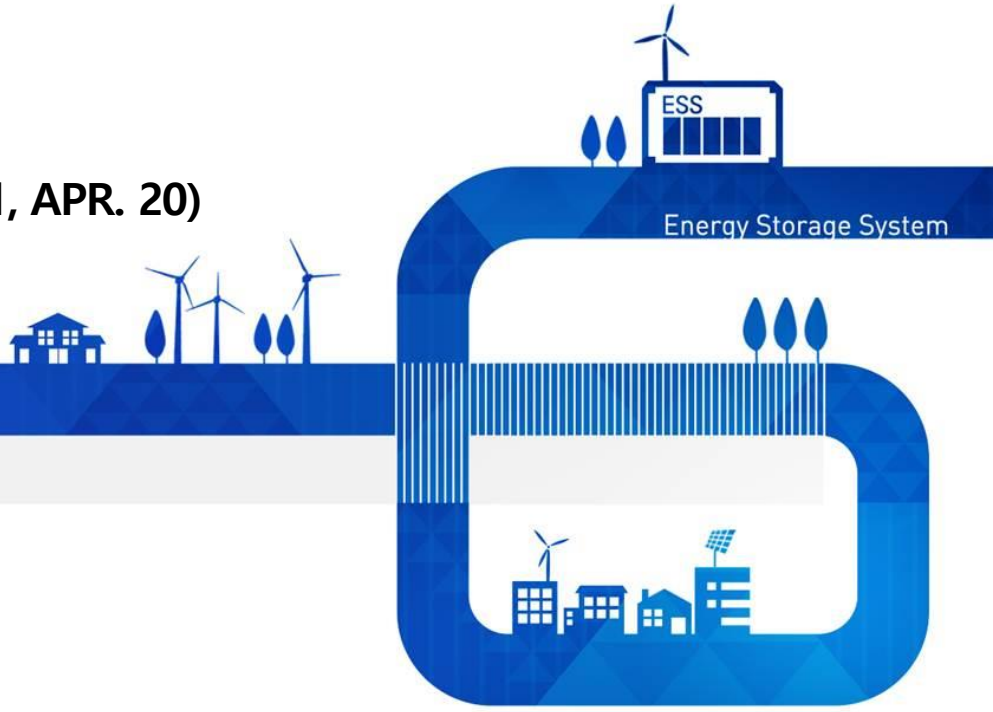
Energy Storage System (ESS) Case Study in Korea

June Choi, Senior Vice President (2021, APR. 20)

LS ELECTRIC



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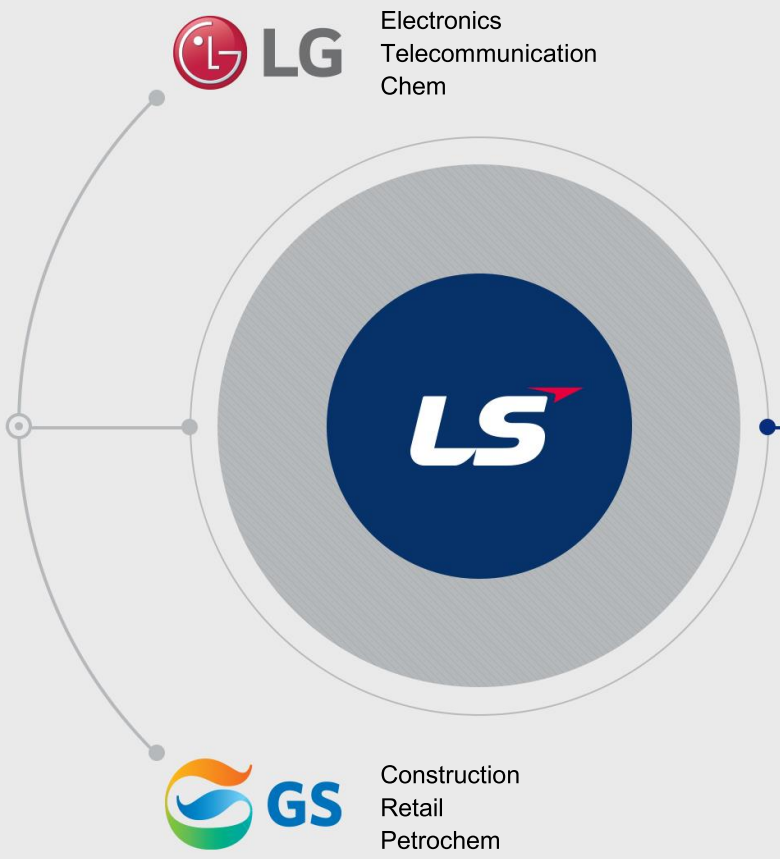
Ⅰ. LS Introduction

