

KEPCO's Energy Storage System Projects For Frequency Regulation

April 19, 2017

ESS

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ESS

1.About KEPCO



Smart Energy Creator

As of Dec. 2015

About KEPCO

Total Assets	\$158 billion
Revenues	\$53 billion
Customers	22,030,215
Employees	20,196

(1USD=1,100KRW)



KEPCO Highlight

- No1. Electric utility & Global 100 companies of Forbes Global 2000 ('16)
- No1. in the electricity supply sector of World bank's Business Environment survey for 2 consecutive years ('15)
- Rated Aa3(Moody's), AA-(S&P, Fitch)

Generation



Transmission



Distribution



Power Sales



Item	Capacity : 97,649MW	Route length : 33,316 c-km	Route length : 465,407 c-km	Customers : 22,030,215
Market share	84%	100%	100%	100%

2-1. Overview of ESS



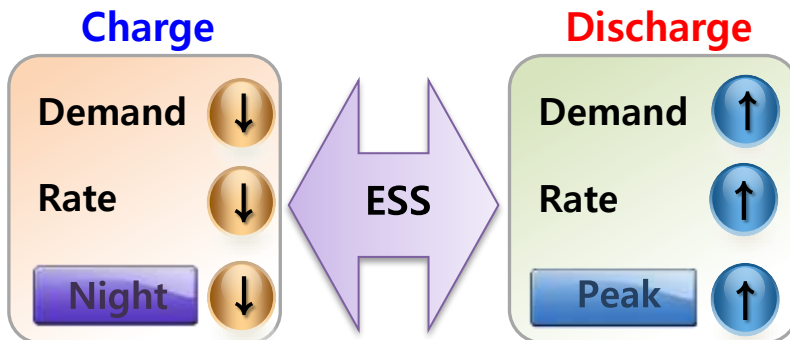
ESS Function

Improve of Energy Use Efficiency

Energy Production → Storing → Using the energy





Stabilization of Supply System

Stabilize the output and Improve the quality of Renewable



* ESS : Energy Storage System

ESS Type

Type	Pumped Hydro	Flywheel	Compressed Air	Battery
Form				
Strength	Long Life time, Large Scale	Rapid Response	Long Life time, Large Scale	High efficiency
Weakness	Environmental Problem	Short time Operate	Geographical Constraint	Few Track Record

2-2. Overview of ESS



ESS Usage in T&D

Item	Frequency Regulation	Stabilization of Renewable	Peak Shaving
Applying Method	Charge when exceeding fr Discharge when being under fr	Smoothen unstable output from the renewable energy	Charge for off-peak time Discharge for peak time
Concept			
Usage	<p>Power Grid</p> <p>[Grid]</p>	<p>[Wind and PV]</p>	<p>[Residential & Commercial]</p>

