

# Utility Scale Energy Storage Application and Development in Korea

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- I** ESS Phase in KEPCO
- II** Jocheon ESS on Jeju Island
- III** Freq. Regulation ESS
- IV** FR ESS Application
- V** FR ESS Response
- VI** Flexible ESS
- VII** Conclusion

# I. ESS Development Phase in KEPCO

Demonstration  
2011 – 2014



4 MW / 2 hr.

**Jocheon Facility (Jeju Island)**

- First Demo. Proj. of KEPCO (Peak Shaving, Freq. Regulation, Renew. Power Stabilization)
- Prove commercial FR ESS cntlr.

F/R ESS  
Commercialization  
2014 – 2018

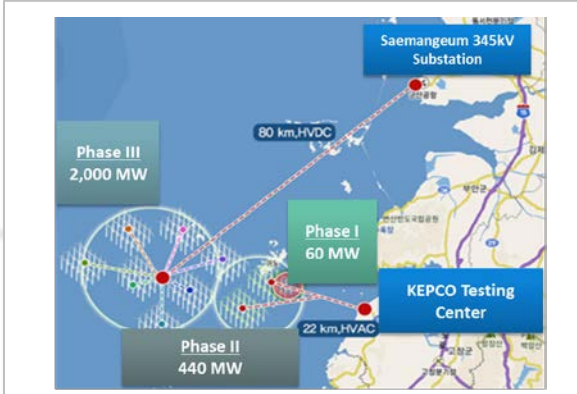


28 MW /15 min. (Seo-Anseong)

**F/R-ESS Project**

- KEPCO BM Proj.(52MW ESS) (Seo-Anseong 28 MW, Shin-Yongin 24 MW)
- And total 500 MW by 2018

Flexible ESS Project  
2015 – 2018

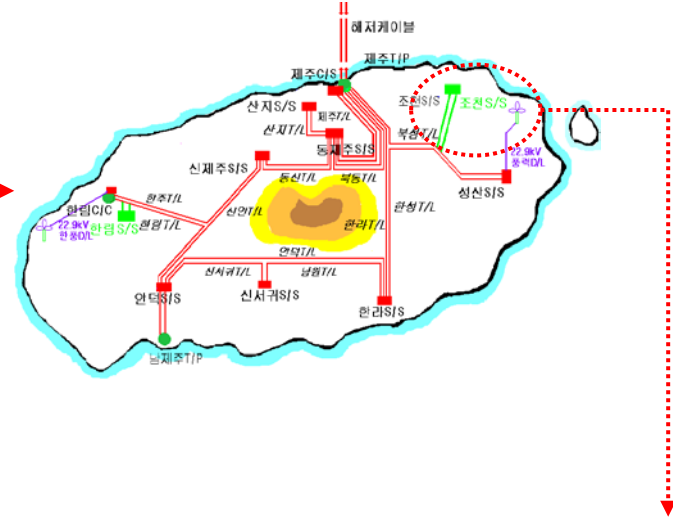
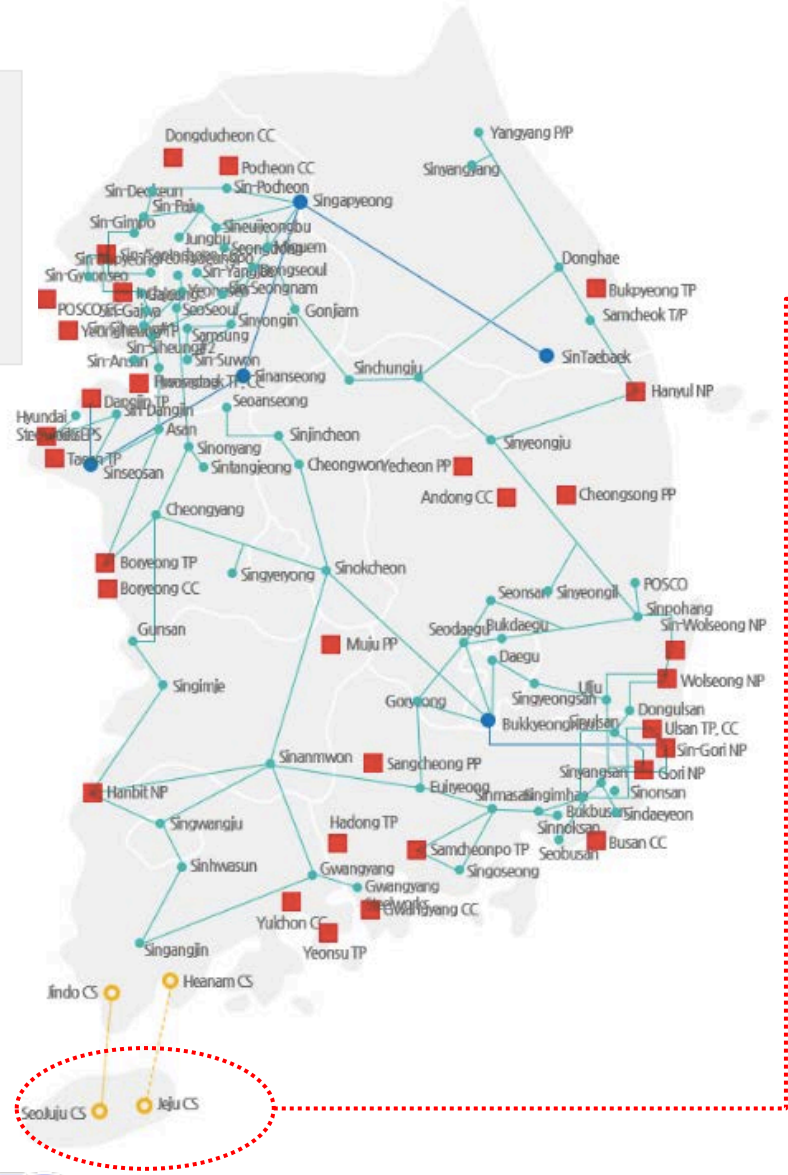


**Development of Flexible ESS Tech**

- 28 MW ESS for Phase I (60 MW) of 2.5GW Offshore Wind Farm
- ESS value up with changing op. strategy depending on the needs of the power grid