LS Group is a Korean conglomerate. It spun off from LG Group in 2003.
LS is leading in the field of electric power, automation, machinery, materials and energy.



- LS Cable & System [1962]
- LS Mtron [2008]
- LS - Nikko Copper [1936]
- LS ELECTRIC [1974]
- yesco [1981]
- GAON [1947]
- E1 [1984]

LS Group

EMPLOYEES	12,700
AFFILIATES	48
SALES	23 B USD
TOTAL ASSET	23 B USD

LS Electric

EMPLOYEES	3,500
SALES	2 B USD

* Financial figures in 2020

Ⅱ. LS Experience Summary in ESS

LS ELECTRIC + LS Energy Solutions

900MW+

Installed energy storage solutions

15+

Number of integrated storage technologies

250+

Successfully installed projects

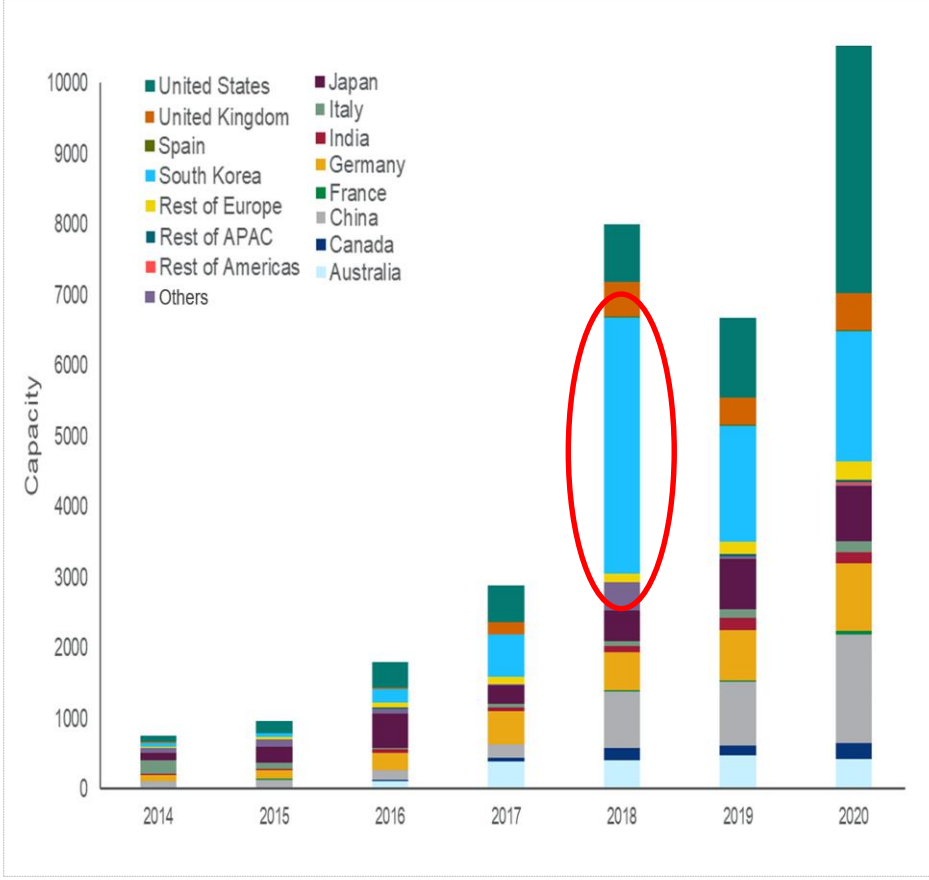
40+

Years of experience in power electronics

Ⅲ. Korea ESS Market Overview

