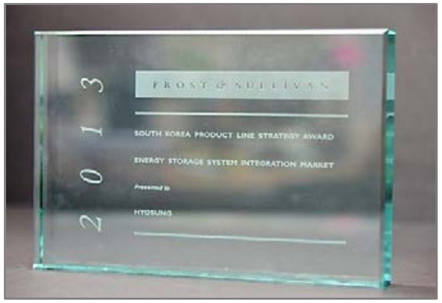
Confidential



2013 Product Line Strategy in ESS Integration Market Award

Upower

Unlimited power

ESS

for Future Energy Solution

Power & Industrial Systems PG

U-POWER Corporation

$12B Revenue Company with 7 Performance Groups. Power and industrial systems performance group's major business area is T&D, motor and pump solutions.

Power and Industrial Systems	Industrial Materials	Textile	Chemical	Information & Communication	Trading	Construction & Engineering
						

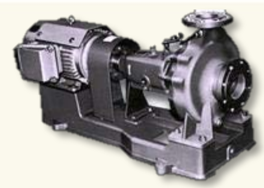
Power Systems PU

- Transformers
- HV Switchgears
- Control Panel
- Substation Project
- HVDC & FACTS
- ESS

Industrial Systems PU

- Motors
- Gear Reducers
- Generators
- Plant
- Chemistry Equipment

HGS PU



- Large Size Pumps
- General Purpose Pumps
- Oil & Gas Pumps
- Desalination Project

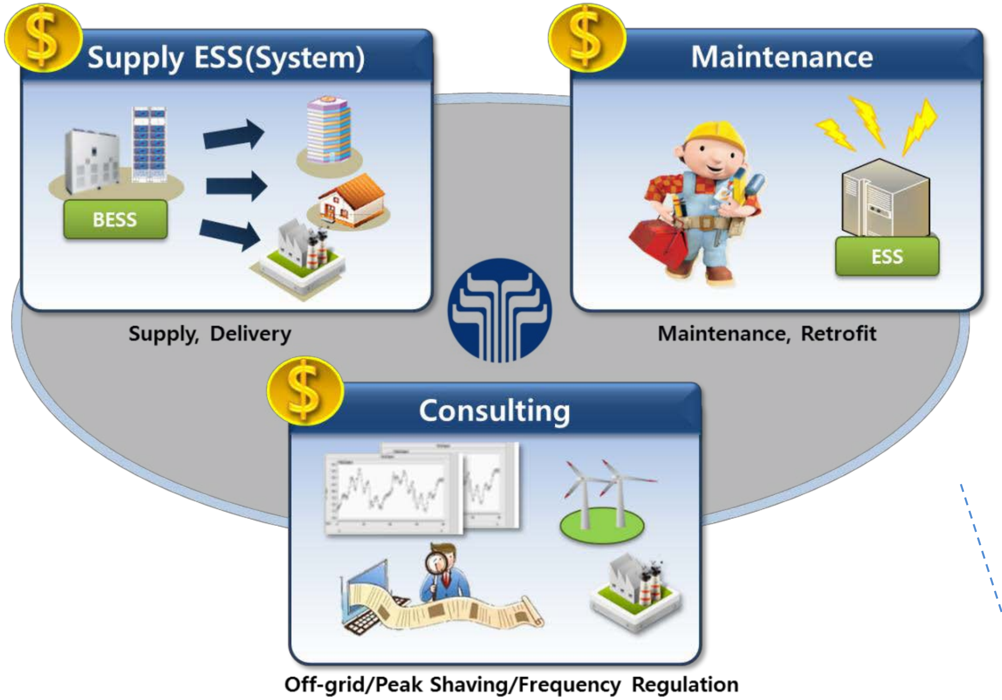
Green Energy

- Wind Turbine System
- Solar Power System
- Fuel Cell System

Provide energy storage solution with grid base engineering know-hows to maximize customers economic benefits with reliable product lines.

Business scope

- As a competent provider of power equipment manufacturing and system service, Hyosung is supplying ESS system, turnkey engineering services and maintenance services.
- Also performing ESS deployment consulting for peak shaving, Renewable integration and Frequency regulation to utilize ESS from generation to end user and off grid.



strengths for ESS

1 Understanding of power systems

- Including the understanding of existing power system, Hyosung has lots of Smart grid project experiences.
  - STATCOM, Wind power, PV(EPC and PCS), ESS and etc.
- Based on experiences, Hyosung is able to provide and sustain customized services.

2 Reliable products

- Over the last 40 years experienced lots of KEPCO's Projects as a main partner and provide electrical equipment to KEPCO.
- Through this process, secured Reliabilities for customers.
- Provides perfect product to customer and that meets requirement of customers.