# II. Jocheon ESS on Jeju Island

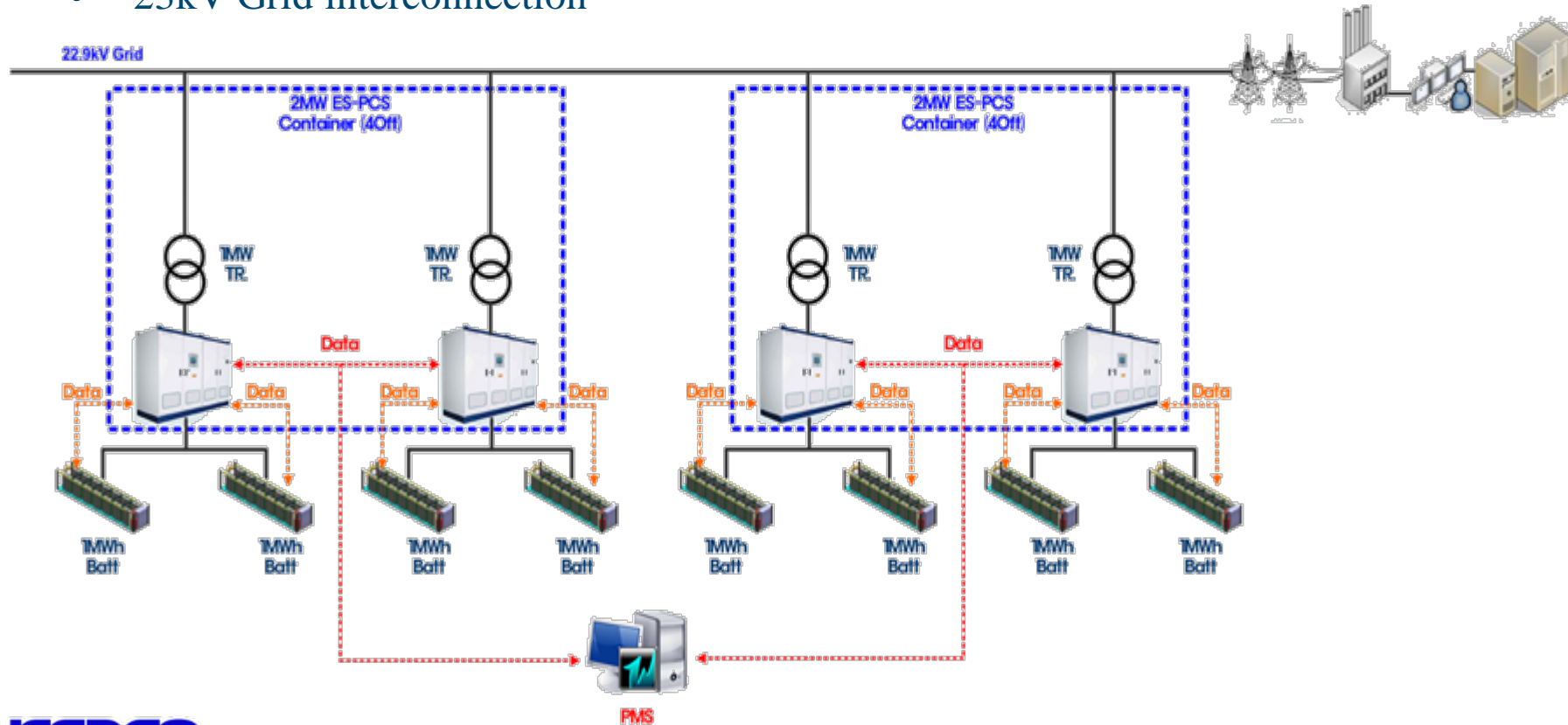
- 765kV Substations
- 765kV Transmission
- 345kV Substations
- 345kV Transmission
- HVDC
- Power Plants



# II. Jocheon ESS on Jeju Island

## ■ Energy Storage System

- Rated Power : 4MW (1MW PCS X 4)
- Rated Energy : 8MWh (1MWh battery in 40ft Container X 8)
- Control : Single PMS (Power Management System)
- 23kV Grid interconnection



# II. Jocheon ESS on Jeju Island

## ■ Test item (PCS)

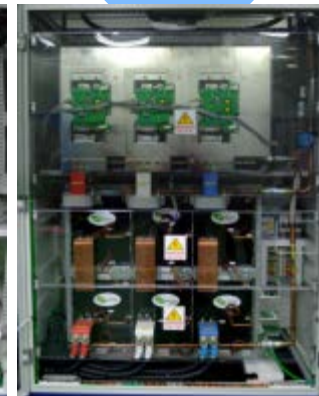
- Efficiency (Average 95.5%)
- Harmonics (Under 5% THD)
- Power Factor
- Response time (about 16ms)
- Protection



