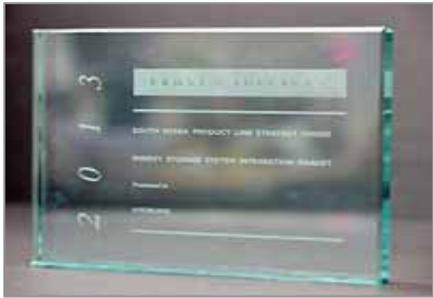


Confidential



2013 Korea Product Line
Strategy in ESS Integration
Market Award



ESS

Adding Value to Energy

Junill Yoon

Senior Manager/ Corporate Strategy Office / Hyosung Corporation

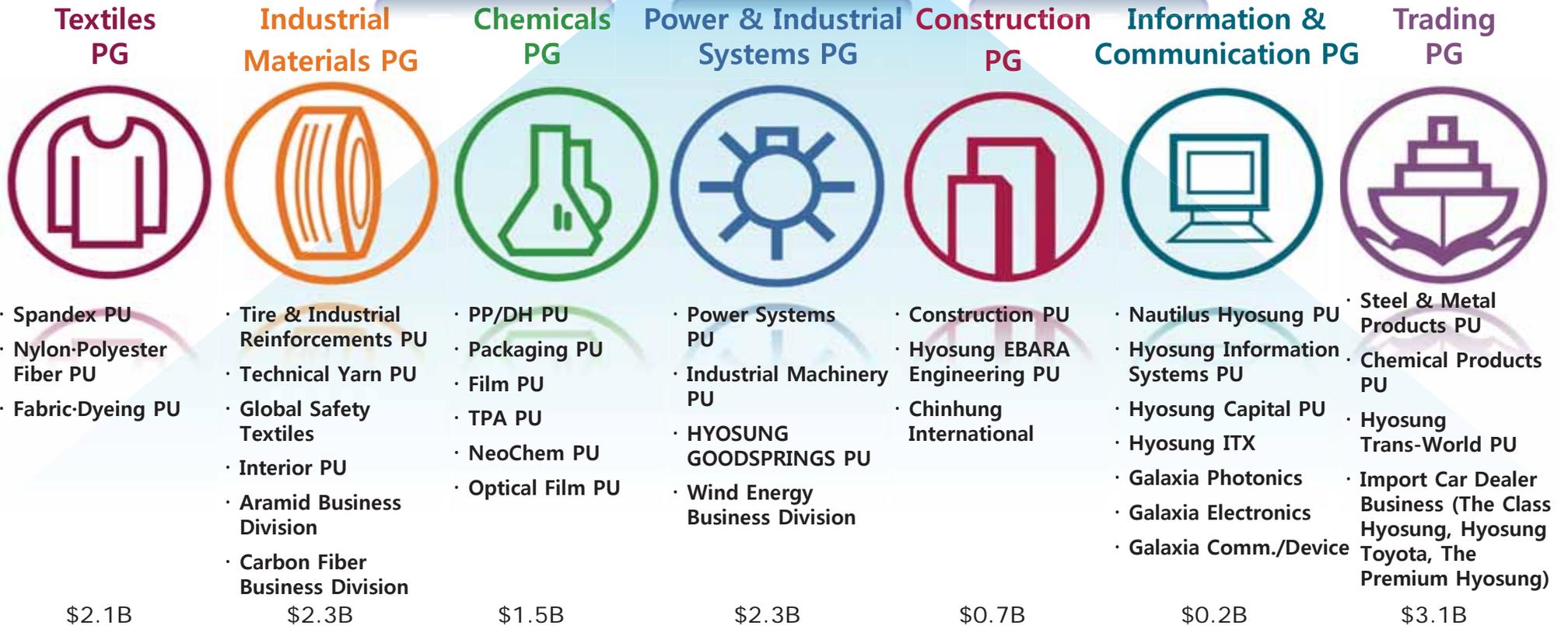
ESS Committee Chair/Korea Smart Grid Association



Hyosung manages Performance Groups (PGs), which are engaged in diverse industrial & technological business areas, including chemicals, synthetic fibers, heavy machinery, construction, trading, and finance.