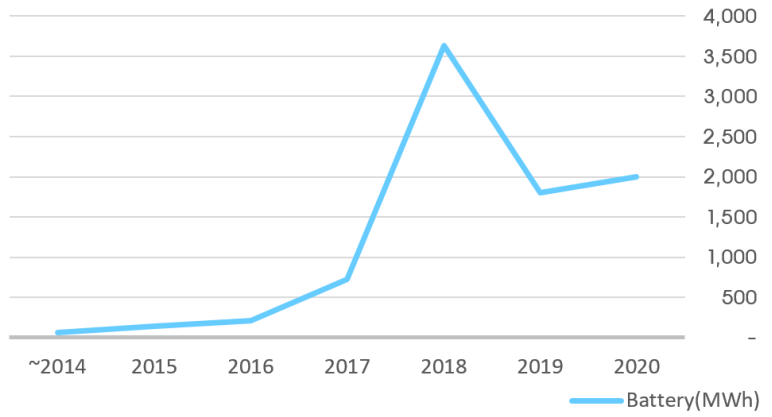
ESS have been widely installed in Korea since 2017 driven by Government Program such as RPS, REC and ESS Incentive program.

ESS Market: Global (MWh)

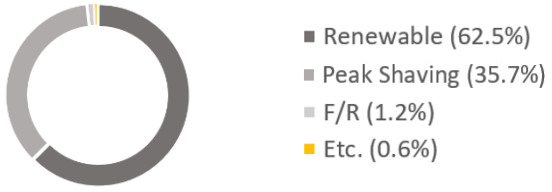


Source : Wood Mackenzie
KESCO(Korea Electrical Safety Corporation)
KOEMA(Korea Electrical Manufacturers Association)

ESS Market: Korea (MWh)



Year	~2014	2015	2016	2017	2018	2019	2020	Total
Battery(MWh)	66	145	207	723	3,632	1,800	2,000	8,573



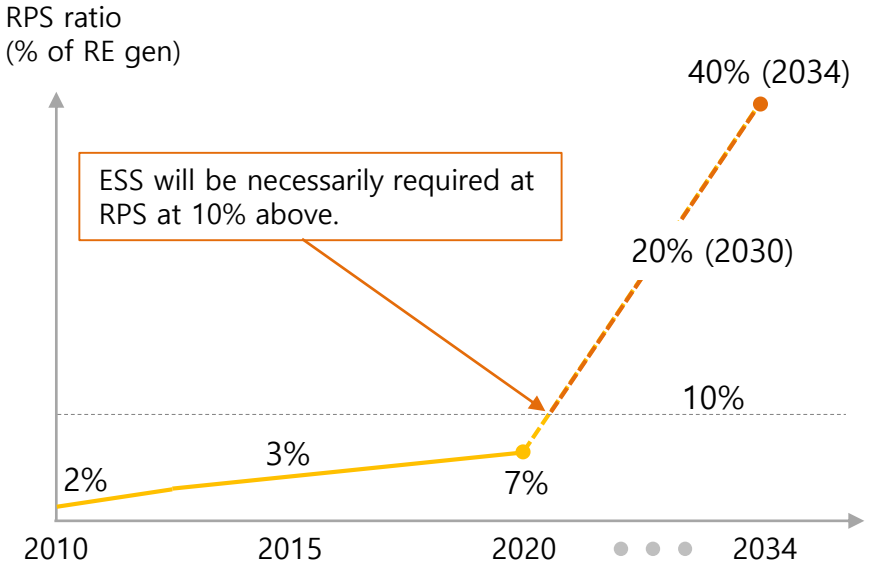
*RPS : Renewable Energy Portfolio Standard
*REC : Renewable Energy Certificate
*F/R : Frequency Regulation

RPS is the main policy tool that helps renewable energy projects become economically competitive by providing market-based incentive.