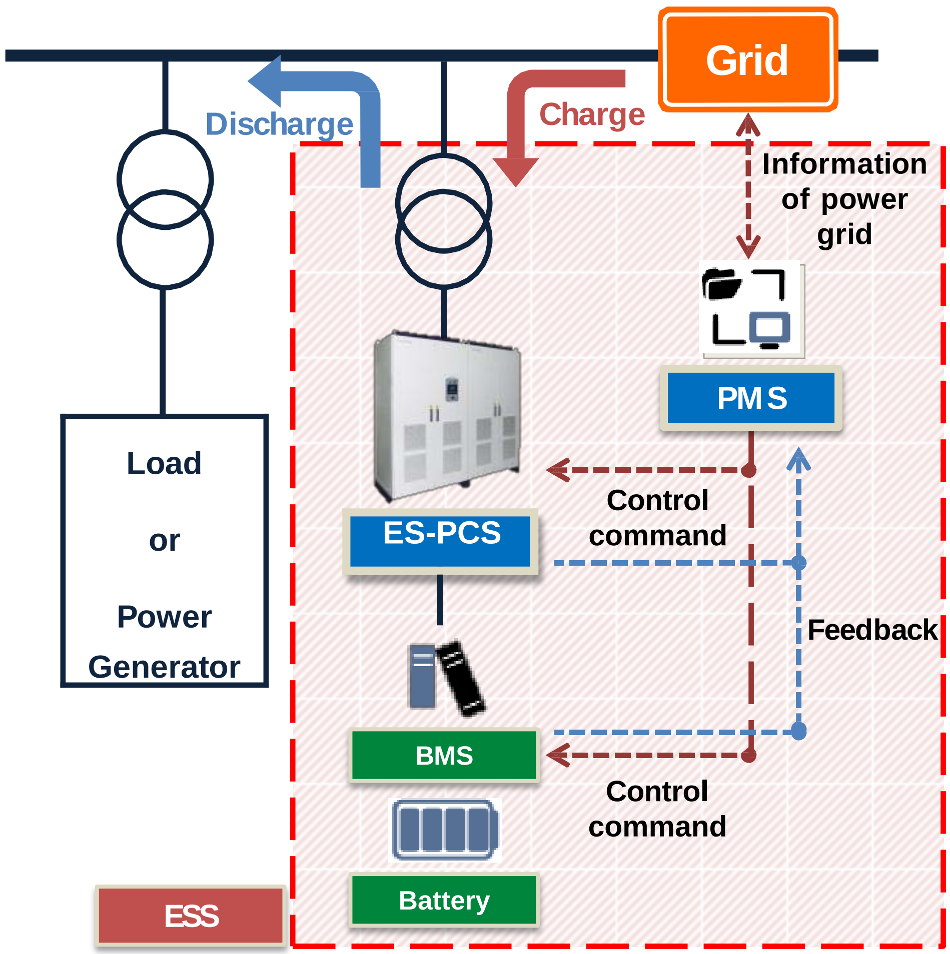
3 Rapid response

- We have been a lot of projects and has strong project pipeline. So Problems encountered during the project implementation could to minimize. Hyosung can respond quickly for the problems.

Definition of ESS

BESS(Battery Energy Storage System), so-called ESS, is a system used for storing electrical energy to secondary battery for timely use.

Concept



Summary

Principle	▪ Storing electrical energy to Secondary batteries (Li-ion, Lead-acid, NaS, etc)
Composition Role	▪ PMS: Control PCS, BMS ▪ PCS: Convert AC/DC, Power quality control ▪ BMS: Control and Monitoring batteries ▪ Battery: Store electrical energy
Life Expectancy	10~20 years
Efficiency	More than 85%
Benefits	▪ Reserving Power electricity ▪ Frequency Regulation ▪ Improving Power quality ▪ Supporting Renewables ▪ Supporting Users for efficient power usage ▪ Voltage control ▪ T&D investment Deferral
Construction Period	Less than 1 year

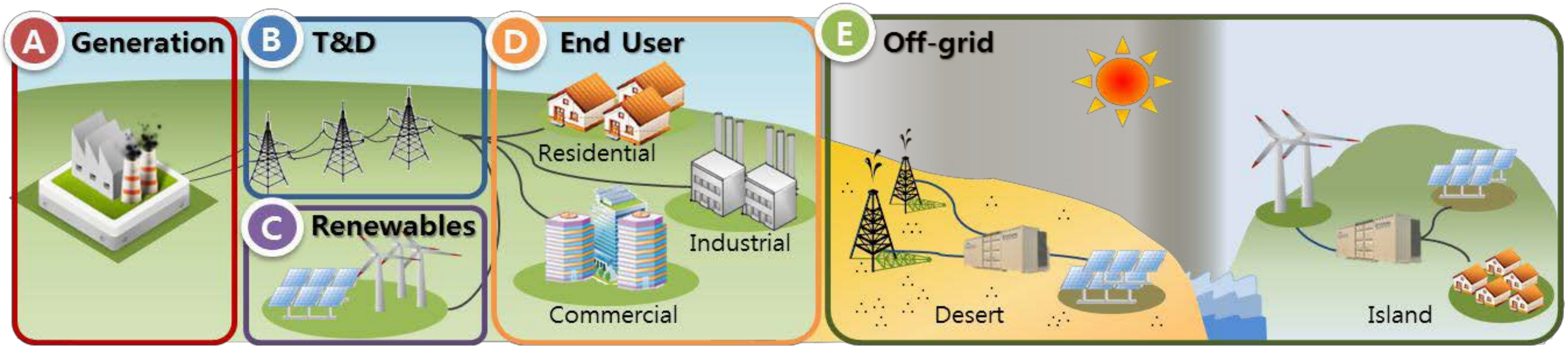
Power Quality

Variability of Renewable Energy Sources, Large Demand and Deviation from the prediction of demand make Regulation Requirement

Short-duration load fluctuation	Demand of electricity	Renewable power generation
"By intensifying short-duration load fluctuation, the importance of frequency stabilization has increased"	"By intensifying electricity demand, importance of power grid efficiency has increased."	"By increasing deployment of renewables, importance of power grid stability has increased.
▪ **Problem : Short-duration load fluctuation** ✓ **Fuel cost increases** - Since peak generation is operated more frequently, costs rise to equal LNG or oil. ✓ **Scheduled generators runs inefficiently** - Load fluctuation depresses Life expectancy and fuel efficiency of scheduled generators.	▪ **Problem : Excessive demand of power electricity use** ✓ **High investment requirements to generation and T&D** - Shortage of generation and T&D capacity may cause power outage. - While power grid becomes more stable, massive investment required to securing more sufficient capacity.	▪ **Problem : Increasing renewables** ✓ **Renewable power system's instability** - Renewable output such as PV and wind is unpredictable and changes unexpectedly. - Renewable's uncontrollable output makes power system unstable.
▪ **Solution : Frequency Regulation** ✓ Frequency regulation corresponding to load variation of short duration reduces burden of center-fed generator	▪ **Solution : Peak Shifting** ✓ ESS reduces peak load in a way of charging during off-peak and discharging during peak	▪ **Solution : Renewable Energy Output control** ✓ ESS make easy to integrate renewables into power grid by smoothing and controlling regular power output
"ESS stabilizes Power grid system"	**"ESS makes power grid system more efficiently"**	**"Output control of ESS reconsiders power grid reliable"**

Applications of ESS

ESS is applicable to power system area entire from generation to end user and has multiple benefits such as improving & stabilizing power quality, supporting renewables and off-grids.