1MW ES-PCS Panel



Main control panel



Inverter panel

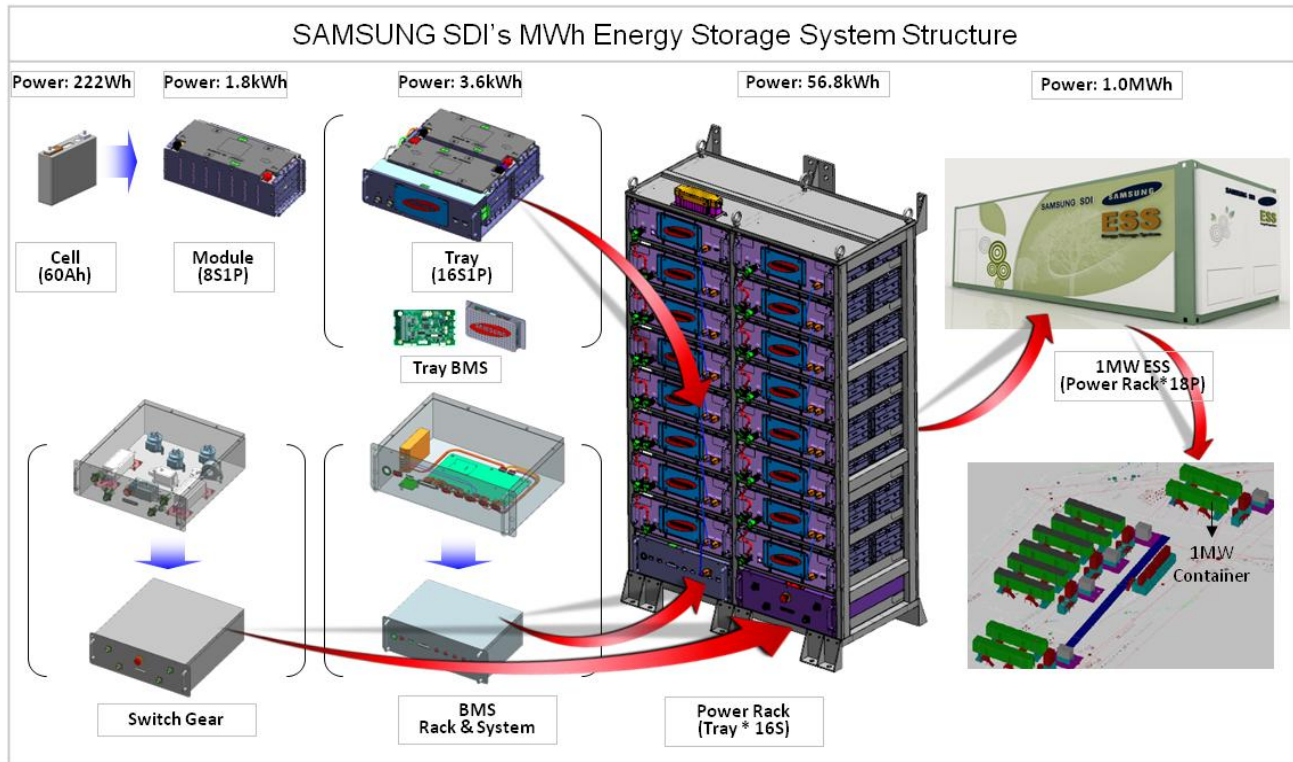


Battery power Incoming panel



# II. Jocheon ESS on Jeju Island

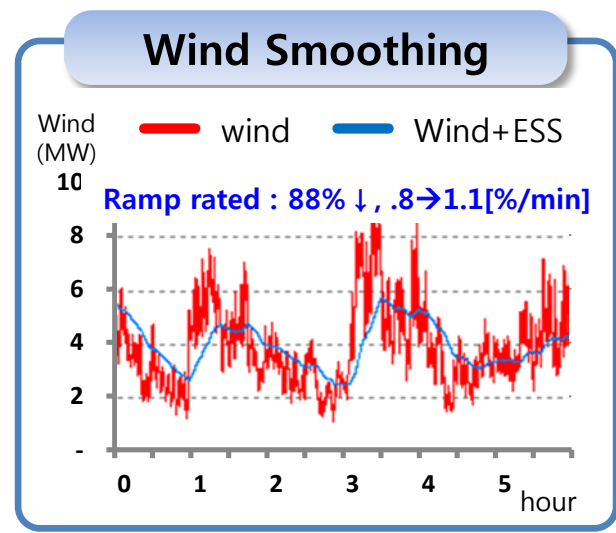
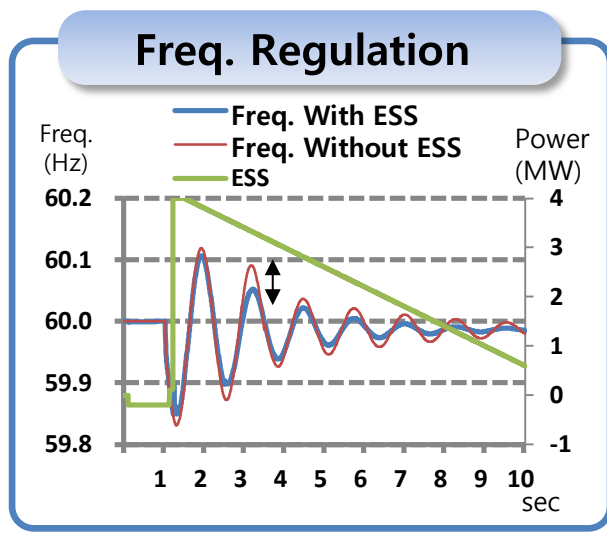
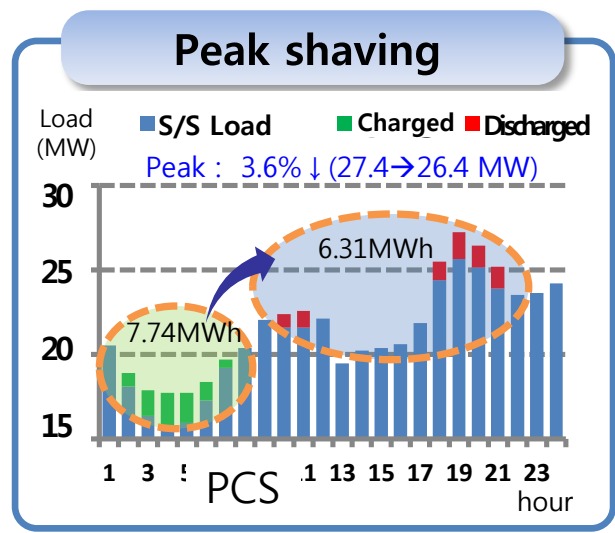
- Test item (Battery System)
  - Cell balance, Efficiency, etc.



# II. Jocheon ESS on Jeju Island

## ■ ESS application demonstration

- Peak shaving : peak demand 27.4MW → 26.4MW
- Frequency regulation
- Wind smoothing : Maximum Power fluctuation (8 → 1.1 %/min)