2014 Revenue: \$12B



Hyosung is ranked No.1 for 4 businesses globally and 9 businesses domestically—the majority of Hyosung's businesses are market leaders in their respective industries.

4 Global No. 1 Businesses



PET Tire Cords



Spandex



Seatbelt Yarn



Airbag Textile

9 Domestic No. 1 Businesses



Nylon



Polyester



BCF Carpet Yarn



PET Bottles



High Voltage Switchgears



Super-High Voltage Transformers



Industrial Motors



Power Plant Pumps



CDs and ATMs

Hyosung Power Systems Performance Unit has customers in 70 different countries



Global Total Energy, Machinery & Plant Solution Provider

Power & Industrial Systems PG

Power Systems PU



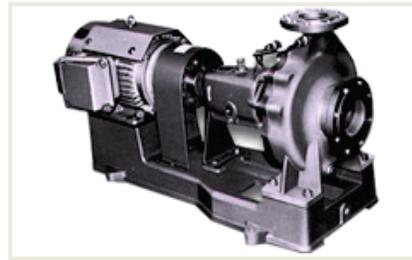
- Transformer
- GIS / GCB
- Control Panel
- Substation Project
- Engineering & Services
- STATCOM
- ESS

Industrial Machinery PU



- Motor
- Gear Reducer
- Plant
- Chemistry Equipment

HYOSUNG GOODSPRINGS PU



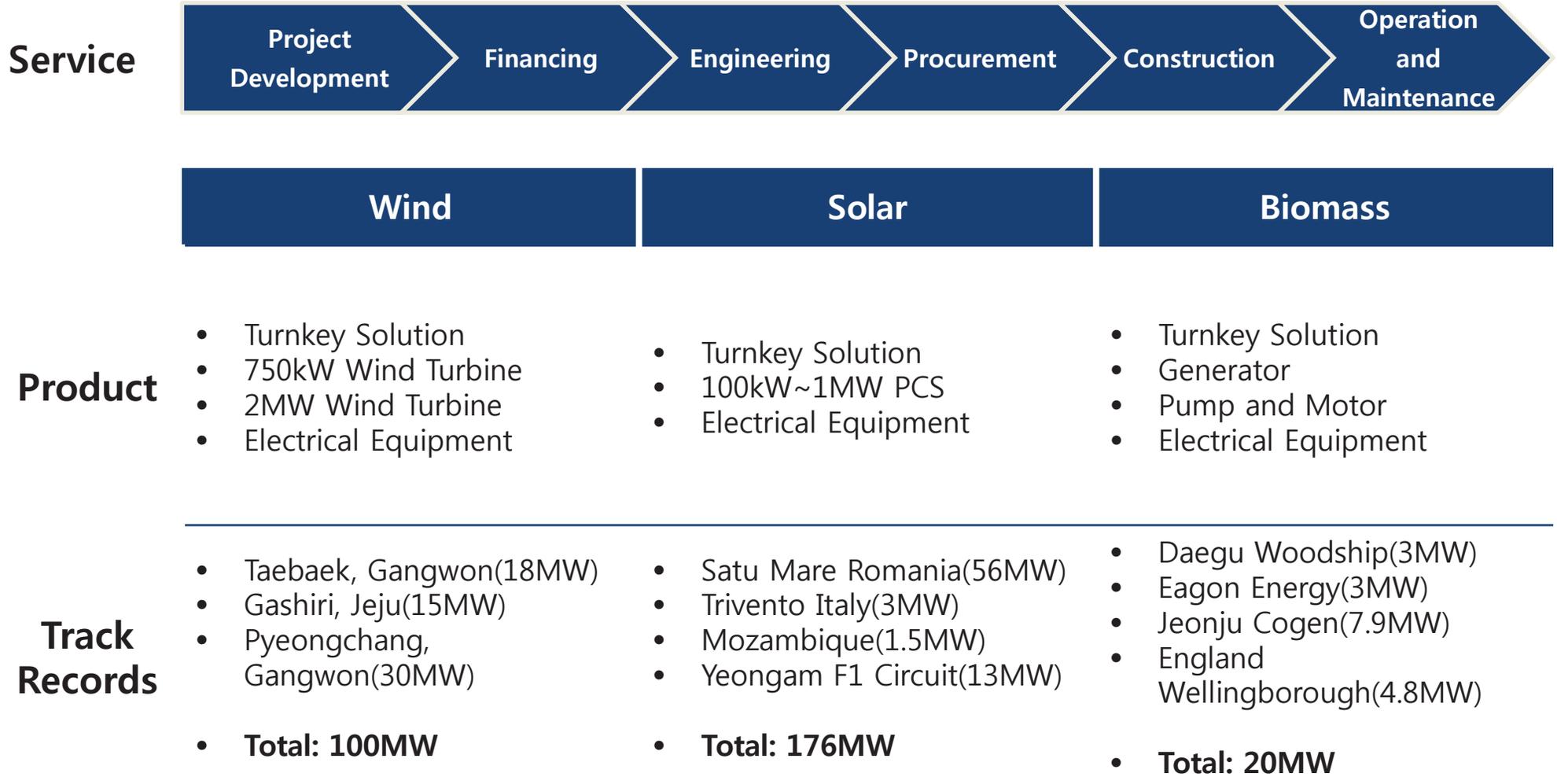
- Large Size Pump
- General Purpose Pump
- Petrochemistry Pump
- Desalination Project