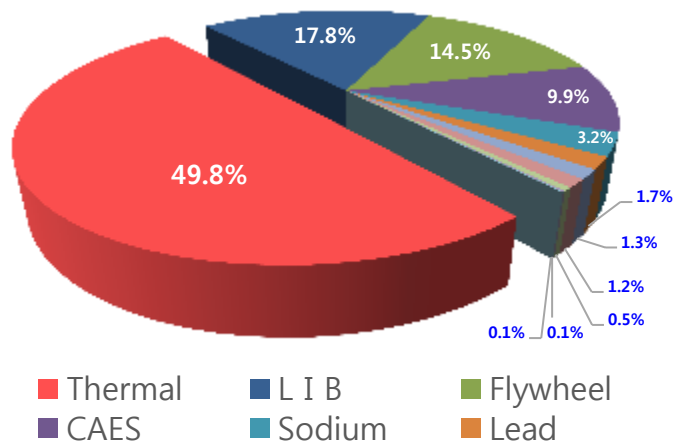
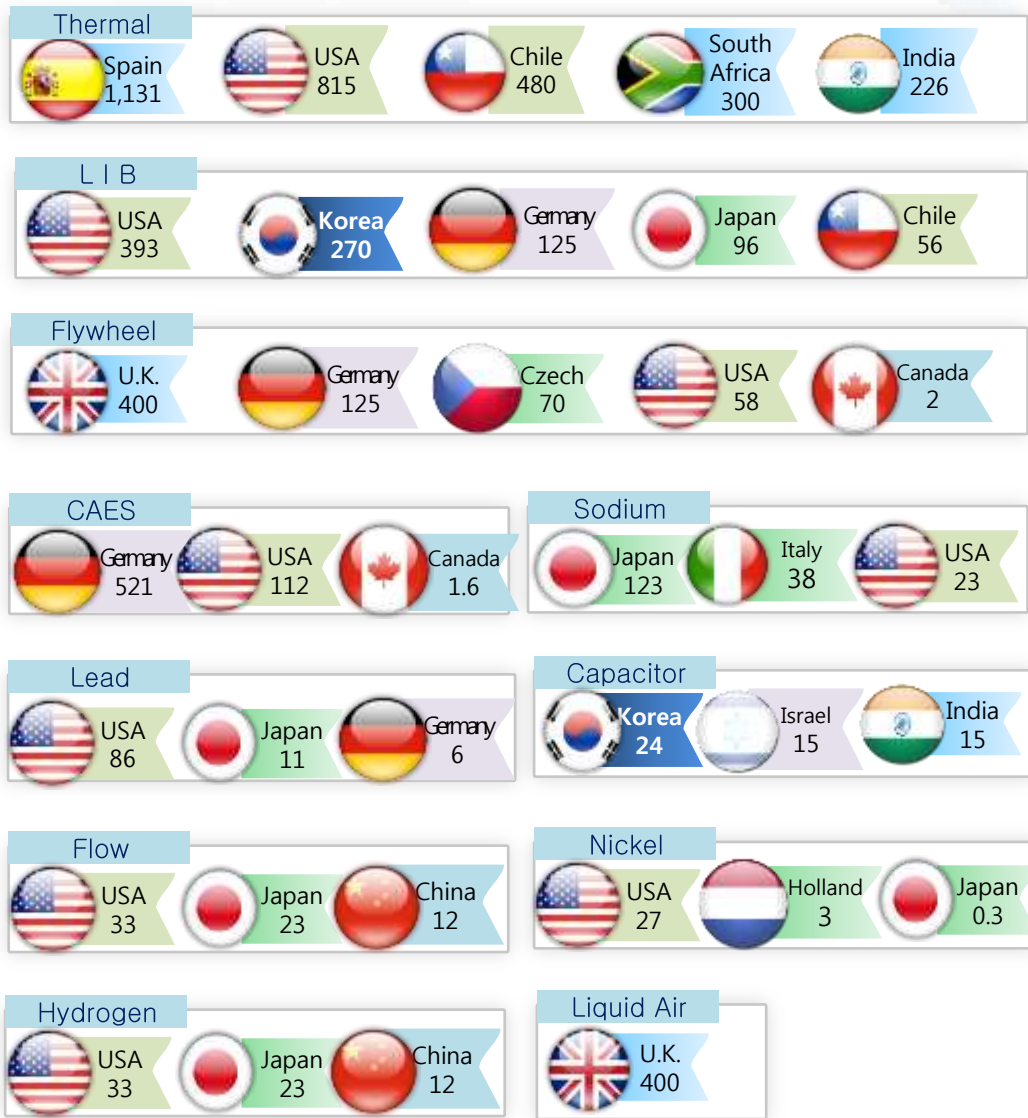
2-3. Overview of ESS

ESS

단위 : MW

ESS Trend by Type

Type	Number of Site (Country/Site)	Capacity(MW)
Thermal	15 / 192	3,205
L I B	23 / 314	1,152
Flywheel	12 / 40	930
CAES	5 / 9	635
Sodium	15 / 68	206
Lead	16 / 83	109
Capacitor	12 / 40	84
Flow	21 / 66	74
Nickel	3 / 6	30
Hydrogen	4 / 8	8
Liquid Air	1 / 1	5
Total		6,438



Ref. : DOE GLOBAL ENERGY STORAGE DATABASE (As of July 2016)

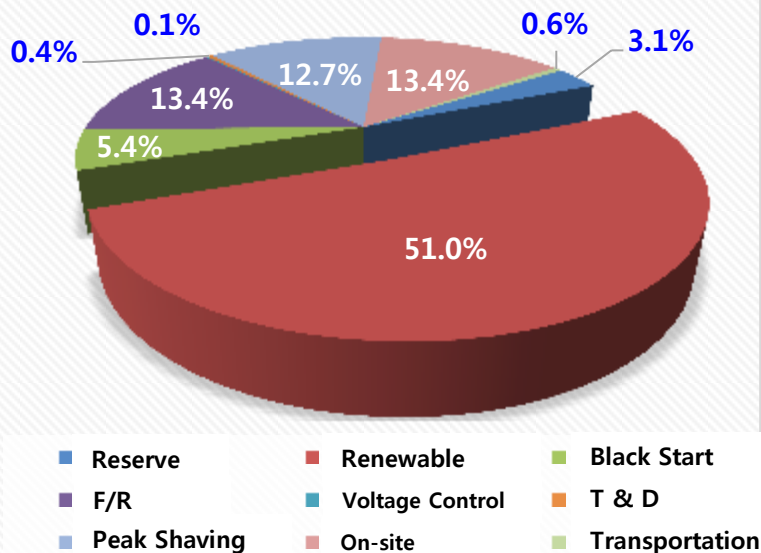
2-4. Overview of ESS



ESS Trend by Application

Application		Number of Site (Country/Site)	Capacity (MW)
Generation	Reserve	13 / 46	198
	Renewable	31 / 244	3,278
	Black Start	9 / 21	347
Transmission & Distribution	F/R	17 / 127	869
	Voltage Control	12 / 19	7
	T&D Deferral	8 / 18	25
Consumer	Peak Shaving	25 / 398	814
	On-site	13 / 24	860
	Transportation Infra	7 / 44	39
Total			6,438

Ref. : DOE GLOBAL ENERGY STORAGE DATABASE ('16.7)



GEN.