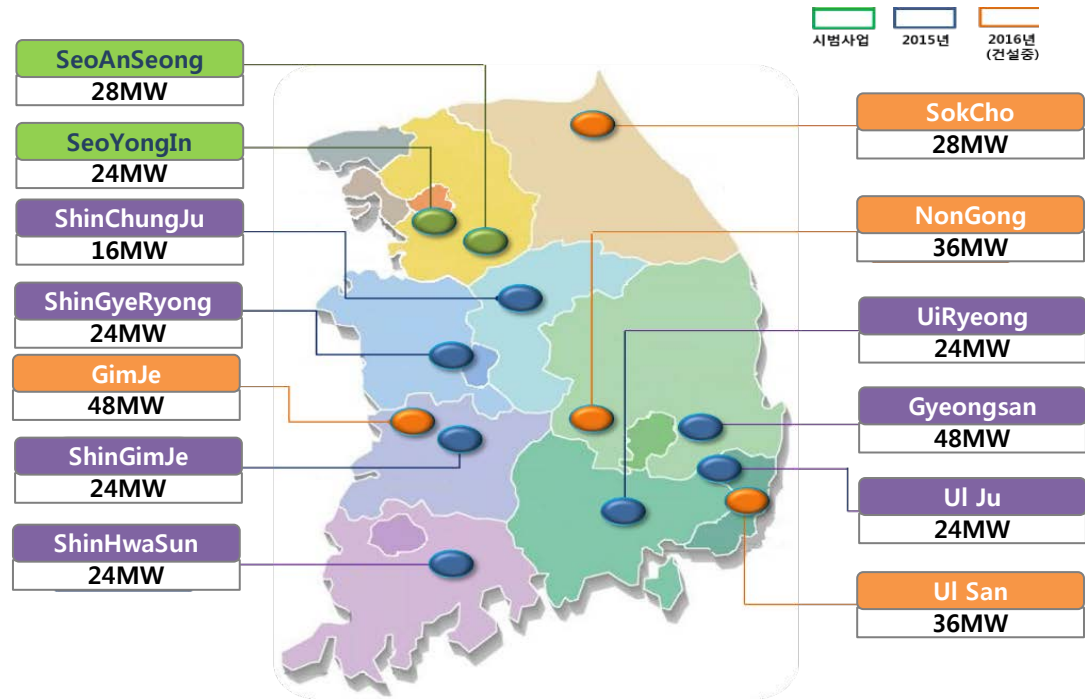




# III. ESS for Frequency regulation

- Since 2015, ESS (Energy Storage System) for GF (Governor Free) is installed up to 236MW in KEPCO

FR ESS	Operational			Planned	Total
	2015	2016	2017	2018	
Rating(MW)	52	184	140*	124	500
No. of Facilities	2	7	4*	4	17



# III. ESS for Frequency regulation

Seo-Anseong ESS Facility (28 MW)



Shin-Yongin ESS Facility (24 MW)



Shin-Gyeryong ESS Facility (24 MW)

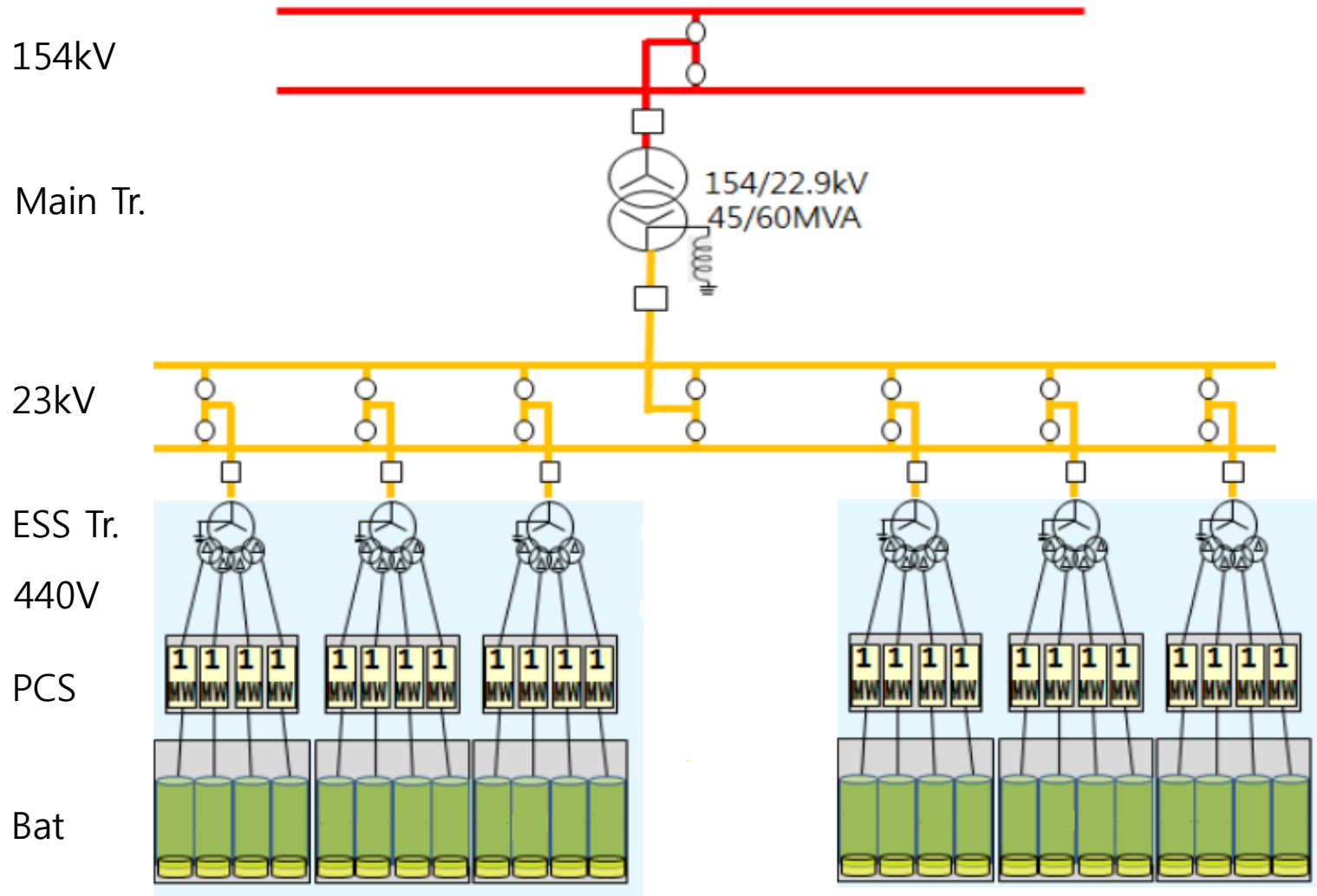


Shin-Hwasun ESS Facility (24 MW)