Green Energy Biz Division



- Wind Turbine System
- Solar Power System
- Fuel Cell

Hyosung has turnkey based renewable energy solutions, in addition to related key components.



Hyosung offers a comprehensive spectrum of smart grid solutions to global clients.

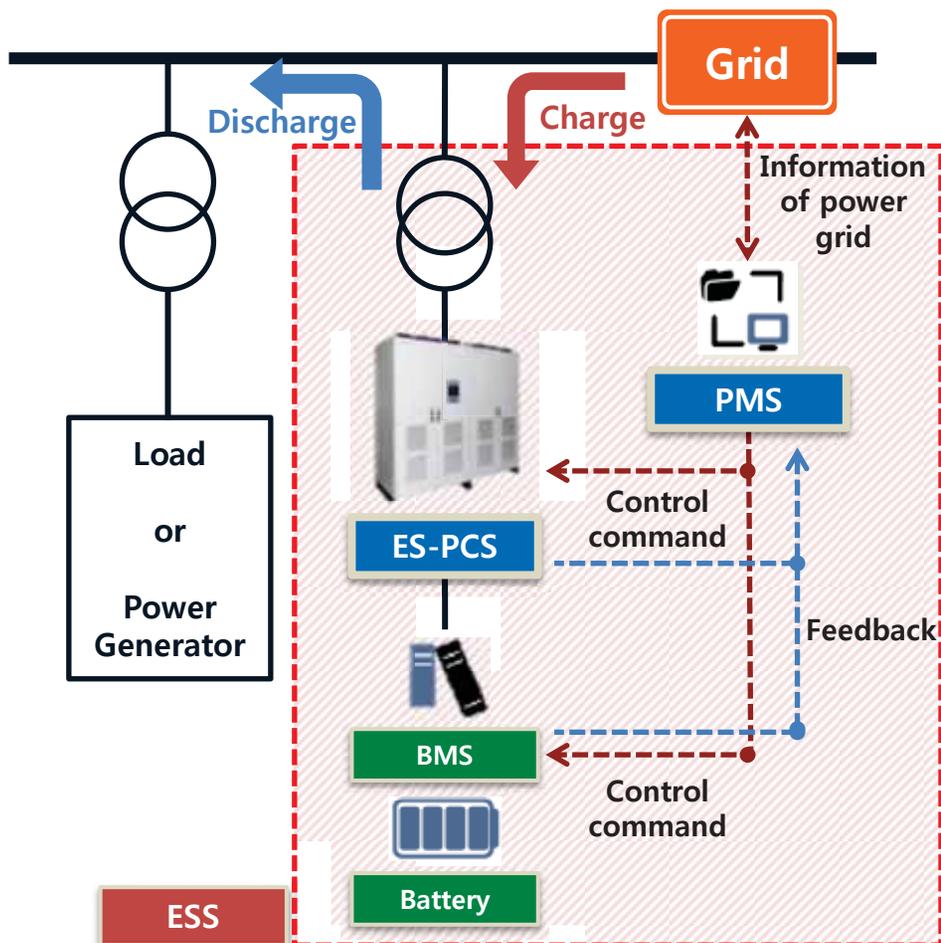
Smart Grid Solutions

	Stabilization	Coupling	Energy Mgmt	Automation	Asset Mgmt
Product	<ul style="list-style-type: none"> STATCOM SVC ESS 	<ul style="list-style-type: none"> HVDC Special Transformer 	<ul style="list-style-type: none"> ESS Micro Grid EMS 	<ul style="list-style-type: none"> Substation Automation ECMS 	<ul style="list-style-type: none"> Conditioning Monitoring Retrofit Refurbishment
Track Records	<ul style="list-style-type: none"> Migeum 100Mvar and 3 sites Total 300Mvar with STATCOM Honam Power plant 4MW ESS for frequency regulation and other 4 MW ESS 	<ul style="list-style-type: none"> Under Development 	<ul style="list-style-type: none"> Gapa island 1MW and Gasa island 1.25MW Microgrid ESS Giheun Samsung SDI 