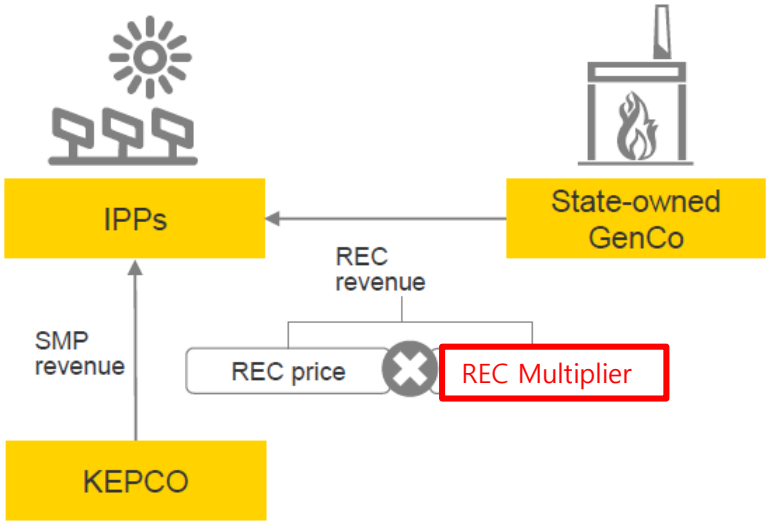
Korea's RPS Scheme

- Power companies with over 500MW of installed capacity must increase their renewable energy mix to a level set by government.
- Renewable energy mix is defined as the proportion of renewable electricity generation in the total non-renewable electricity generation.
- Government is working to increase existing RPS target to achieve 'Renewable Energy 3020' plan.

RPS ratio (% of RE generation)



RPS mechanism



Source: Korea Energy Agency

REC multiplier is set to provide strong incentive for hybrid application (solar & wind).

REC multiplier for solar plant

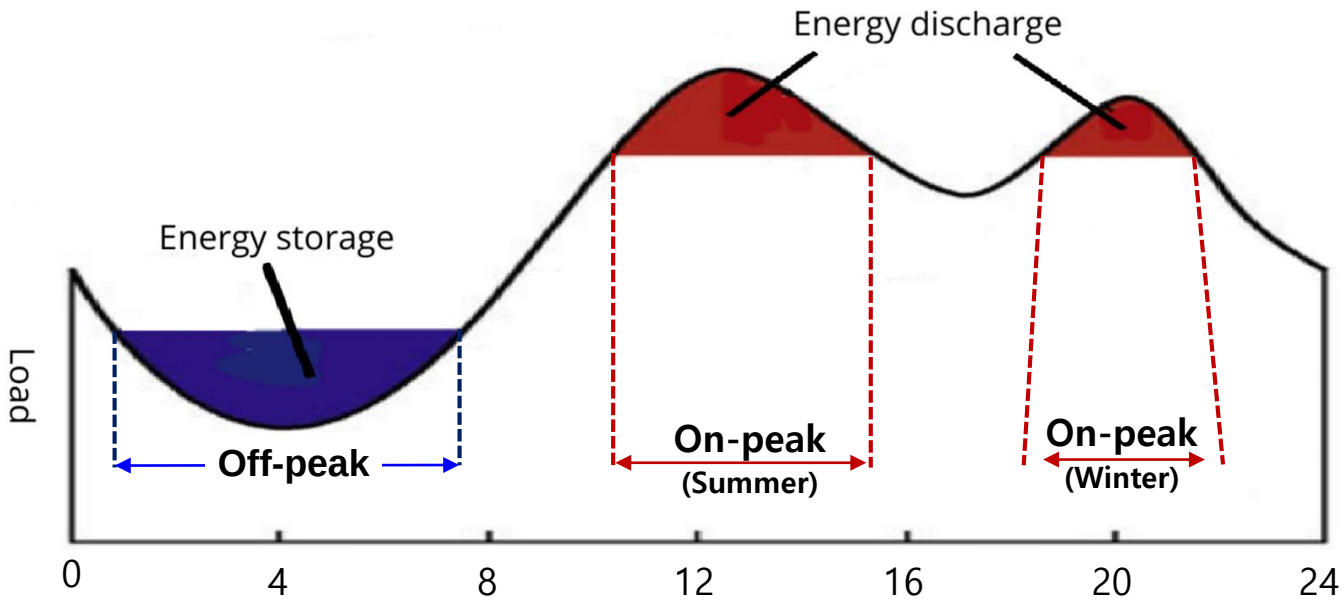
Type	Details	Multiplier
Ground mount	Under 100 kW	1.2
	100 kW ~ under 3 MW	1.0
	Over 3 MW	0.7
Rooftop type	Under 3 MW	1.5
	3 MW and over	1.0
Floating type		1.5
BTM Net metering		1.0
Solar with ESS	**'18.01 ~ '20.06**	**5.0**
	'20.07 ~ '20.12	**4.0**