A Generation

- **Improving Generation efficiency**
  - **Load leveling:** Aiding generators by smoothing load fluctuation
  - **Peak Shaving:** Decentering peak load
  - **Spinning reserve:** Supplying seconds-scale reserve
  - **Frequency Regulation**: Improving power quality

B T&D

- **Ancillary services**
  - **T&D Deferral:** Defer additional investments by reduce load
  - **Voltage Support**: Responding sharp drop of voltage in a grid

C Renewables

- **Controlling Renewable output**
  - **Output smoothing:** Smoothing irregular output power
  - **Constant power control:** Controlling peak generation

D End User

- **Supporting Effective Power usage**
  - **Time of Use response:** Charge at off-peak, discharge at on-peak
  - **Power Quality & Reliability:** Prevent blackout & voltage drop
  - **Energy Management:** Power usage management and UPS

E Off-grid

- **Supply power to the grid insufficient area through renewables integration**
  - **Power storing:** Store produced electricity through renewable energy in the areas of power does not reach such as island and desert

Major applications are frequency regulation, demand response and renewable integration.

	Frequency Regulation	Demand Response	Renewable Integration
Purpose	▪ Providing spinning reserves ▪ Stabilizing power grid with regulating frequency ▪ Supplying reserve to grid	▪ Doing arbitrage with charging in off-peak and discharging in peak. ▪ Distracting load in peak time (Peak shifting)	▪ Smoothing output of wind and photovoltaic generators ▪ Postponing investments to additional T&D infrastructure integrated renewables
Discharging Time	Less than 10~30 minutes	More than 2 hours	Depends on T&D Infra and Wind Resources
Benefits	▪ Saving fuel and overhaul cost of frequency regulation by conventional generation ▪ Stabilizing power grid with fast response performance ▪ Improving power quality	▪ Reducing risk of power shortage in peak time ▪ Postponing investments to additional power plant ▪ Doing arbitrage with electricity	▪ Maximizing revenue of selling power with timely discharging ▪ Stabilizing power grid ▪ Saving cost of grid operation with controlling renewables power output
Major user	Grid operator, Generation company	End-users	Renewables power plants
Case of installation	▪ 1MW ESS (PJM for ancillary service) ▪ 8MW ESS (NYISO for Frequency Regulation) ▪ 4MW ESS (KEPCO for supplying reserve and improving power quality in Chochun S/S)	▪ 1MW/1MWh Samsung SDI Ki-heung Plant, Gyeonggi Province ▪ 250kW/500kWh Guri Agricultural & Marine Products Wholesale Market, Gyeonggi Province	▪ 15MW ESS (Kahaku, Hawaii for integrating wind power plant) ▪ 10MW ESS (Kaheawa, Hawaii for integrating wind power plant) ▪ 1.125MW ESS (Lanai, Hawaii for integrating solar power plant) ▪ 800kW ESS (Haengwon, Jeju for integrating w

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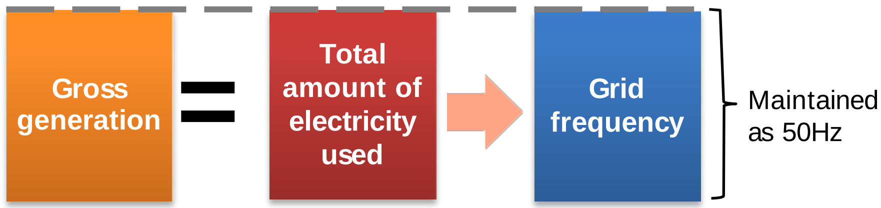
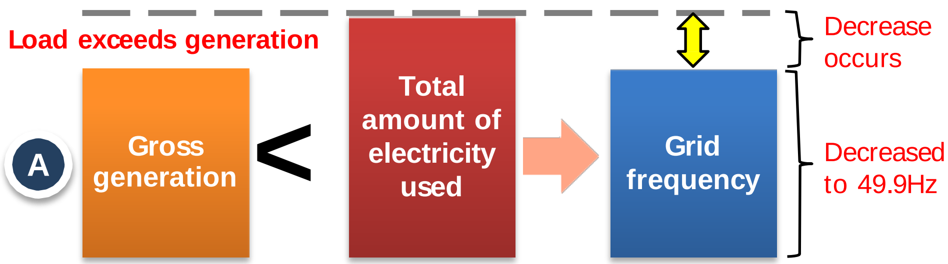
Frequency Regulation

Grid frequency is determined by balance between gross generation and total amount of electricity used. Frequency regulation by ESS is more beneficial than conventional load following power plants.

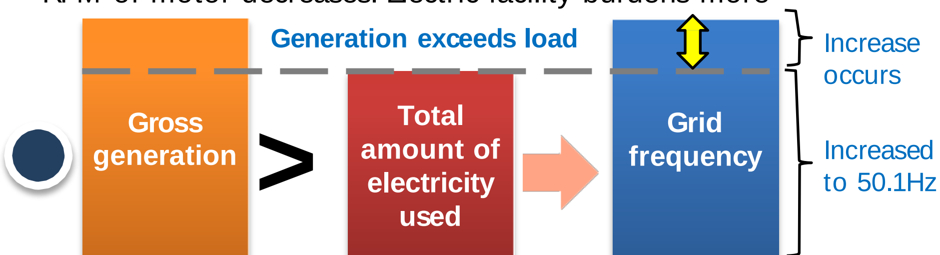
Principle of change of frequency



- Generation balancing with total usage of electricity maintains grid frequency as 60±0.2Hz.



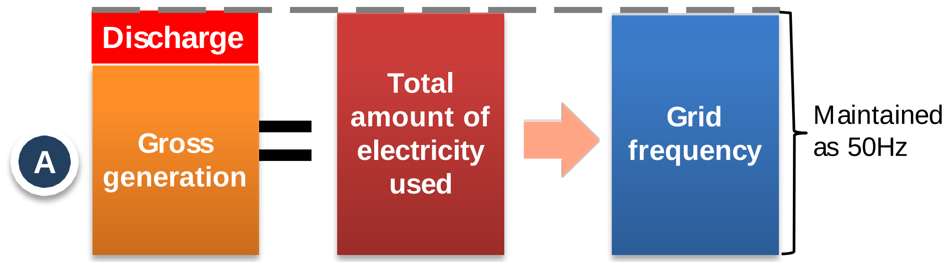
- Grid frequency decreases when generation lacks compared to total usage of electricity.
- RPM of motor decreases. Electric facility burdens more