1MW and Duzon Bizon 0.5MW Energy Mgmt. ESS 	<ul style="list-style-type: none"> Boryung TPP ECMS (500MW * 4 Unit) Pochun CCPP ECMS (450 * 2 Unit) Supplied PJT : 45 Projects (include ongoing PJT) 	<ul style="list-style-type: none"> Saudi Arabia(SEC/NG) On-line PDM Shin-uljin Nuclear power plant On-line PDM Supplied PJT : 136 Projects (include ongoing PJT)

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.

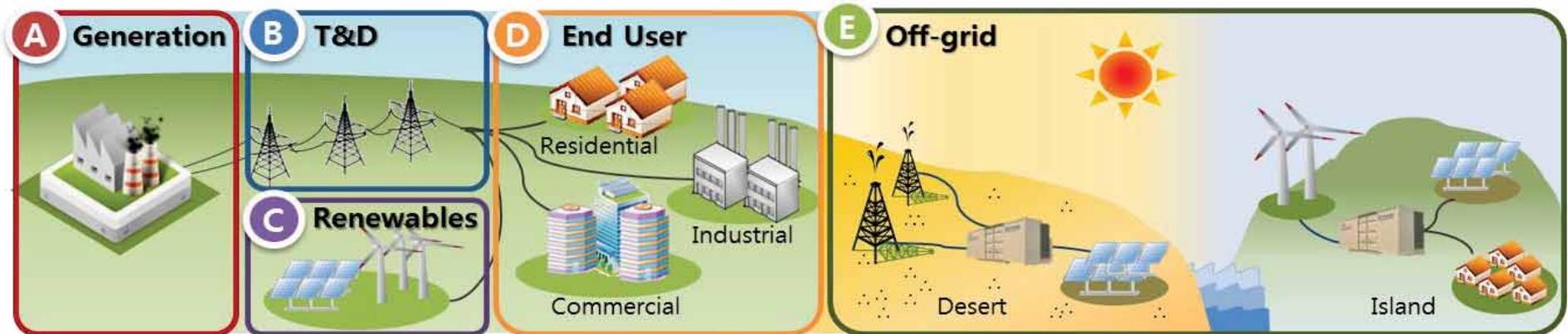
Concept



Summary

Principle	<ul style="list-style-type: none"> Storing electrical energy to Secondary batteries (Li-ion, Lead-acid, NaS, etc)
Composition Role	<ul style="list-style-type: none"> PMS: Control PCS, BMS PCS: Convert AC/DC, Power quality control BMS: Control and Monitoring batteries Battery: Store electrical energy
Life Expectancy	10 years
Efficiency	More than 85%
Benefits	<ul style="list-style-type: none"> 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

ESS is applicable to entire power system area starting 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