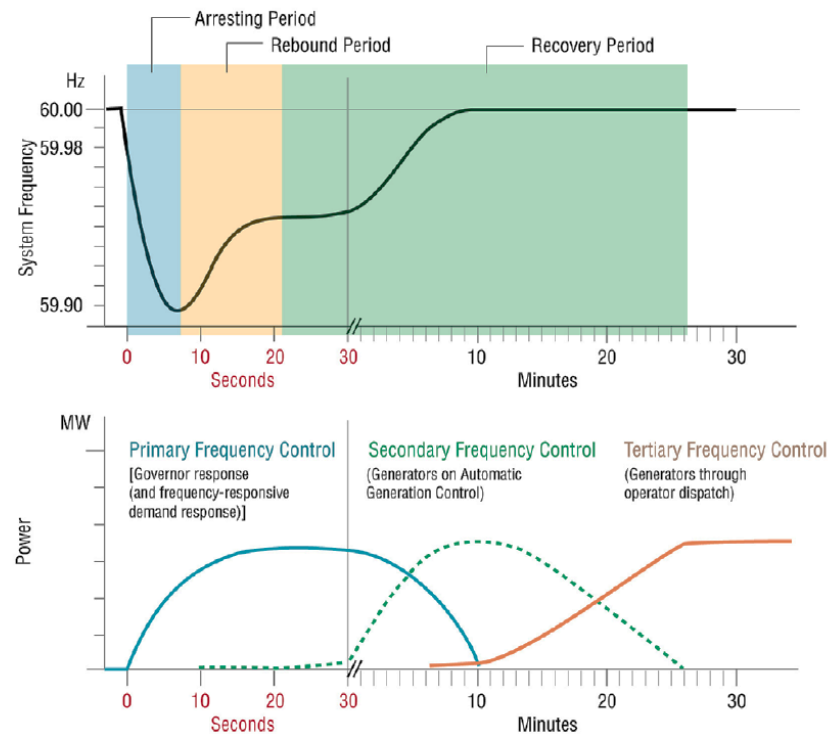
# III. ESS for Frequency regulation

## ■ Configuration of 24MW FR ESS(example)



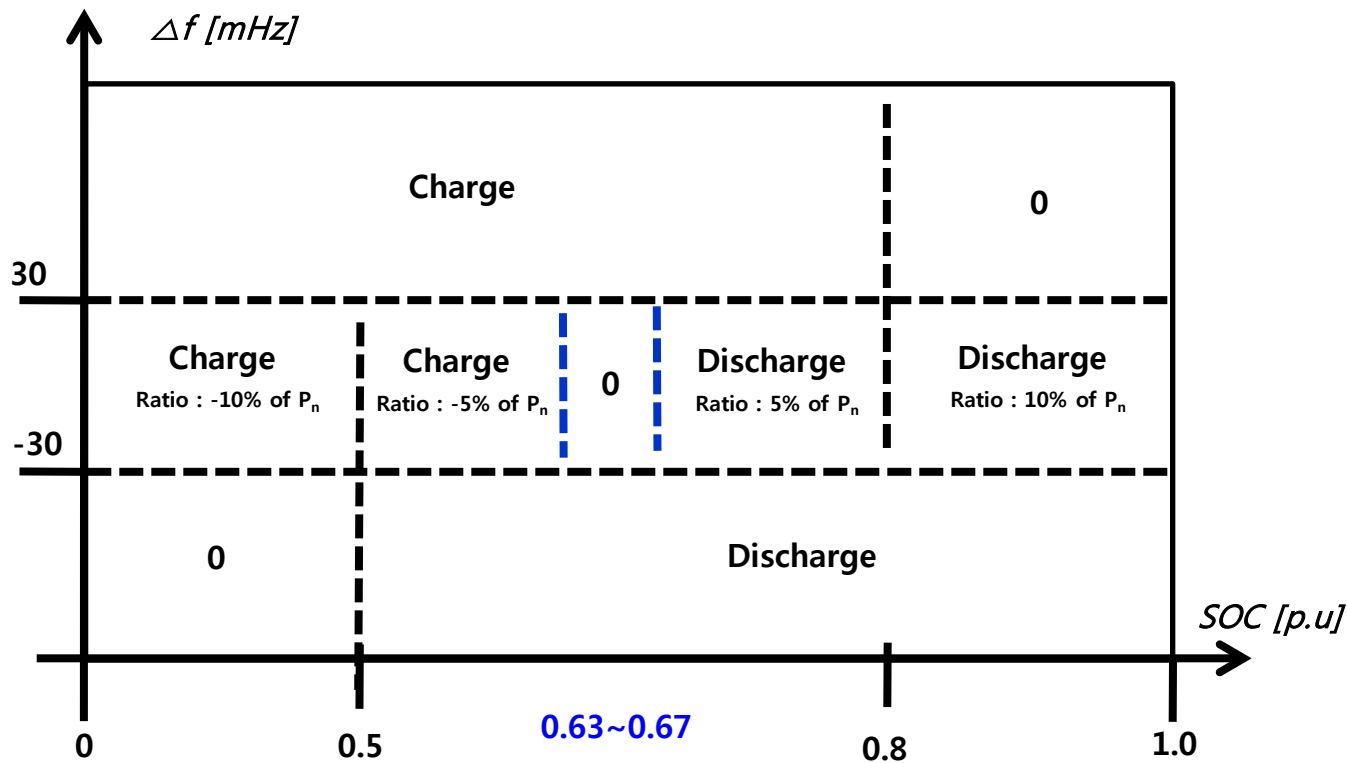
# IV. FR ESS Application

- Major objectives is Primary Frequency Control to maximize fast response benefit.
  - We defined two ESS operation modes
    1. Steady state control mode
    2. Transient state control mode



# IV. FR ESS Application

- FR Algorithm for steady state
  - Over deadband ( $\pm 0.03\text{Hz}$ ) : droop control with speed regulation
  - Within deadband : recovery control of battery SOC