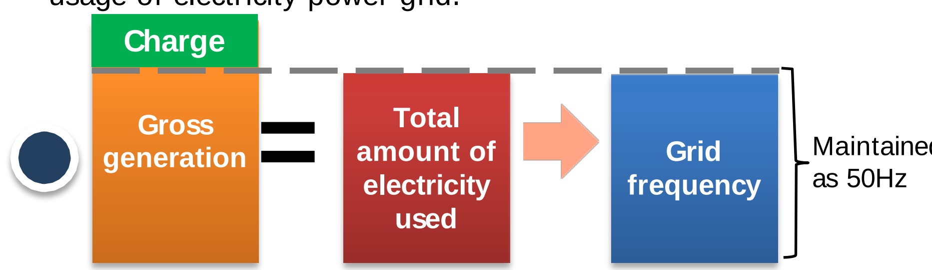
- Grid frequency increases when generation exceeds total usage of electricity.
- RPM of motor increases. Electric facility burdens more

Frequency regulation provided by ESS

"ESS frequency regulation service enables replacing conventional generators"



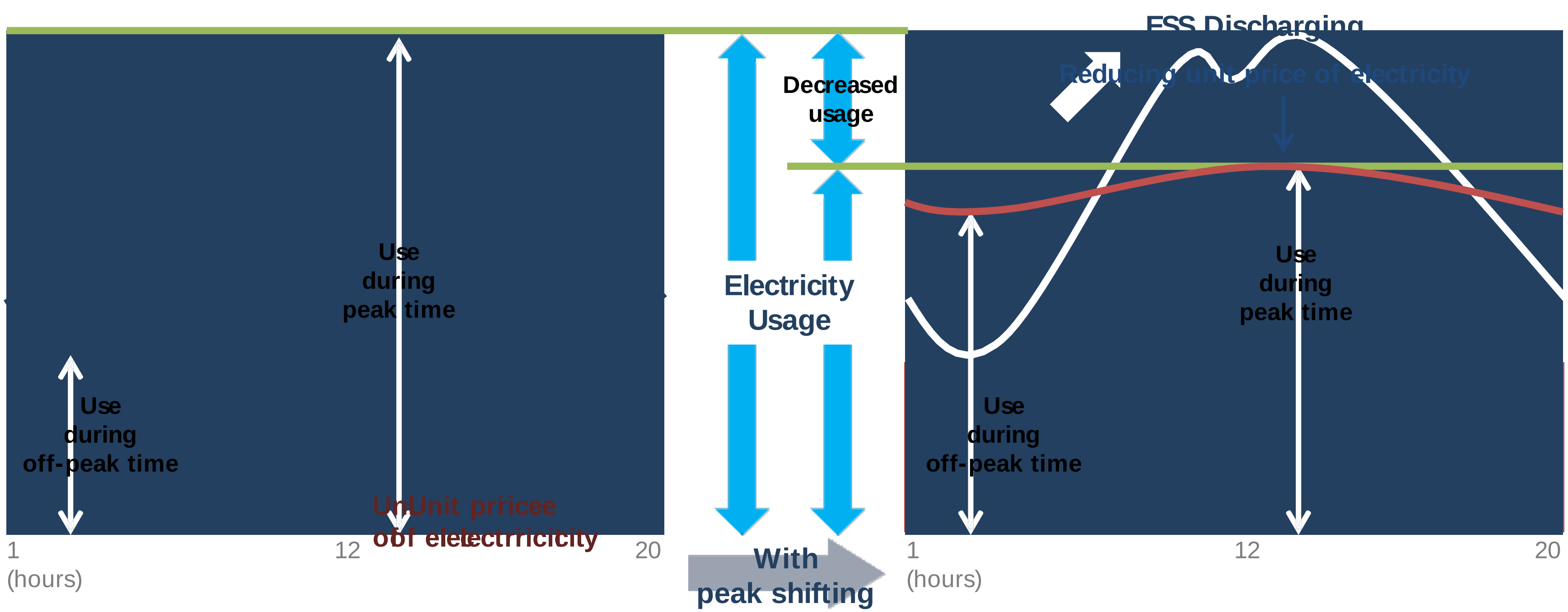
- ESS discharges when grid frequency decreases.
- Increased gross generation meets the balance with total usage of electricity power grid.



Peak Shifting

ESS can reduce electricity rates with discharge during peak time. It increases efficiency of generation capacity.

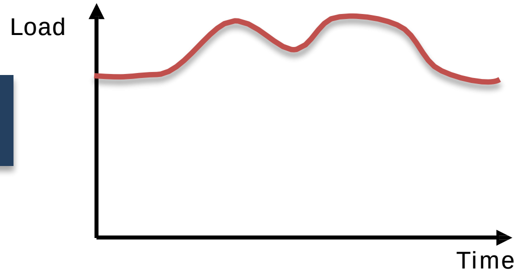
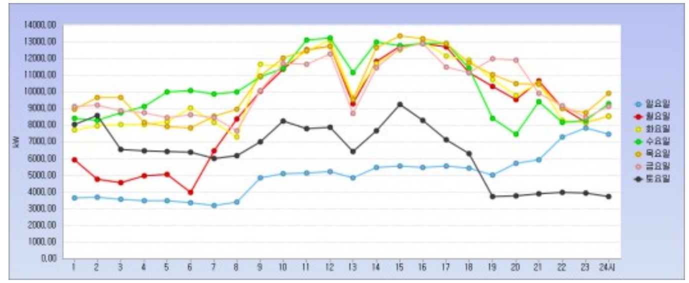
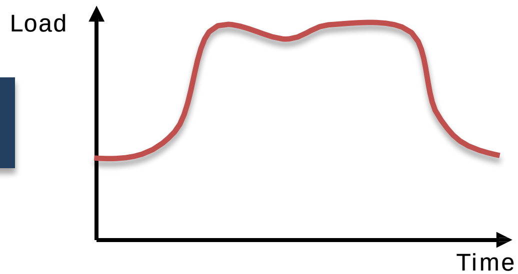
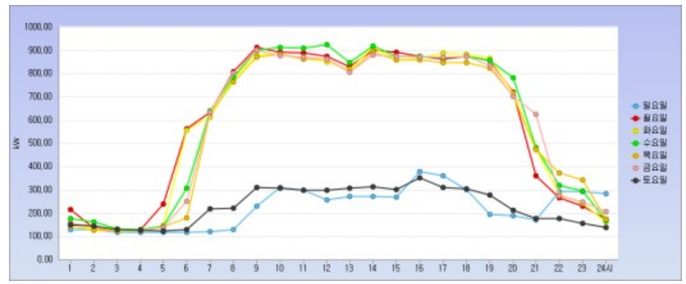
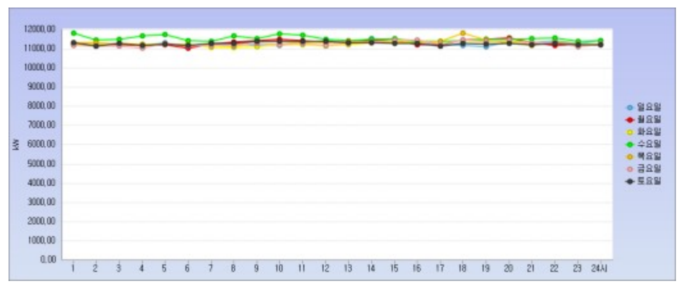
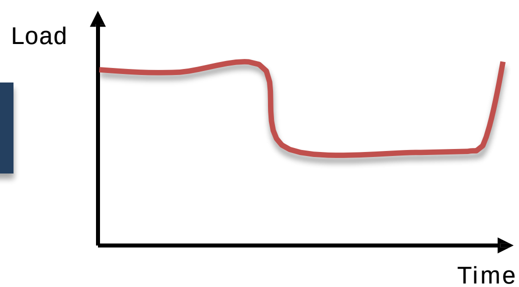
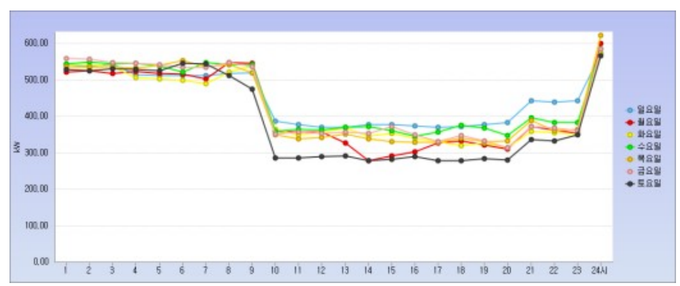
As-is (without ESS)	To-be (with ESS)