Reserve

USA 75	Chile 56	Japan 34	Philippines 10	U.K. 5
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Renewable

Spain 1,132	USA 723	Chile 480	South Africa 100	India 240
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Black Start

Germany 321	USA 23	Italy 2	Haiti 0.7	Holland 0.4
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T&D

F/R

USA 306	Korea 244	Japan 105	Germany 56	Italy 45
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Voltage control

Spain 1.6	Guiana 1.6	U.K. 1.2	China 1.2	Australia 1
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Deferral

USA 11	Italy 6	Germany 2	U.K. 2	India 1
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Consumer

Peak Shaving

USA 410	Germany 278	Japan 37	Korea 15	China 13
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On-site

Germany 387	Czech 70	U.K. 1.2	USA 1	Nigeria 1
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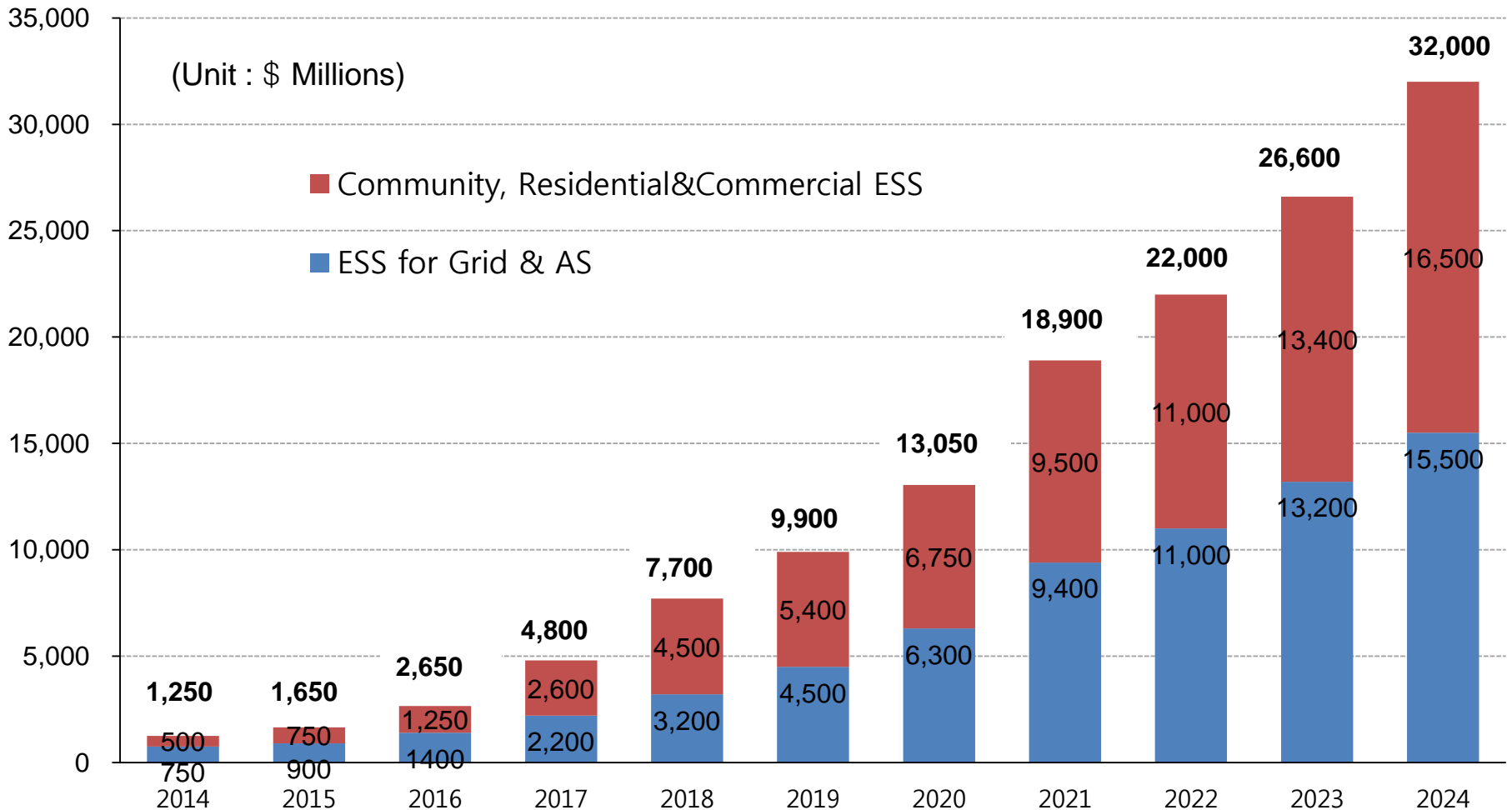
Transportation Infra