REC multiplier for other renewables

Type	Details	Multiplier
Hydro, On-shore wind, Marine tidal, other bio-energy, BTM Net metering		1.0
Off-shore wind	Within 5 km	2.0
	Between 5 ~10 km	2.5
	Between 10 ~15 km	3.0
	More than 15 km	3.5
Wind with ESS	**'18.01 ~ '20.06**	**4.5**
	'20.07 ~ '20.12	**4.0**

Discharging energy on-peak hour and charging energy during off-peak were incentivized to accelerate ESS deployment in C&I market.

✓ **Exclusive Rate for ESS in C&I market**



1. Charge incentive rate program

50% discount on the electricity rate for the energy charged by ESS during off-peak hour (midnight)

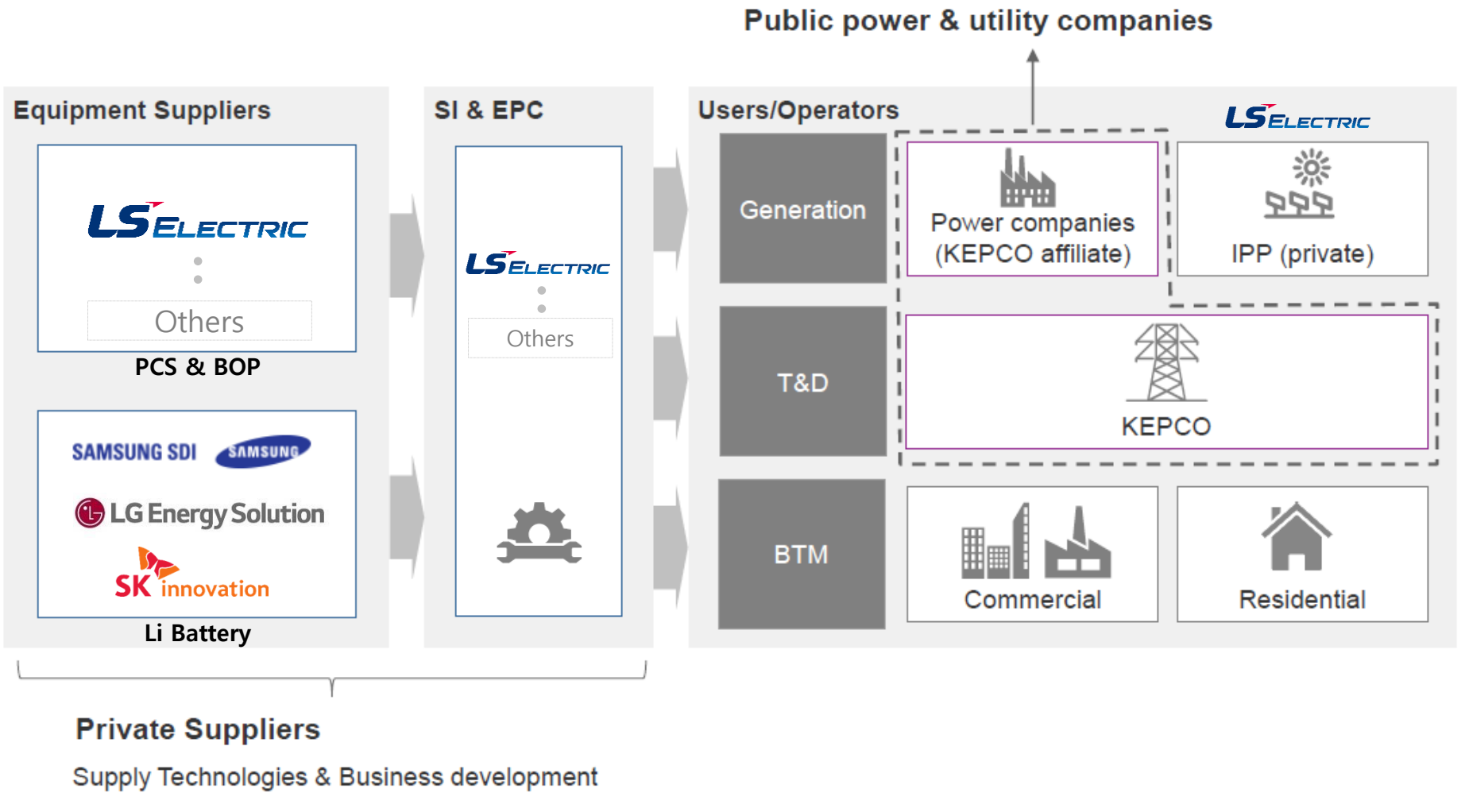