# IV. FR ESS Application

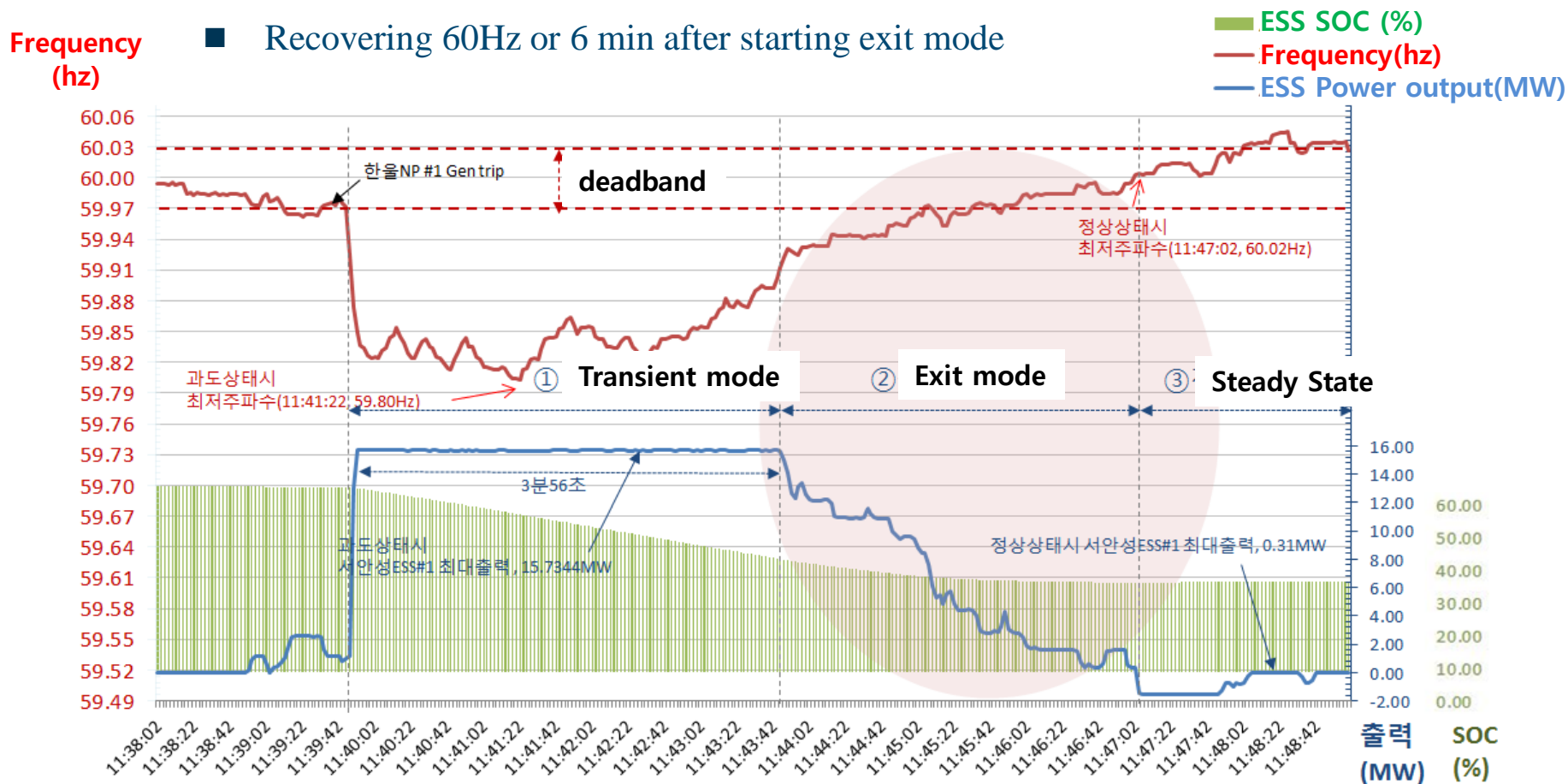
- FR Algorithm for transient state
  - Operation mode (steady state → transient state)
    - Condition
      - under 59.97 Hz and
      - ROCOF lesser than - 0.028 Hz/sec during 1000 msec.
    - Operation
      - Power :  $\Delta\text{Hz} \times K(\text{sys. freq. char. Constants, } 787 \text{ MW}/0.1\text{Hz})$
  - Exit mode (transient state → steady state)
    - Condition
      - Positive freq. ramp above 59.9 Hz still after 1 sec
    - Operation
      - Speed regulation : 0.16% (Droop control)
      - Until recovering 60 Hz or 6 min after starting exit mode

# V. FR ESS Response

## ■ Response to Hanul NP #1(950MW) trip ('16.1.19 11:39:48)

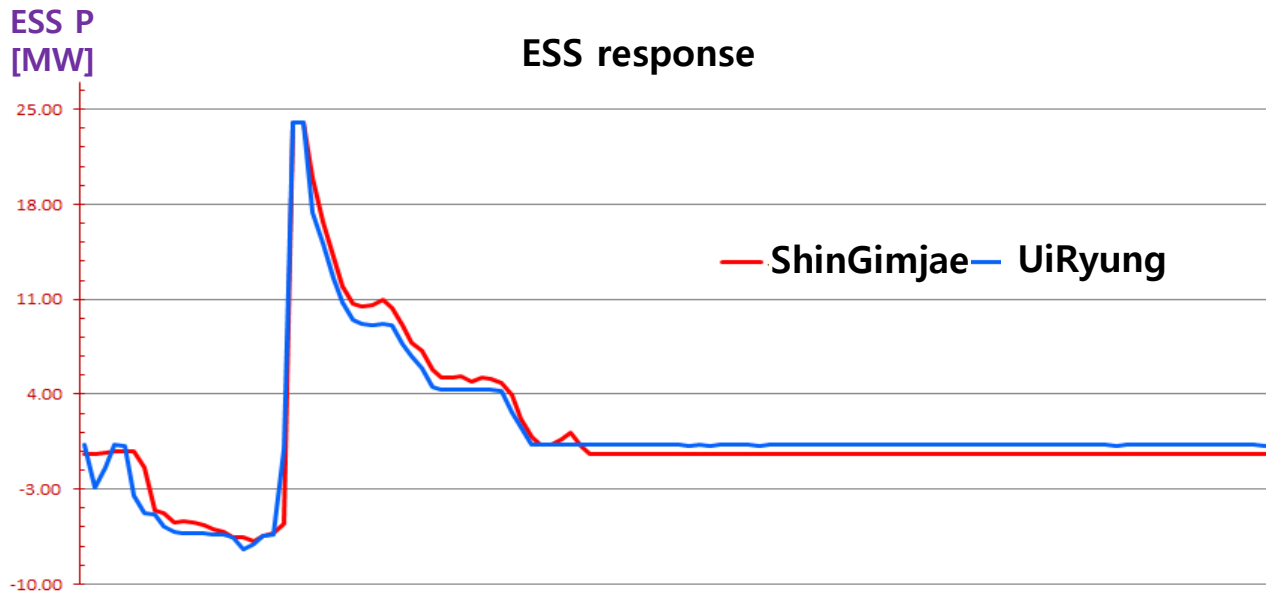
### ➤ Seo-Anseong ESS #1(16MW)

- Transient exit mode : triggered within 200msec.
- Recovering 60Hz or 6 min after starting exit mode