- Total generation capacity should be larger than sum of peak load and reserves.
- Massive investments to power plants for peak load are required in conventional ways.

- ESS charge during off-peak and discharge during peak to reduce peak load.
- Peak shifting makes grid operation costs lower and possible to postpone additional investments of power plants construction.

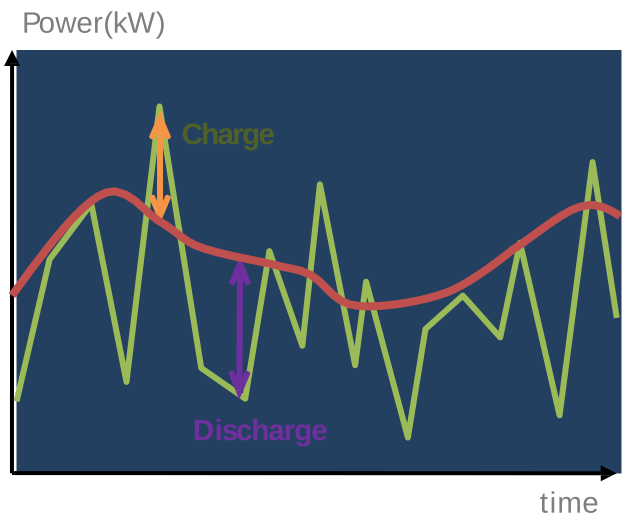
ESS Economics according to Power usage patterns

Power usage pattern		Industry Example		ROI
A		• Heavy Industry (MW Class)		High
B		• Commercial Building (300kW~1MW)		Mid
C		• Chemical/IDC (MW Class)		Low
D		• Refrigeration (300kW~1MW)		Low

Renewables integration

Intermittent power of renewable sources make power grid unstable. ESS is a solution for renewables integration by output smoothing and constant power control.

Output smoothing



① PCS : observing power(usual time)

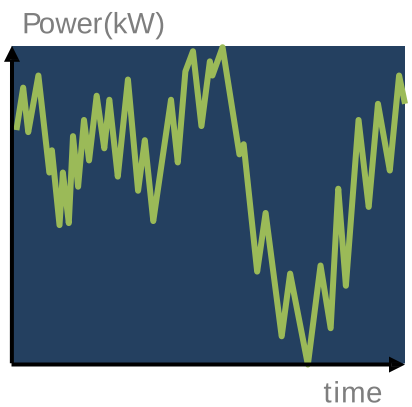
② EMS→PCS : smoothing command

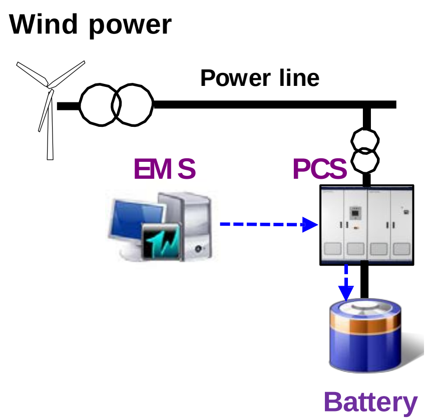
③ PCS : smoothing operation

④ PCS→Battery : charge/discharge order

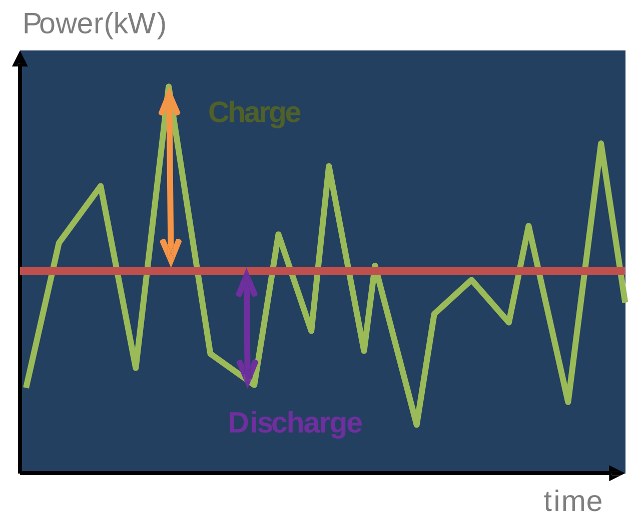
⑤ Battery : charge/discharge

Output of renewables





Constant power control



① PCS : observing power(usual time)

② EMS→PCS : power control command

③ PCS : constant power control operation

④ PCS→Battery : charge/discharge order

⑤ Battery : charge/discharge

Renewable integration engineering process

In order to integrate renewable energy with conventional power grid and ESS, an aggregator preferentially needs to make sure to verify following 6 decision making processes.

