost of the Connected Building

- $\boldsymbol{Price}\times\boldsymbol{kWh}\times\eta\_dch\times\boldsymbol{day}$
- Calculated by each season due to different prices.

	Summer	Spring·Fall	Winter
Electricity Cost Revenue	133,294 won	137,142 won	108,756 won

② Annual Peak Reduction Cost

- 548,800 won/kW*5kW=2,744,000 won

③ EV Charging Cost

- $\boldsymbol{Price}\times\boldsymbol{kWh}\times\eta\_ch\times\boldsymbol{day}$
- Calculated by each season.

④ Battery Life Cost

- $\boldsymbol{C\_Life}\times\boldsymbol{kWh}\times\boldsymbol{day}$
- 71.43won/kWh×10kWh×365days=260,714 won

	Summer	Spring·Fall	Winter
Charging Cost	137,652 won	133,578 won	121,452 won

Total Revenue ⇨ ①+②-③-④=**2,469,796 won/year**

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Green Energy Independence Plan in Ulleungdo

Power Plants

Namyang Diesel (10,500kW) | Chusan Hydro (700kW) | Jeudong Diesel (8,000kW)

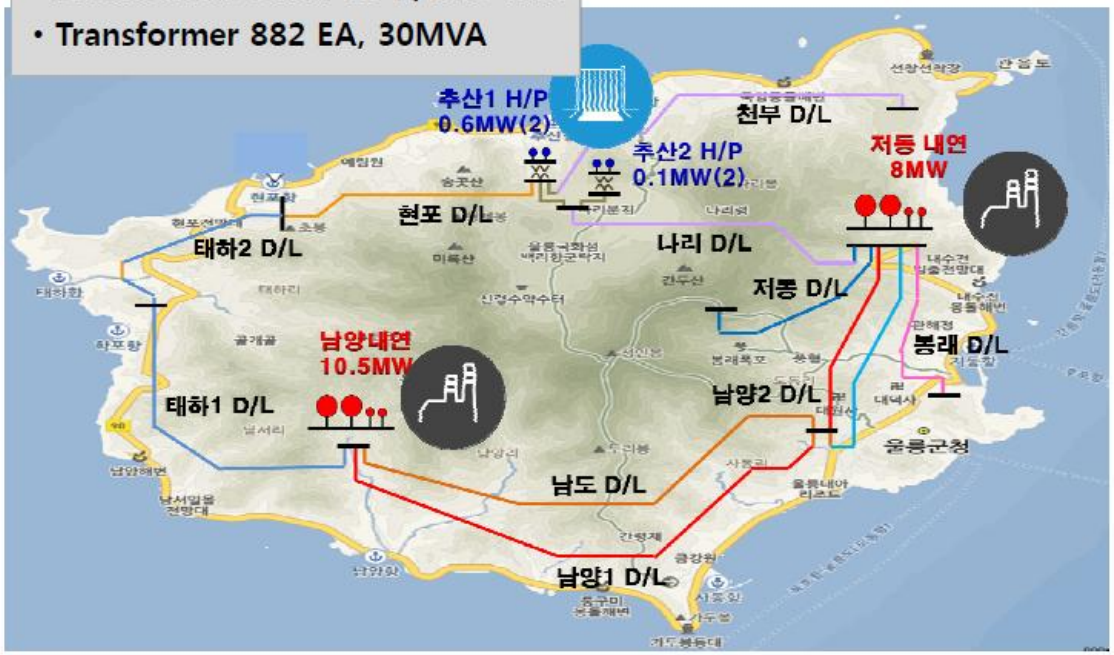
PV (217kW)

※ PV is installed on the 21 customer's house roof-top (not connected to grid)

Contents		Capacity (kW)	Ratio (%)
Diesel	Nam Yang	10,500	54%
	Jeo Dong	8,000	41%
Renewables	Hydro	700	4%
	PV	217	1%
Total		19,417	100%