Korea 25	China 7	USA 4	Japan 2	Holland 0.7
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2-5. Overview of ESS



Global ESS Market Outlook (2014 – 2024)



(Source : Navigant Research 4th Quarter Report of 2014)

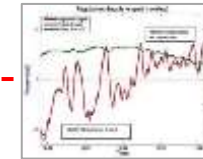
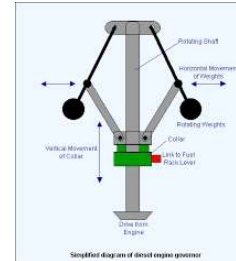
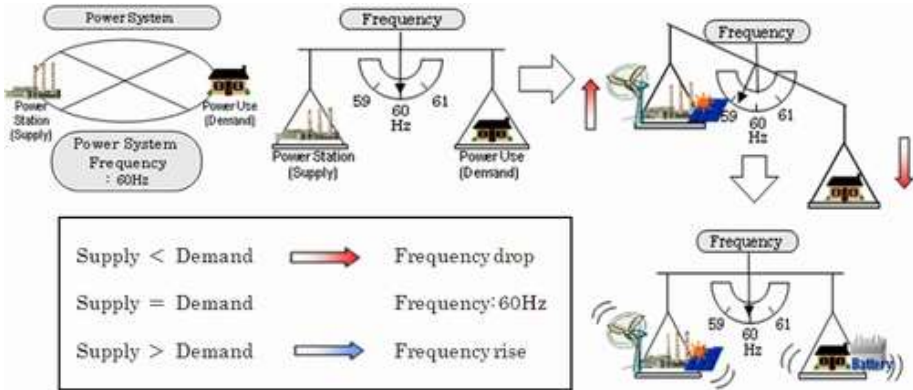
3. What is Frequency Regulation?



How to maintain the frequency

Frequency Regulation(FR)

- To maintain the power frequency (50 or 60Hz) constantly caused by discrepancy of Supply and Demand to a standard



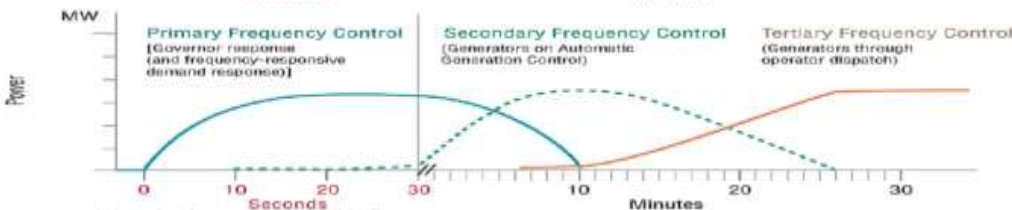
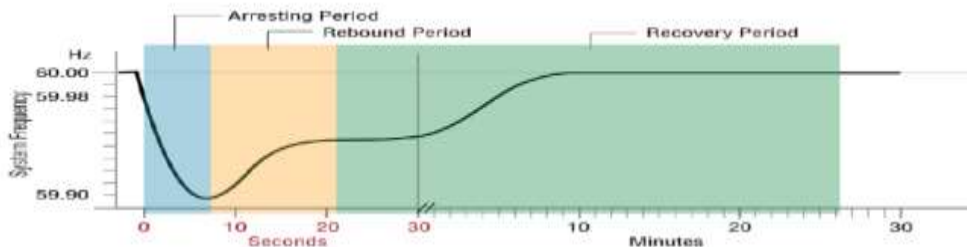
<Governor Free>

<System Operator>



Response

Control



Reserved power for FR (5% of its capacity)