Understanding Resource

- Simple resource classification (takes at least 1 year for feasibility study at the wind farm or solar farm)

Siting Consideration

- Siting wind turbines or PV and assessing feasibility of location : wind or PV characteristics, Access distance, Spacing, Environmental impact, seismic activity & etc.

Power Grid Analysis

- Analysis transmission capability for grid interconnecting safety & reliability
- Minimize amount of transmission infrastructure

WTG/PV-ESS Interconnection Design

- Evaluating amount of power output and volume of WTG/PV to interconnect with ESS
- Deriving optimal ESS power and energy parameter design

Simulation

- Secure WTG/PV-ESS safety & reliability
- Verifying ESS design integrity

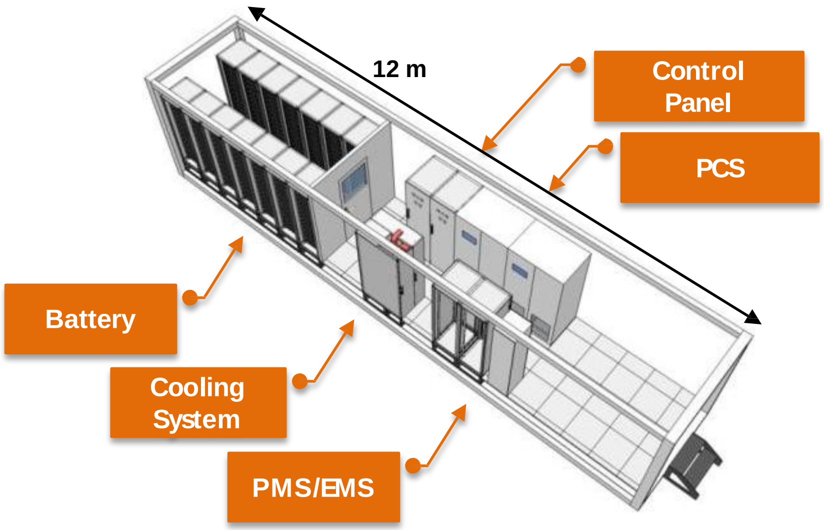
Wind/ PV-ESS Integration Design

- Identifying reliable supplier
- Detail designing and Final designing
- Acquiring land rights

Composition of basic ESS installation

ESS could be installed with container type or structure type depends on capacity or Customer's need.

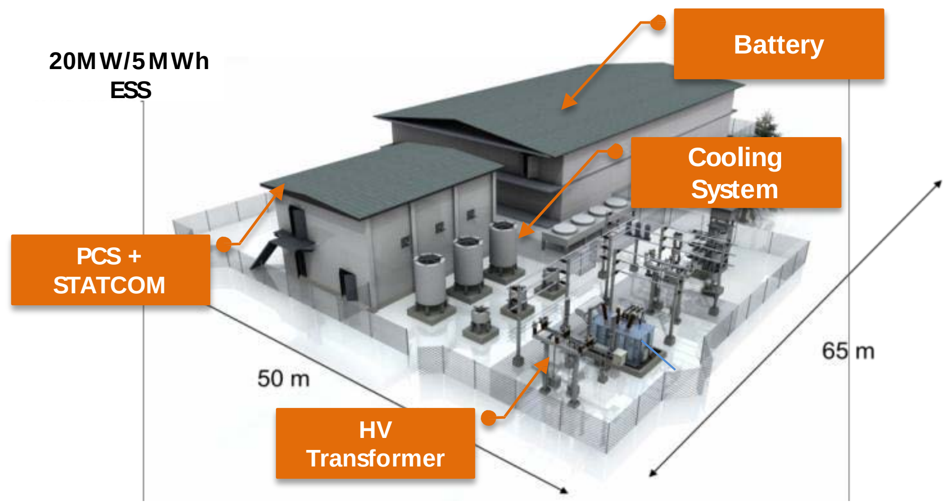
Container Type ESS (500kW)



* Installation Concept of HYOSUNG ESS

- Configured with PCS, Battery, HVAC, DC Link, monitoring module and fire fighting equipment, and may include transformer and switchgear panel if necessary.
- Up to 1MW/500kWh (Standard 40ft. container)
- Transportable form production is also possible upon Customer's need.
- Due to the nature of Battery, optimization design of air-cooling and fire safety equipment are critical design elements.

Structure type ESS (20MW)



* Installation Concept of ABB DynaPeaQ

- Most BESS more than 10MW of the U.S. is in the form of building structure include PCS, STATCOM and Battery.
- Battery and PCS is required isolation or blocking for fire prevention.
- STACOM can compensate active and reactive power with BESS.

ES-PCS provides highly effective power conditioning system for all kinds of storage technology.

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ES-PCS (HS-E1000G) Function

Control panel | Inverter panel | Battery input panel

Bi-directional power control	Controlling power inflow and outflow between battery and power grid
Power quality compensation	Compensating voltage (reactive power) of power grid
Grid synchronization	Providing phase angle by estimating system voltage phase
Protecting grid	Protecting power grid based on IEEE Standard 1547
Communication interface	Communicating with BMS and EMS for effective operation of ESS