Distribution Facilities

- Distribution Grid : 10 D/L 124km
- Transformer 882 EA, 30MVA



- **Power Load Status('13)**

Capacity	Max	Average	Min
19.4 MW	10.9 MW	7.1 MW	4.9 MW

- **Operating Margin('13) : 19 million $ Deficit**

Source : kepcos sg biz case and micro grid project in ulleung, KEPCO

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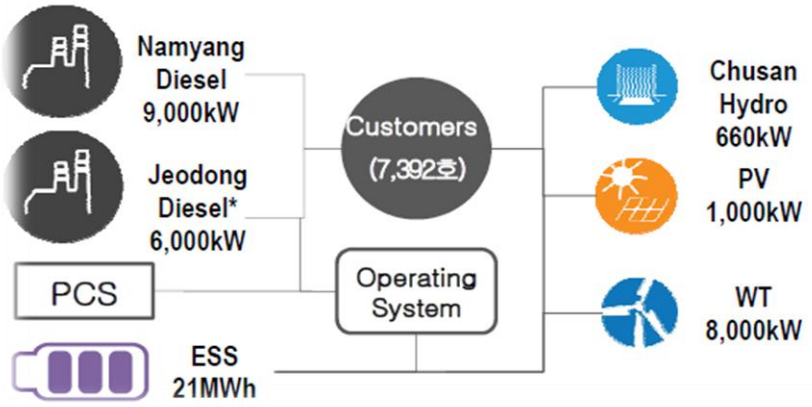
Green Energy Independence Plan in Ulleungdo

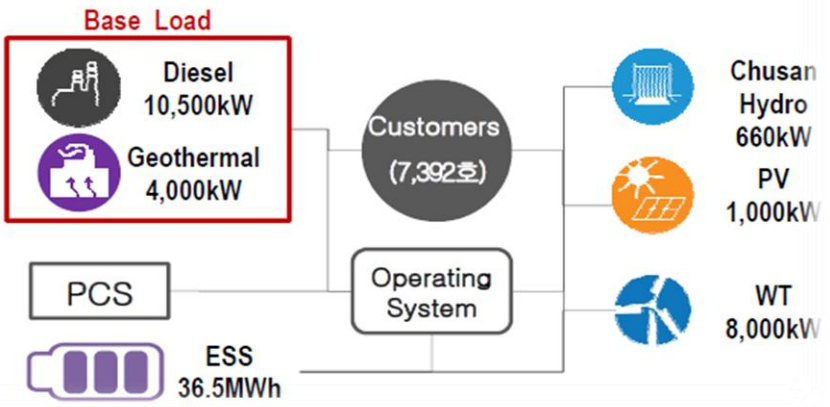
As is (MW)	
Diesel	Hydro
18.5	0.7

To be(MW) : Step 1('15~17) / Step.2 ('18~20)						
	Diesel	Hydro	WT	PV	Geo-thermal	ESS (MWh)
Step 1	15.2	0.66	8.0	1.0	0	21
Step 2	10.5	0.66	8.0	1.0	4.0	36.5