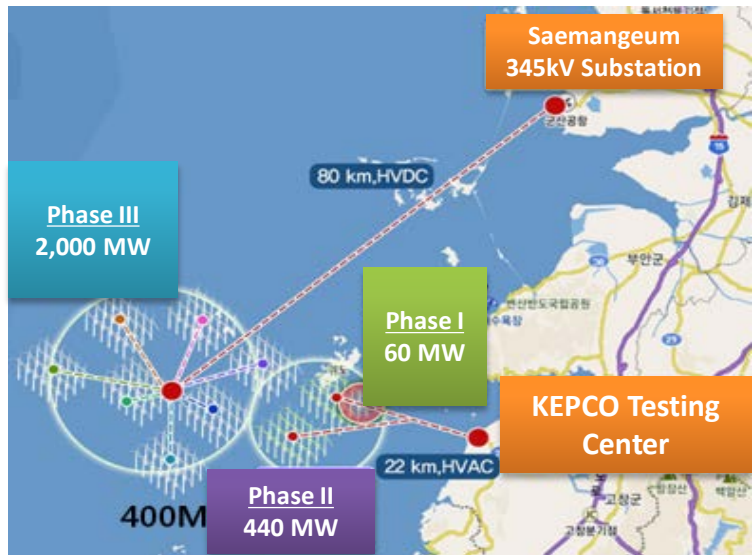
# V. FR ESS Response

- Issue and future study (Freq. pick-up system)
  - Different ESS response owing to different freq. signal conditioning system



# VI. Flexible ESS Project

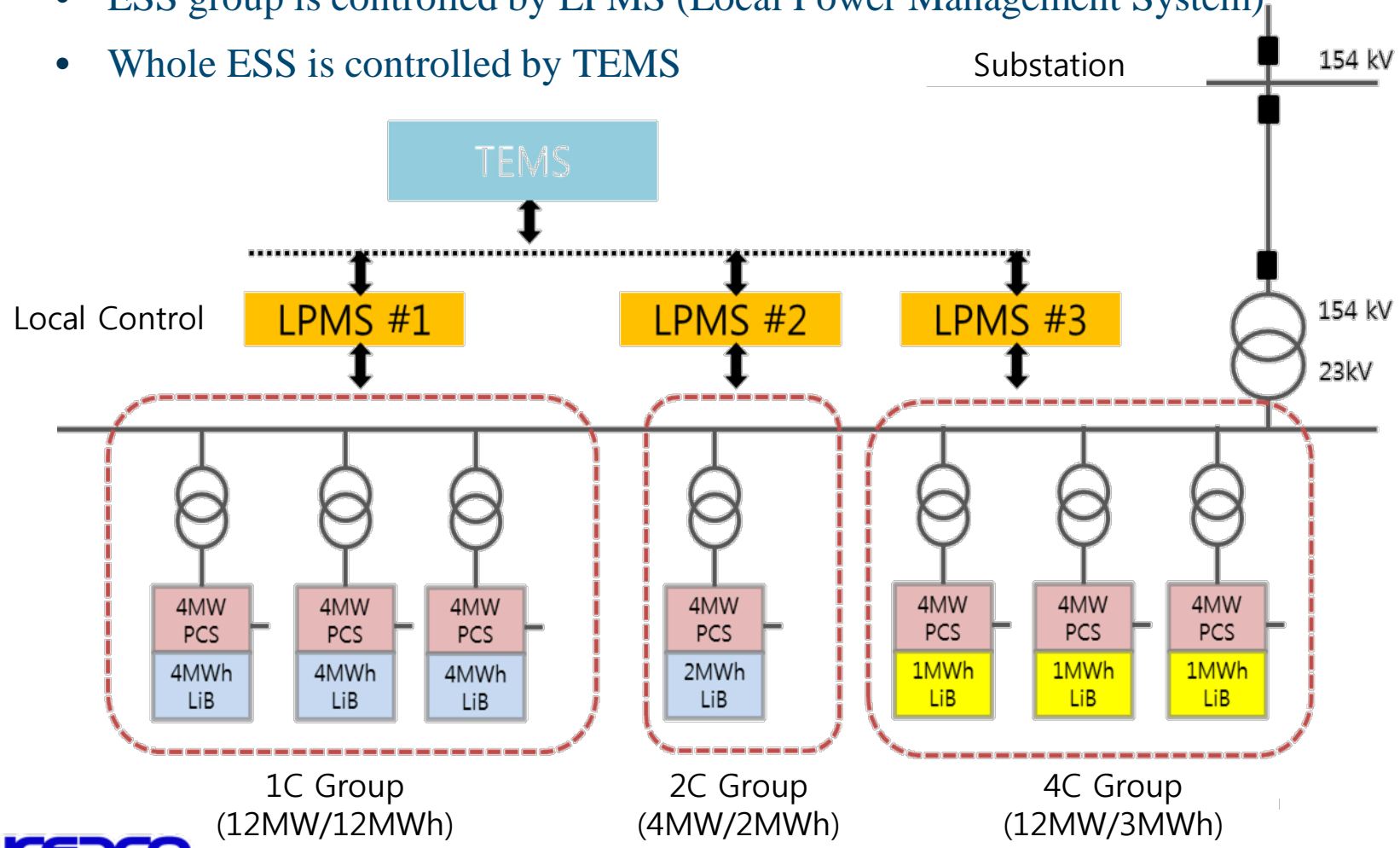
- Multi-Purpose ESS development
  - Optimal operational strategy for technical and economical solution
  - Supply & demand issue (renewables, peak), power system (FR)
- 28 MW ESS for renewable energy integration
  - To be integrated with 60 MW off-shore wind farm



# VI. Flexible ESS Project

## ■ 28 MW ESS configuration

- We defined three ESS Group by Power – Energy ratio
- ESS group is controlled by LPMS (Local Power Management System)
- Whole ESS is controlled by TEMS

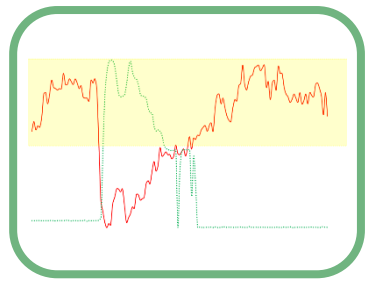




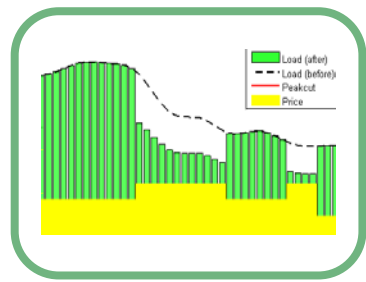
# VI. Flexible ESS Project

## ■ LPMS application mode

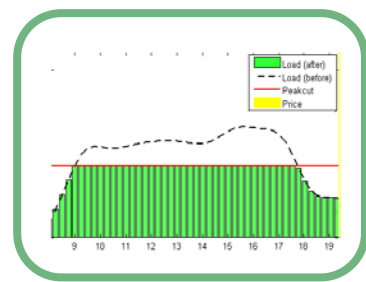
- LPMS have an adjustable control time step from 20ms to 1hour
- Operation mode can be changed by user or TEMS
- Flexible ESS can perform the following functions