Actual Output of Generator

95 %

100 %

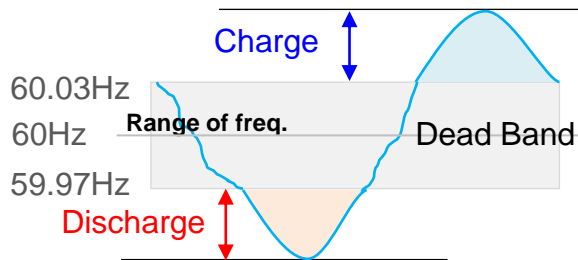
Rated Capacity of Generator

[Reserved power for FR] <9/18>

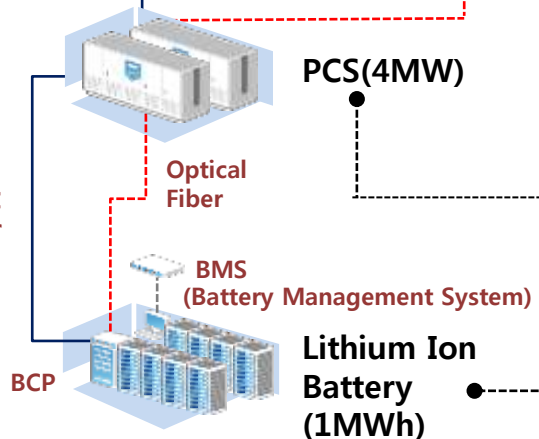
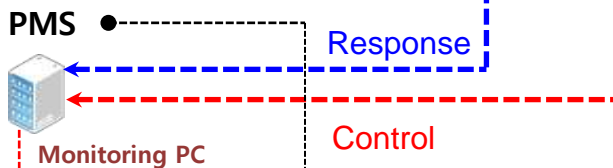
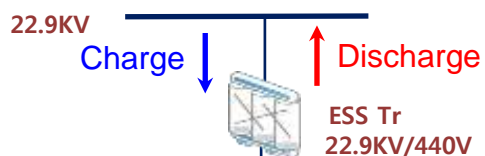
4-1. KEPCO's FR ESS Project



The Composition and Role of ESS



[ISO's EMS]













- **Power Management System**
Acquires the frequency and control charge/discharge
- **Power Conditioning System**
Convert AC/DC from battery to grid
- **Battery**
Storage the electricity with DC

4-2. KEPCO's FR ESS Project



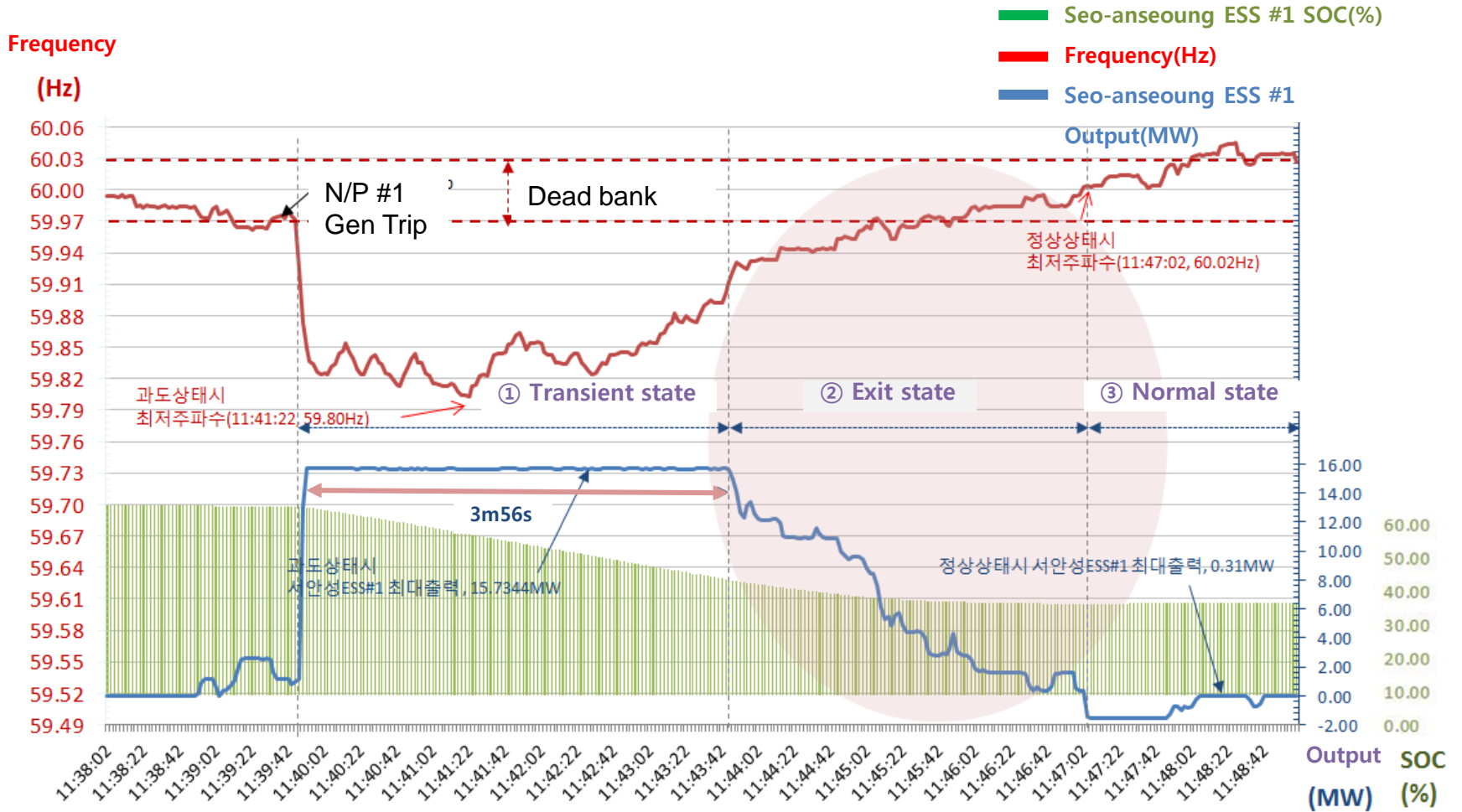
KEPCO's Pilot Project : 2 Types of FR ESS