Step 1



Step 2



Source : kepco sg biz case and micro grid project in ulleung, KEPCO

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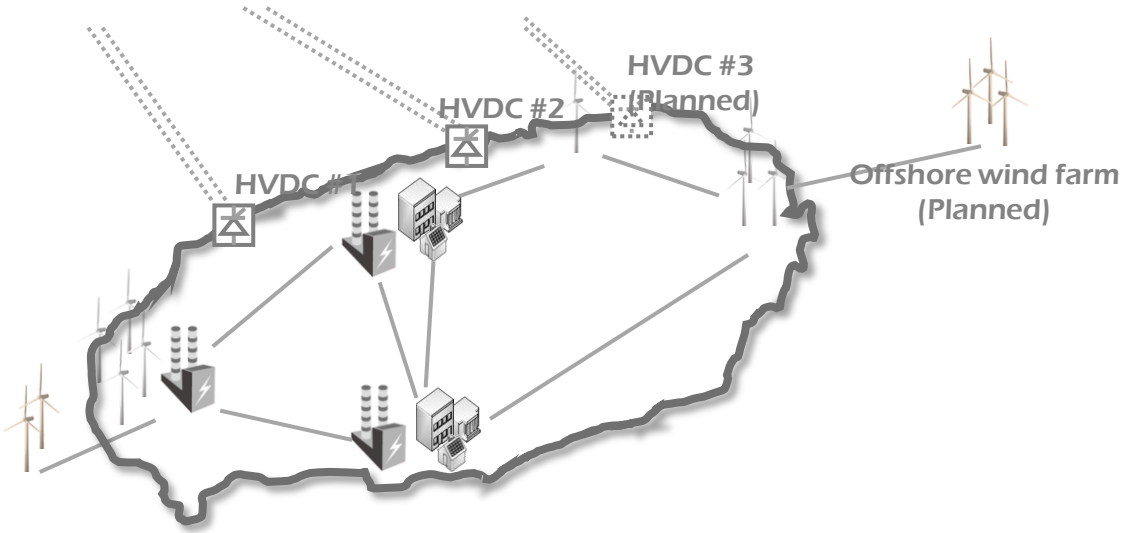
Changes Begin from Jeju Island

- **Overview of Jeju-island**
  - **Power generation**
    - Conventional Unit: 590MW, Wind: 153.3MW, PV: 48.4MW
  - **Bidirectional HVDC systems**
    - HVDC #1 300MW, HVDC #2 400MW
  - **Power consumption**
    - Peak Load: 762MW
    - Avg. Load: 523MW



- **Long-Term Strategy**
  - **Supplying 1 Million EV through 2030**

Jeju Carbon Free Island 2030

❑ Goal of Carbon Free Island by the 2030

❑ Development of renewable generation

❑ All thermal power plants are replaced to renewable energy

❑ Acceleration of EV

❑ All cars are replaced to electric vehicle (EV)

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Jeju Carbon Free Island 2030

❑ Renewable & EV Infrastructure

- ❑ Wind, Solar, Fuel Cell
- ❑ ESS
- ❑ Quick Charger

❑ ICT based EV and DG Integrated Management

- ❑ Energy management
- ❑ Energy forecasting
- ❑ DG control
- ❑ EV maintenance
- ❑ Charger maintenance