ES-PCS Specifications

	HS-E100G	HS-E250G	HS-E500GL	HS-E1000GL
Battery Voltage	450~850V_{DC}	450~880V_{DC}	450~850V_{DC}	760~1050V_{DC}
Battery Current	245A_{DC}	612A_{DC}	1,220A_{DC}	1316A_{DC}
Rate Power	110kW	250kW	500kW	1MW
Output Voltage	3Φ, 380V_{AC}	3Φ, 380V_{AC}	3Φ, 290V_{AC}	3Φ, 440V_{AC}
Output Current	167A	380A	996A	1312A
Efficiency	>97% (at rated power)	>96% (at rated power)	>97% (at rated power)	>96% (at rated power)
Frequency	60Hz (±0.5Hz)	50Hz/60Hz (±0.5Hz)	60Hz (±0.5Hz)	60Hz (±0.5Hz)
Rate Power Response time	< 20ms (1 cycle)	< 20ms (1 cycle)	< 20ms (1 cycle)	< 20ms (1 cycle)
THD	<5%	<5%	<5%	<5%
Power Factor	>99%	>99%	>99%	>99%
Standard	IEC 62477-1 (Safety) IEC 61000-6-2, 4 (EMC) SGSF-04-2012-01	IEC 62477-1 (Safety) IEC 61000-6-2, 4 (EMC) SGSF-04-2012-01	IEC 62477-1 (Safety) IEC 61000-6-2, 4 (EMC) SGSF-04-2012-01	IEC 62477-1 (Safety) IEC 61000-6-2, 4 (EMC) SGSF-04-2012-07
Comm. port	CAN2.0, RS422	CAN2.0, RS422	CAN2.0, RS422	CAN2.0, RS485
Dimensions (㎣)	1200(L) x 850(W) x 2120(H)	2400(L) x 850(W) x 2120(H)	2200(L) x 990(W) x 2120(H)	2700(L) x 1100(W) x 2180(H)
Weight	1,070 kg	2,250 kg	1,200 kg (w/o TR and AC)	2,800 kg (w/o TR and AC)
Cooling	Forced air ventilation	Forced air ventilation	Forced air ventilation	Forced air ventilation
Ambient temperature	-20~50℃	-20~50℃	-20~50℃	-20~50℃

Multi-functional ESS for Substations

Soported multiple projects of power grid integration ESS for performance verification on a variety of features and for Research on Utilization.

Jocheon Substation (KEPCO, 4MW/8MWh)

Hong Kong CLP (CLP, 400kW/350kWh)

- Linked with substation, for Renewables output smoothing, Active & Reactive power Controlling and Black start
- Integrator :
- PCS : 4MW (1MW x 4, HYOSUNG)
- Battery: 8MWh (Samsung SDI)

- For Load leveling, Peak shifting, PV power generation quality improving
- Integrator :
- PCS : 500kW (250kW x 2, HYOSUNG)
- Battery: 350kWh (Samsung SDI)

Peak Shaving and Load Leveling ESS for Electricity users

Supported multiple ESS projects for electricity users to reduce electricity charge.

Samsung SDI Giheung plant (1MW/1MWh)

- Reduce power electricity demand charge (max $96 mil/year) and power electricity rate charge (max $25 mil/year) by peak reduction.
- Installed for separate outdoor building

Linke with KEPCO's 22.9kV Power grid

- PCS : 1MW (1MW x 1)
- Battery: 1MWh (Samsung SDI)

Guri Agricultural Market (250kW/500kWh)

- Reduce power electricity demand charge (max $23 mil/year) and power electricity rate charge (max $12 mil/year) by peak reduction.
- Installed for separate outdoor building
- Linked with KEPCO's 22.9kV Power grid
-
- PCS : 250kW (250kW x 1)
- Battery: 500kWh (LG Chemical)

Off Grid Solution

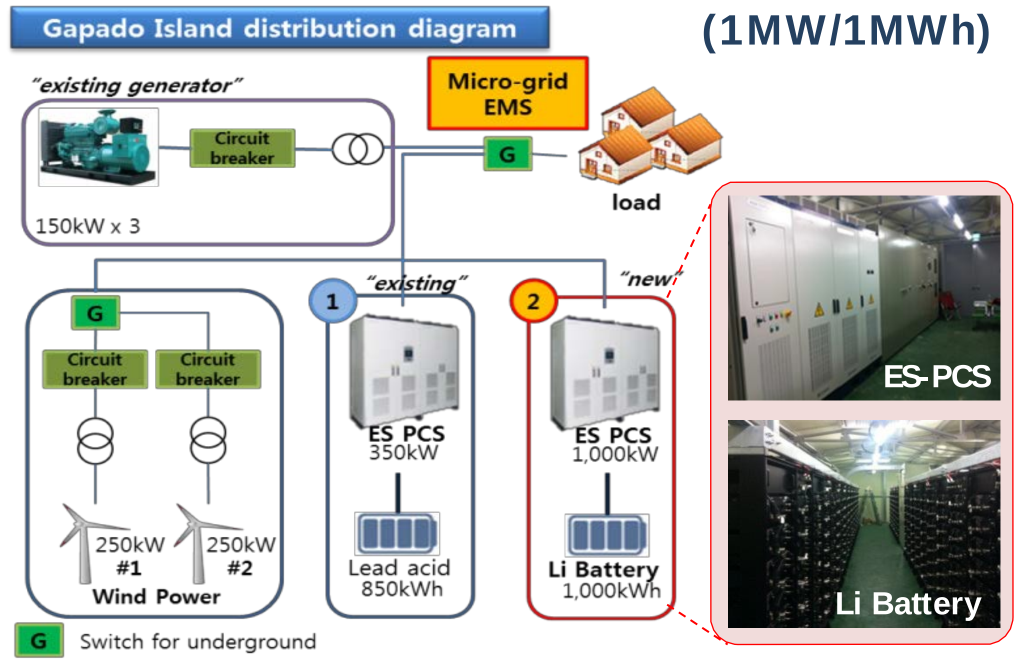
Constructed the Off-Grid system based on PV generator in Mozambique and Carbon Free Island in Gapado island, Korea

Mozambique Off-grid PV generator-ESS

(900kW/20MWh)

Gapado Renewable & Off-grid Integration

(1MW/1MWh)



- Electricity supply using PV generator and ESS in Mozambique - Mavago(550kW), Mecula(400kW), Muembe(350kW) - under contemplation of grid-connected photovoltaic system
- Integrator : HYOSUNG
- PCS : 900kW (single phase 5kW x 180, SMA)
- Battery: Lead acid battery from MASTERBATTERY)

- Electricity supply using wind power and ESS to over 200 residents in Gapado island
- Integrator :SUNG
- PCS : 1MW x 1
- Battery: SDI 1,000kWh