Item	Primary Frequency Control (Governor Free)	Secondary Frequency Control (Automatic Generation Control)
Main Purpose	Prevent from freq. drop at an early stage	Increase its output at a signal from ISO's Energy Management System for grid
Operation Type	Respond by itself based on freq. status	Ramp up/down by the signal from ISO
Pilot Project (52MW) 2 sites	<p>28MW FR ESS (Battery : 12MWh, PCS : 28MW)</p> 	<p>24MW ESS (Battery : 18MWh, PCS : 24MW)</p> 
	Energy Capacity	15 min-Li battery
System Provider	<p>(PCS)  </p> <p>(Battery)  </p>	<p>(PCS)  </p> <p>(Battery)  </p>

5-1. Performance Verification



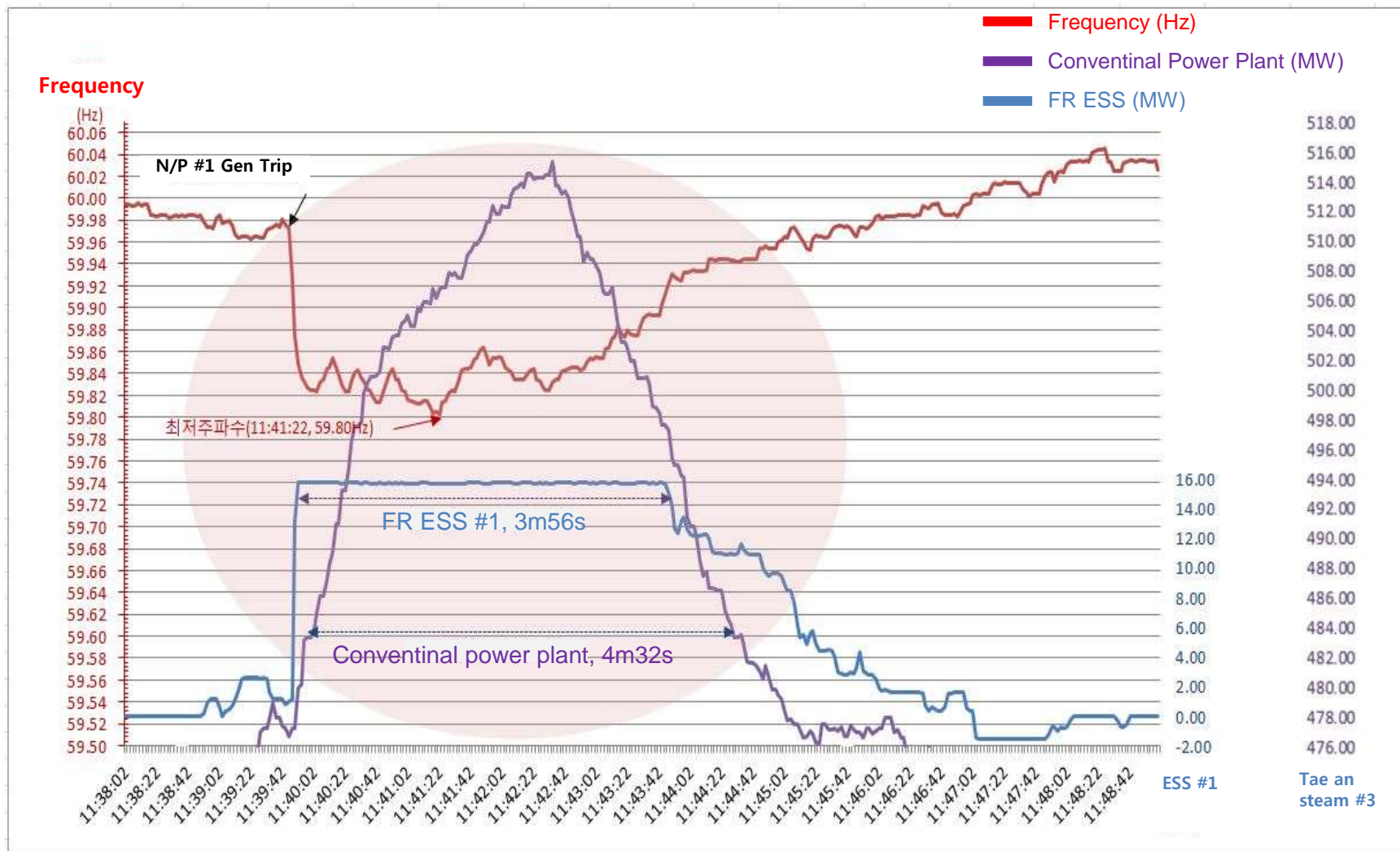
Hanwul #1 N/P shut down (Jan.10, 2016)