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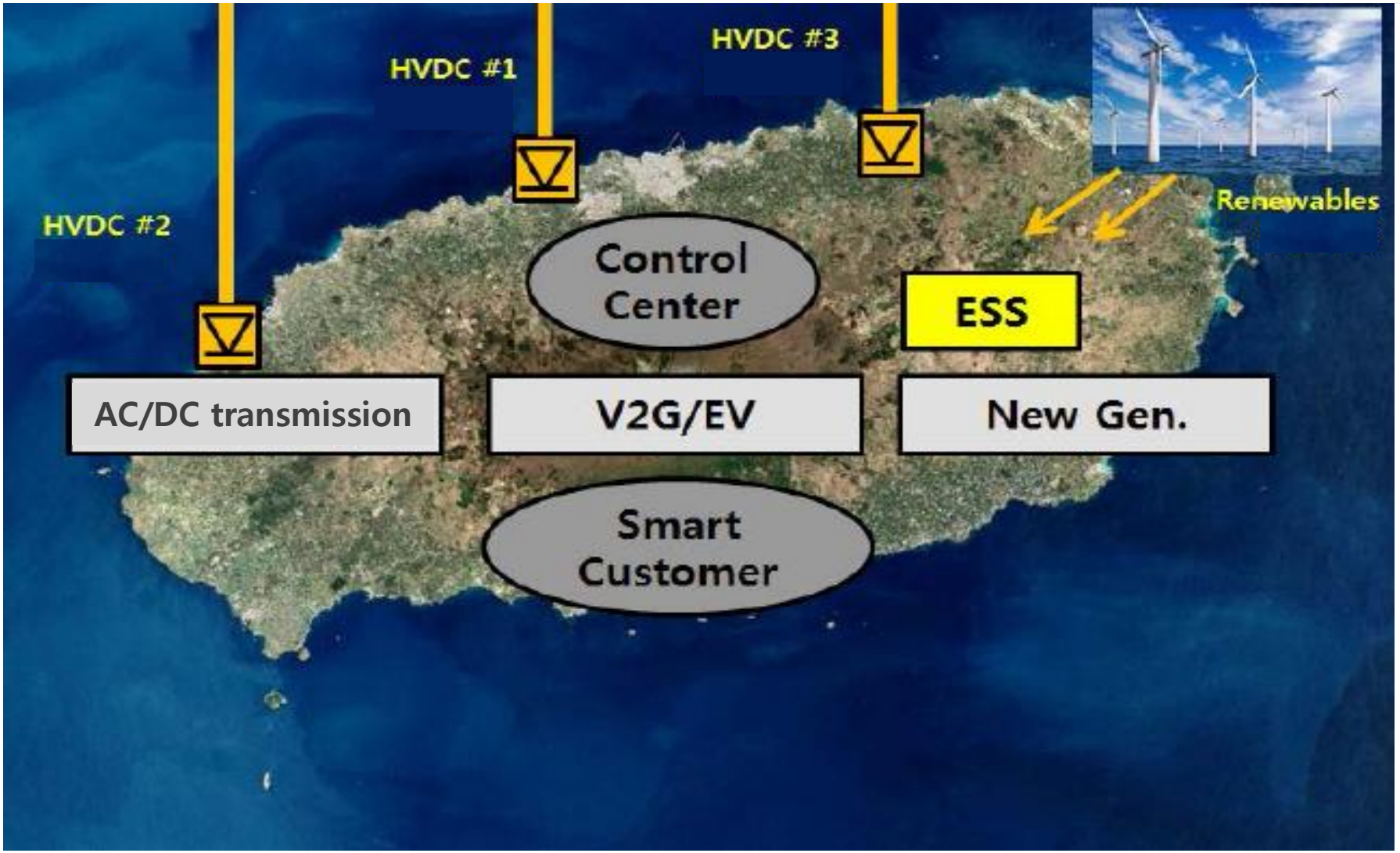
Global Eco-Platform Jeju

❑ Renewable Energy Plan

		Present	1st (~2018)	2nd (2019 ~2020)	3rd (2021 ~ 2030)
Renewable (Intermittence)		210MW	730MW	1,350MW	2,690MW
Fuel Cell				60MW	520MW
ESS			410MW (670MWh)	670MW (1,010MWh)	1,300MW (1,900MWh)
Ratio of Renewable		13%	35% ↑	55% ↑	85~100%
EV	Private	788	52,000	125,000	309,000
	Taxi	6	1,700	1,700	4,300
	Rental	58	2,250	8,200	33,000
	Bus	-	(route) 171	(route) 275	(route) 566 (etc.) 3,000
Total EV (ratio)		852 (0.3%)	55,000 (20%)	135,000 (40%)	377,000 (100%)
Fast-charging		79	3,100	5,400	150,000