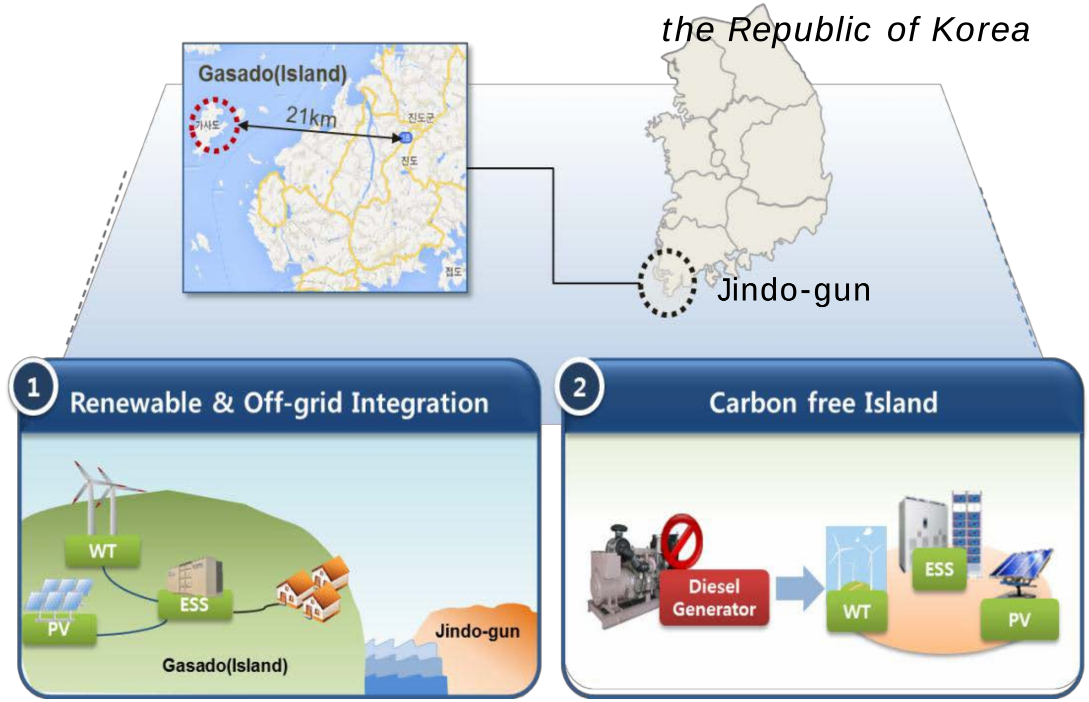
Off Grid Solution

Supplies the installation of 1.25MW/3MWh ESS solutions on Gasado by September 2014

Gasado Stand-alone microgrid ESS(1.25MW/3MWh)

[Korea times, 2014. 3. 13]

[Groundbreaking ceremony]



- Renewable & Off-grid Integration
- Carbon free Island
- Integrator : HYOSUNG
- PCS : HYOSUNG 250kW X 1, 500kW X 2
- Battery: KOKAM 3,000kWh

ESS Projects

ESS solution provider also providing static synchronous compensator which stabilizing the power grid.

		Jeju Smart Renewable	Jeju Smart Place	Jo-cheon Substation Project	Samsung SDI Project	2012 Smart grid Project for Peak shifting	Hong Kong CLP Project	Mozambique Off-grid PV generator	Frequency Regulation ESS	2013 Smart grid Project for Peak shifting	Renewable & Off-grid Integration	Renewable & Off-grid Integration
		Korea	Korea	Korea	Korea	Korea	Hong Kong	Mozambique	Korea	Korea	Korea	Korea
End User		KEPCO	KT (Korea Telecom)	KEPCO	Samsung SDI	KT (Korea Telecom)	CLP	FUNAE	KPX (Korea Power Exchange)	Duzon Biz-on	Jeju Provincial Government	KEPRI (Korea Electric Power Research Institute)
Installation site		Haengwon wind farm (Jeju Island)	Sehwa middle school (Jeju Island)	Jo-cheon Substation (Jeju Island)	Samsung SDI Gi-heung Plant	Guri Agricultural Market	Kowloon	Mavago, Mecula, Muembe	Korea East West Power Company (EWP)	Duzon Biz-on at Chun-cheon	Gapado Island (off-grid)	Gasado Island (off-grid)
Config.	PMS	Dynamic Power Control	Building Energy Management	Dynamic Power Control	Building Energy Management	Community Energy Management	Dynamic Power Control	Off-grid PV control	Frequency Regulation	Building Energy Management	Off-grid	Off-grid
	PCS	800kW x 1	20kW x 6	1MW x 4	1MW x 1	250kW x 1	250kW x 2	5kW x 180	1MW x 4	250kW x 2	1MW x 1	250kW x 1 500kW x 2
	Battery	Li-ion 200kWh (Samsung SDI)	Li-ion 180kWh (Samsung SDI)	Li-ion 8MWh (Samsung SDI)	Li-ion 1MWh (Samsung SDI)	Li-ion 500kWh (LG Chemical)	Li-ion 300kWh (Samsung SDI)	Lead acid 20MWh (Sebang)	Li-ion 2MWh (SK Innovation)	Li-ion 1.6MWh (Samsung SDI)	Li-ion 1MWh (Samsung SDI)	Li-ion 3MWh (Kokam)
	STATCOM	1MWA x 1	-	-	-	-	-	-	-	-	-	-
Applications		▪ Load leveling ▪ Peak shifting ▪ Output control of wind power	▪ Load leveling ▪ Peak shifting	▪ Black start ▪ Control of active/reactive power	▪ Load leveling ▪ Demand response	▪ Peak Shifting ▪ Demand Response ▪ Arbitrage	▪ Peak Shifting ▪ Load Leveling ▪ Renewable Energy Integration	▪ Off-grid PV generator	▪ Frequency regulation	▪ Load leveling ▪ Demand response	▪ Load leveling ▪ Peak shifting ▪ Output control of wind power	▪ Off-grid ▪ Carbon free Island
Construction period		2009. 12 ~ 2011. 05	2009. 12 ~ 2011. 05	2011. 07 ~ 2014. 06	2012. 03 ~ 2012. 10	2012. 08 ~ 2012. 12	2012. 11 ~ 2013. 08	2013. 01 ~ 2013. 12	2013. 06 ~ 2016. 06	2013. 08 ~ 2013. 12	2013. 08 ~ 2014. 06	2014. 03 ~ 2014. 09
operation period		2011. 06 ~ 2013. 05	2011.06 ~ 2013. 05	2013. 09 ~ 2014. 06	2012. 10 ~ In operation	2012. 12 ~ In operation	2014. 06 ~ In operation	2013. 12 ~ In operation	2014. 12 ~ 2016. 06	2013. 12 ~ In operation	2014. 01 ~ In operation	2014. 09 ~