5-2. Performance Verification



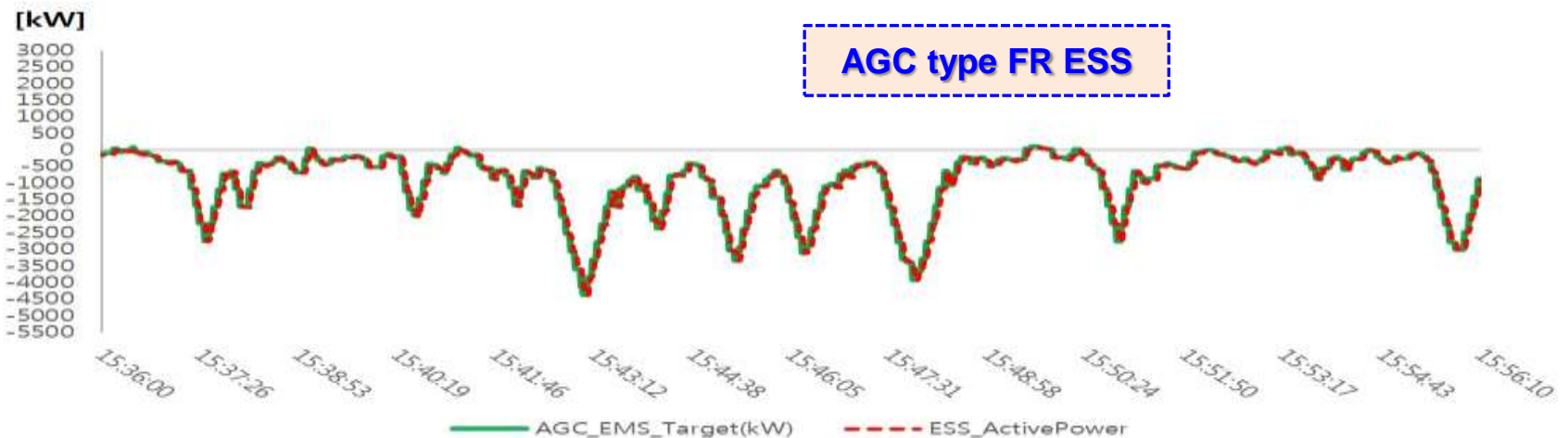
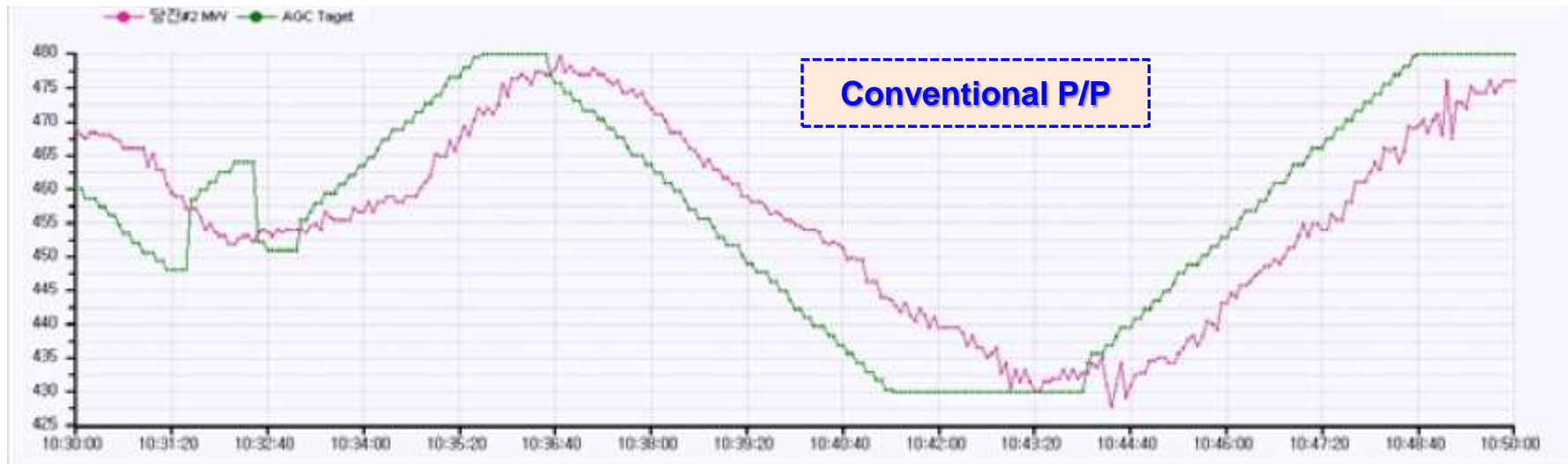
The Comparison between conventional P/P and FR ESS (G/F Type)



5-3. Performance Verification



The Comparison between conventional P/P and FR ESS (AGC Type)