Jeju New Grid



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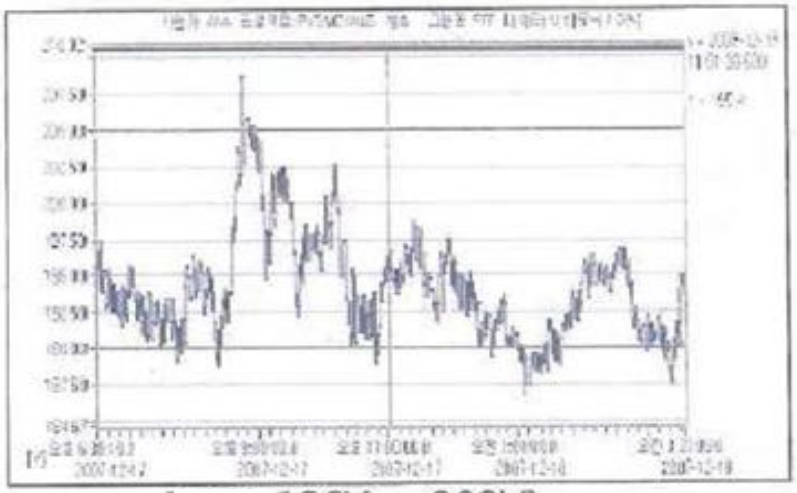
East Asia, Now

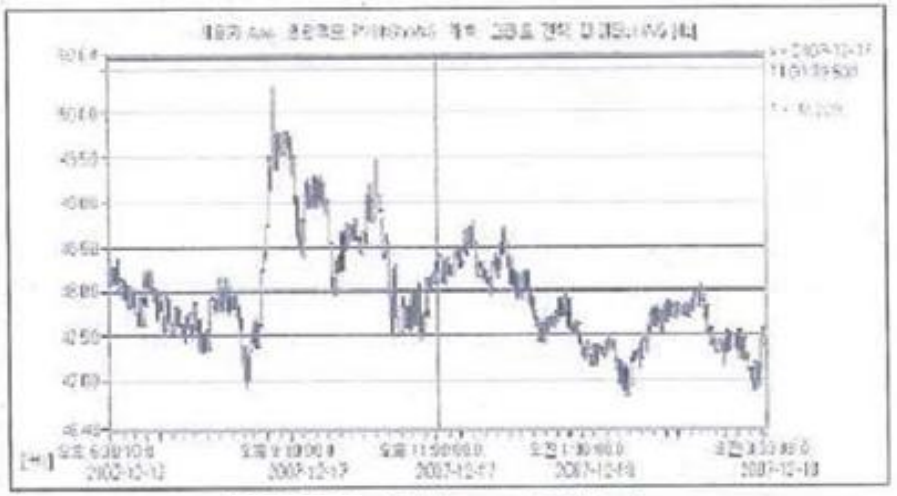
North Korea Now

Power Quality

- Rated frequency : 60Hz ± 5%
- Rated voltage : 220V, ± 6%, -13%



[Volt: 186V ~ 209V]



[Freq. : 47Hz ~ 51Hz]

- Frequent blackout by facility malfunction, power shortage
- Lifetime-shortening of transmission & distribution facility by low-quality frequency, low power factor