2. Discharge incentive rate program

Providing rate deduction as the amount of the discharged energy during on-peak hour

Rate deduction [KRW] = Total discharged energy [kWh] x base rate [KRW/kWh] x 1/3

V. ESS Value Chains and LS ELECTRIC Market Positioning

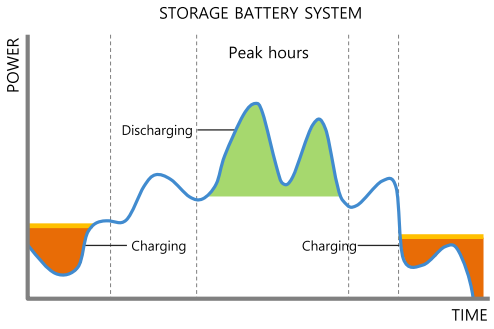
Korea has a complete eco-system to implement ESS projects.



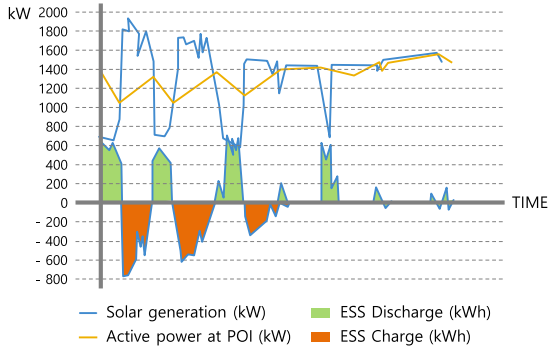
IV. ESS Applications

ESS can be used for various grid support applications using its fast response and high conversion efficiency.

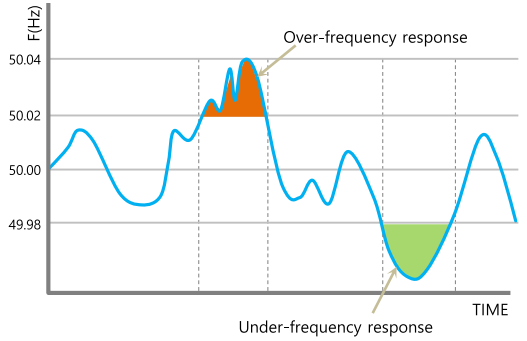
Arbitrage Energy Time Shift



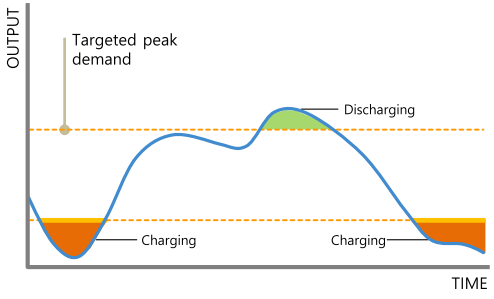
Ramp Rate Control(Smoothing)