5-4. Performance Verification



Pros and Cons of Conventional P/P vs ESS

Conventional Power Generator	Energy Storage
Slow ramp rate	Very fast ramp rate
Limited ramp rating range	Maximum ramp range(3~4 times)
Designed to generate	Designed to balance
Burns fuel	No fuel consumption
Emit pollutants	No emissions
Consumes water for cooling	No water consumption
Unlimited output duration (A fuel is supplied continuously)	Limited output duration (until a charged energy be consumed)

6. Interim Technical Criteria



Technical Criteria for FR ESS (Tentative)

Classification	Standard SOC	Range of SOC in normal state	Duration time of ESS output	
			SOC 100%	At standard SOC
Governor free	65%	Standard SOC \pm 10%	15min	8~11min
AGC	50%	-	30min	12~18min

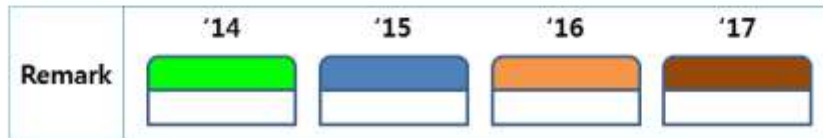
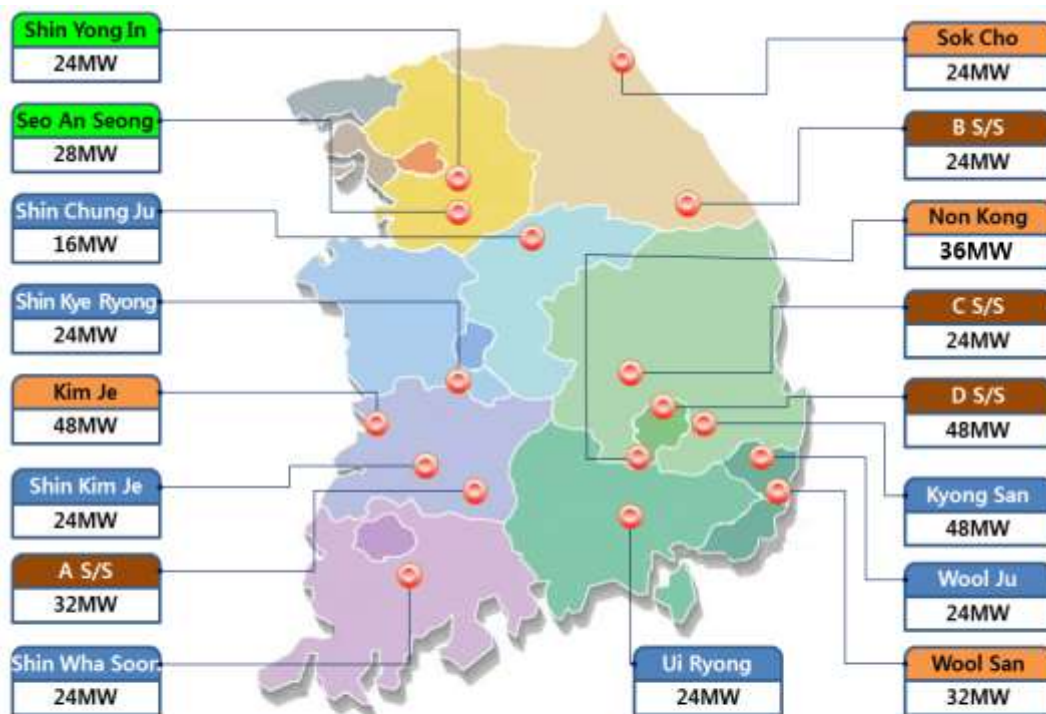
Advantages of ESS

- Because of **its fast, almost instant response** it is **more effective** in providing ancillary service
- **Can ramp up and down much faster and easier** than conventional P/P
 - Nearly vertical ramp rate, well under 200ms to full output
 - No ramping wear and tear, unlike fossil fuel generator
- **No Shut down/startup costs**, unlike fossil fuel generator
- **Allows generators to focus on producing energy** at maximum efficiency
- **Provides enormous flexible ramping capacity** for a given interconnection size

7. Project Status and Plan



Item	2014	2015	2016	2017	Total
Capacity	52MW	184MW	140MW	124MW	500MW
Status	Commercial Operation(236)		Under Const.	Plan	



8. Benefits and Effectiveness



Cost reduction

- allows the **low cost generator** required to be held in reserve to be **sold more power**
- **Spinning reserves can be reduced** due to the fast and accurate response

Power quality

- **Increases efficiency and co-optimization** of the resources
- Be able to **respond to in milliseconds** to frequency regulation requirement
- Enable to accept even more renewable generation to the system

Improve reliability

- Can **ramp up much faster than conventional P/P** when transient situation
- Provide enormous flexible ramping capacity

Q & A



Thank for your attention



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Smart Energy Creator
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