Reunification by connecting Electricity

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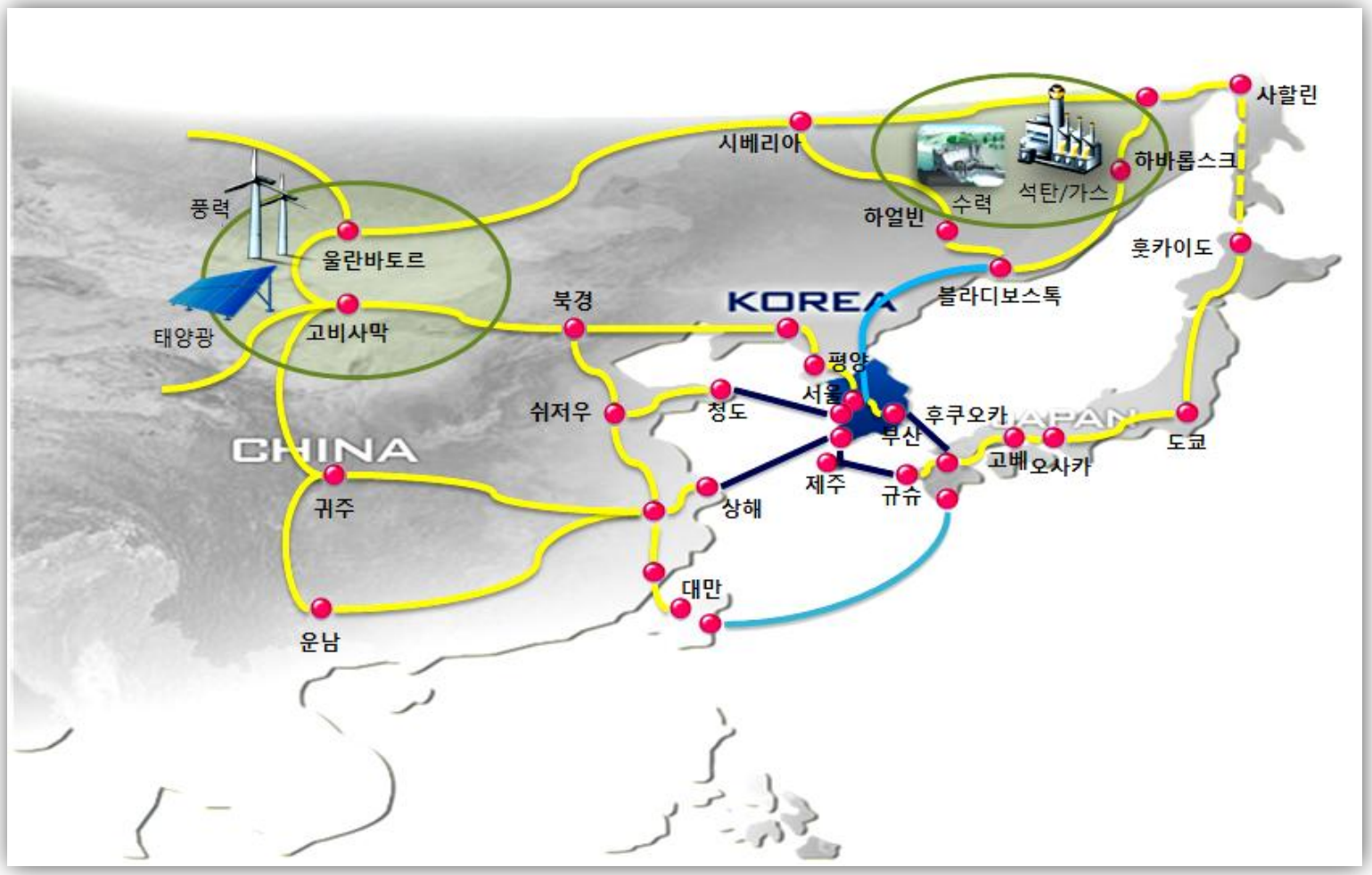
East Asia super grid



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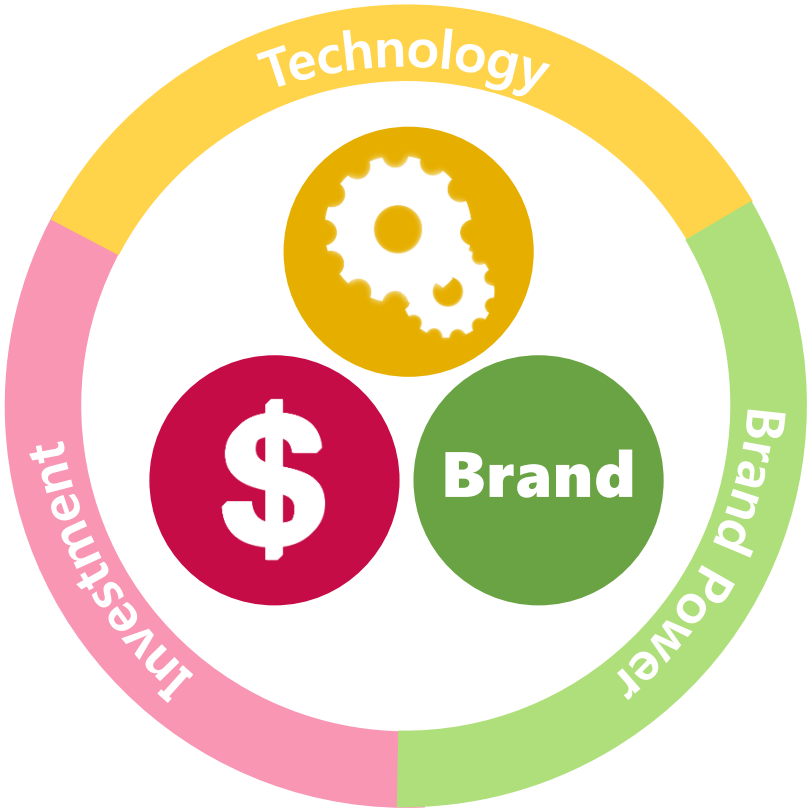
KEPCO is doing WELL