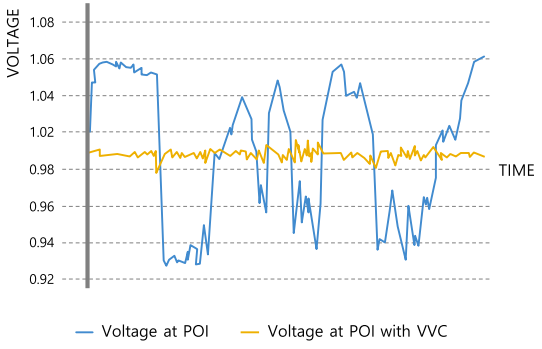
Frequency Regulation



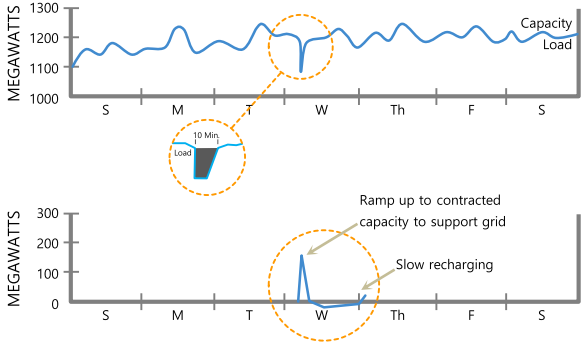
Peak Shaving



Voltage Regulation



Spinning Reserve



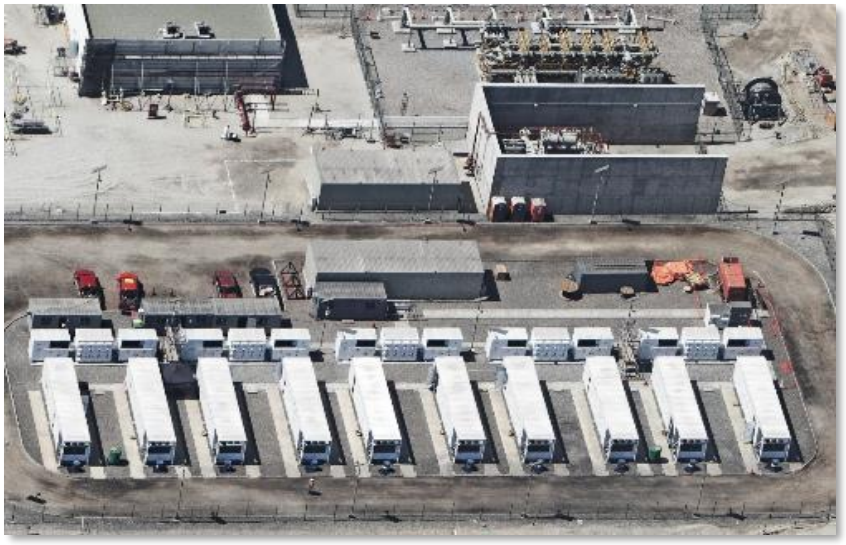
Energy Storage System
Frequency Regulation, Spinning Reserve

Location	Ansung / Ulsan / Chungju, Korea
Project Size	64 MW / 24 MWh
Application	FR, Spinning reserve
Commissioning	2014, 2015, 2016
Role	System Integrator

Energy Storage System
RE Smoothing

Location	Hokkaido, Japan
Project Size	39 MW PV / 14 MWh ESS
Application	RE
Commissioning	2017
Role	System Integrator, O&M

Energy Storage System
Frequency Regulation, Spinning Reserve



Location	Cochrane Facility, Chile
Project Size	20 MW / 6 MWh
Application	FR, Spinning Reserve
Commissioning	2015
Role	System Integrator

Energy Storage System
Renewable Integration

Location	Minnesota, USA
Project Size	15 MW / 30 MWh
Application	RE
Commissioning	2018
Role	PCS

Energy Storage System

Arbitrage Energy Time Shift, Peak Shaving

Location	SeAH Group - 5 subsidiaries, Korea
Project Size	34 MW / 175 MWh
Application	Arbitrage Energy, Peak Shaving
Commissioning	2018
Role	System Integrator, O&M

SeAH Besteel	Gunsan	102MWh
SeAH Steel	Pohang	25MWh
SeAH Special Steel	Changwon	30MWh
SeAH Besteel	Changyoung	8MWh
SeAH Coated Metal	Gunsan	9MWh

Energy Storage System
Renewable Integration

Location	YoungAm, Korea
Project Size	93 MW PV/ 242 MWh ESS
Application	Renewable Integration
Commissioning	2020
Role	System Integrator, O&M

Energy Storage System
Fast Frequency Response

Location	Texas, USA
Project Size	10 MW / 10 MWh
Application	FFR
Commissioning	2019
Role	System Integrator

Thank you !

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