G/F



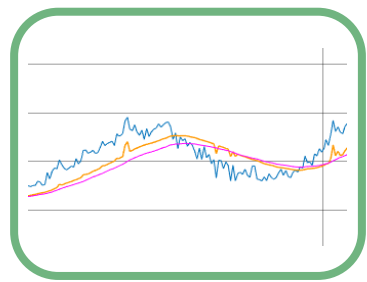
Arbitrage



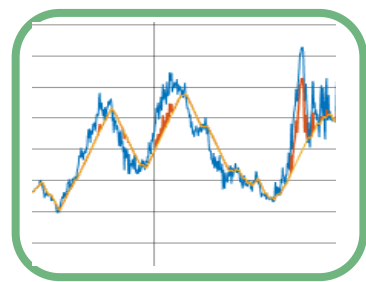
Peak shaving



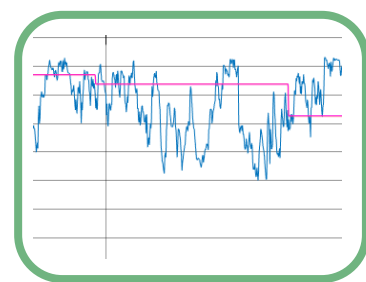
Wind Shift



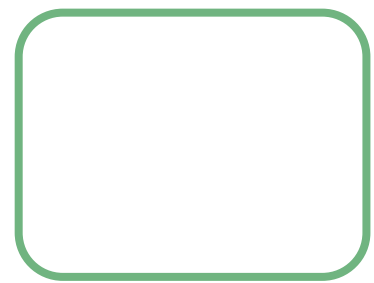
Smoothing



Ramp limit



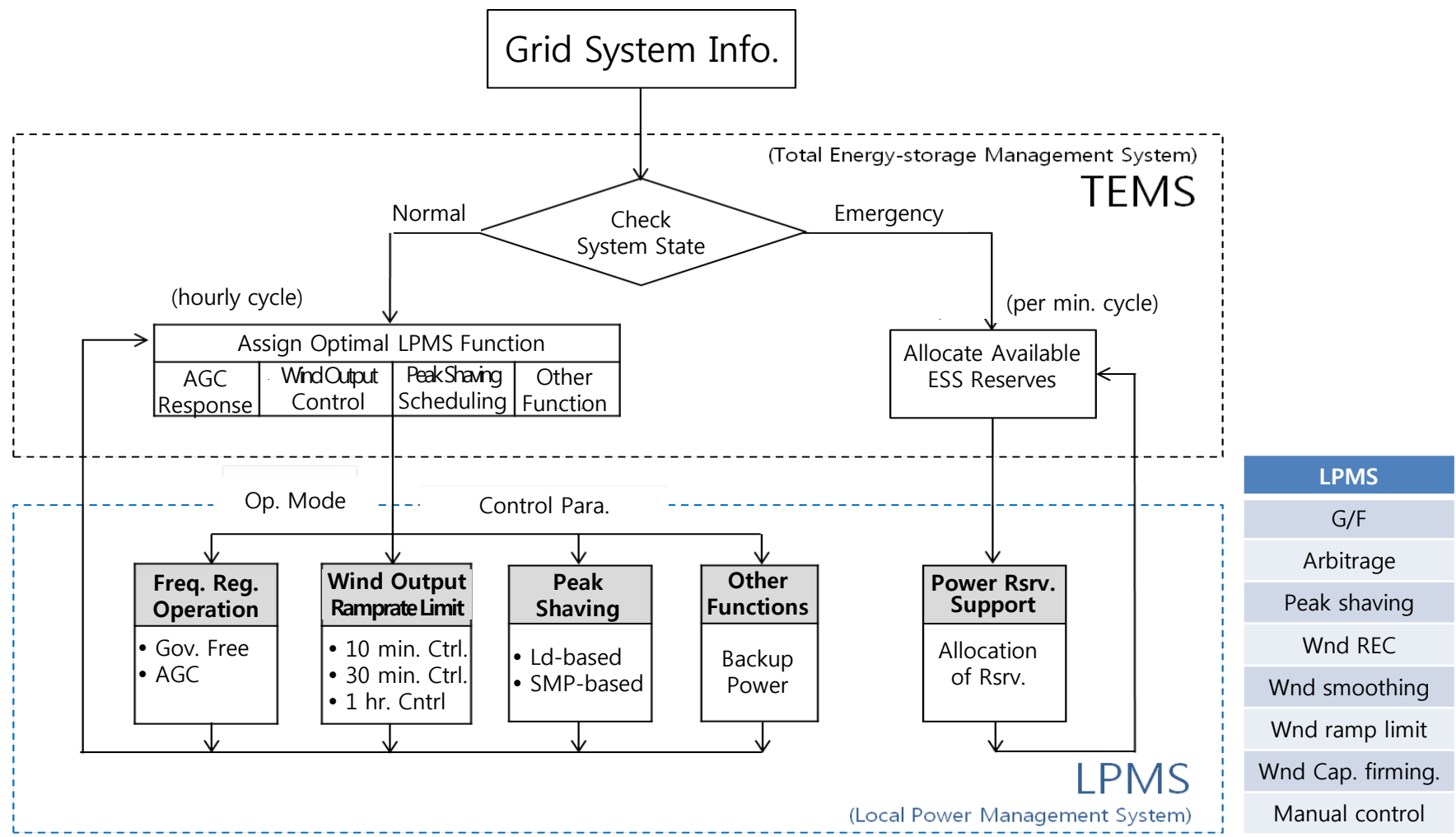
Capacity firming



External control

# VI. Flexible ESS Project

## TEMS control block



# VII. Conclusion

- KEPCO demonstrated Energy Storage System (2011~)
  - Peak shaving, FR, Wind Smoothing by Jocheon 4 MW / 8 MWh in Jeju
  - Flexible ESS for multi function and fleet control (2014~2018)
- KEPCO has got a lot of know-how about operation and installation from about 400MW ESS.
  - Siting, PCS and BMS performance test, communication design, etc.
  - PCS and Battery performance also improved.
- KEPCO will further develop various technologies to expand the use of ESS.
  - Multi Modular ESS, Smart Inverter, Etc.



# Thanks

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