Forbes The World's Biggest Public Companies

KEPCO	#97	Korea Electric Power	South Korea
Enel	#104	Enel	Italy
IBERDROLA	#139	Iberdrola	Spain
Duke Energy	#148	Duke Energy	United States
nationalgrid	#160	National Grid	United Kingdom
Exelon.	#191	Exelon	United States
NEXTera ENERGY RESOURCES	#212	NextEra Energy	United States



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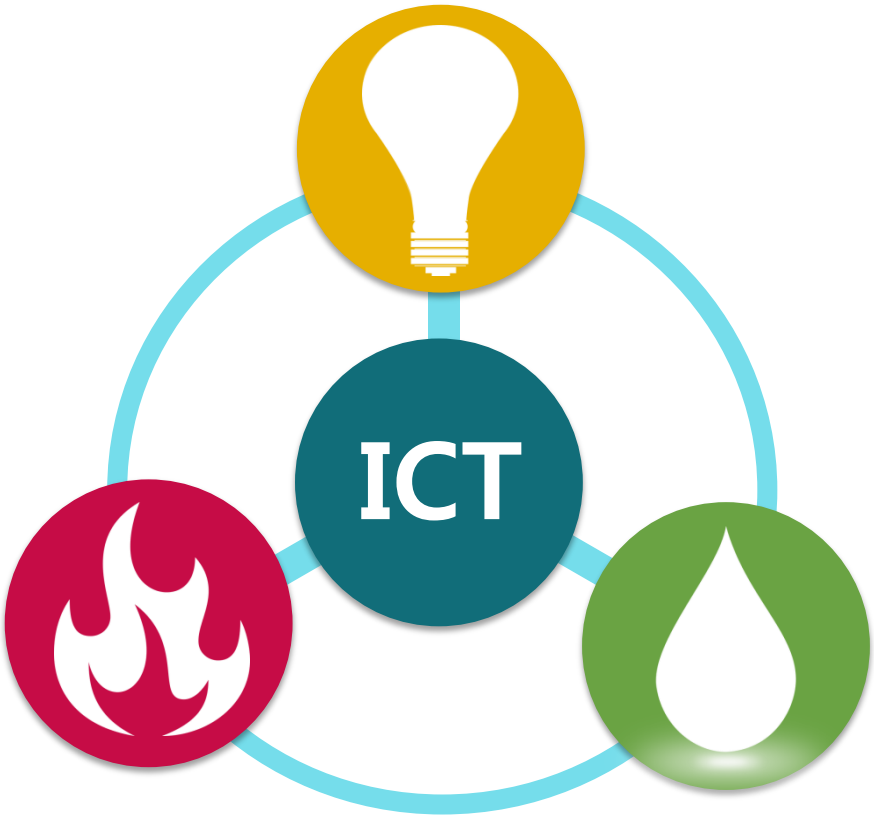
Solution : Convergence



Let’s go together