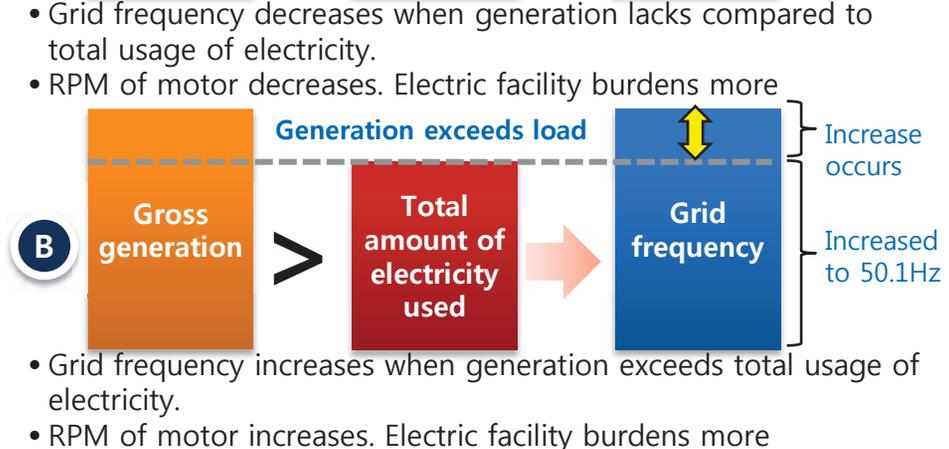
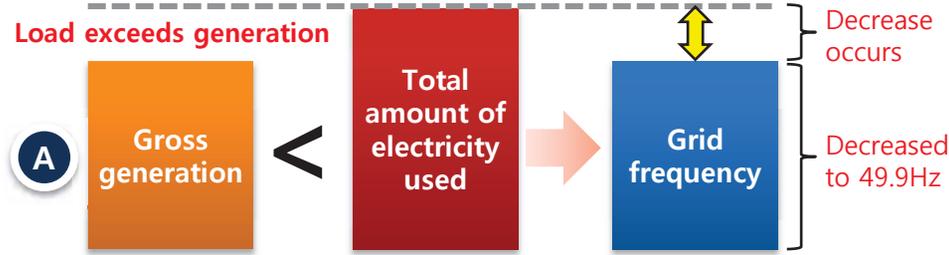
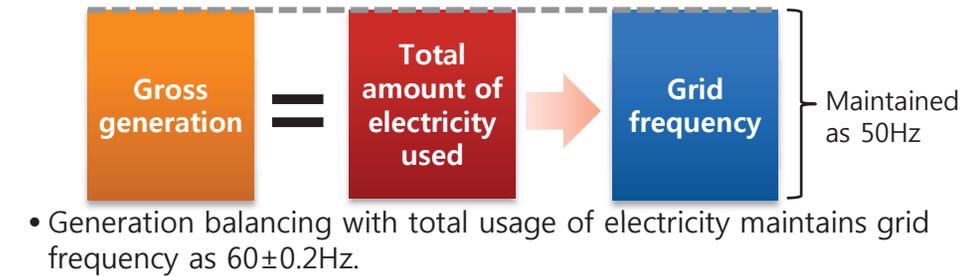
E Off-grid

▪ 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

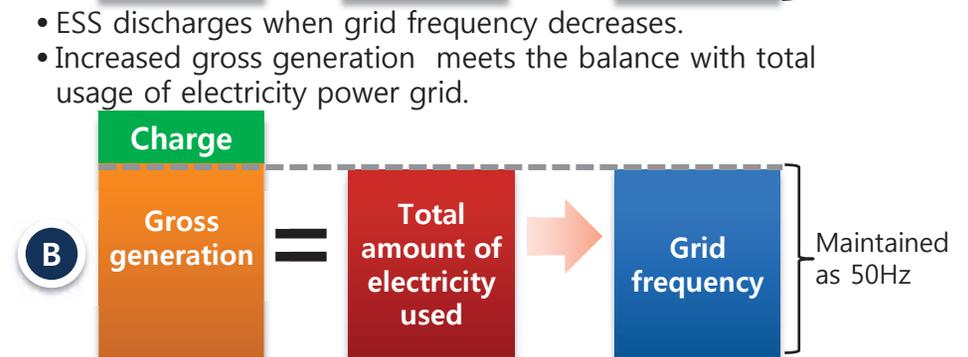
Grid frequency is determined by balance between gross generation and total amount of electricity used. Frequency regulation by ESS is more beneficial than conventional load following power plants.

Principle of change of frequency



Frequency regulation provided by ESS

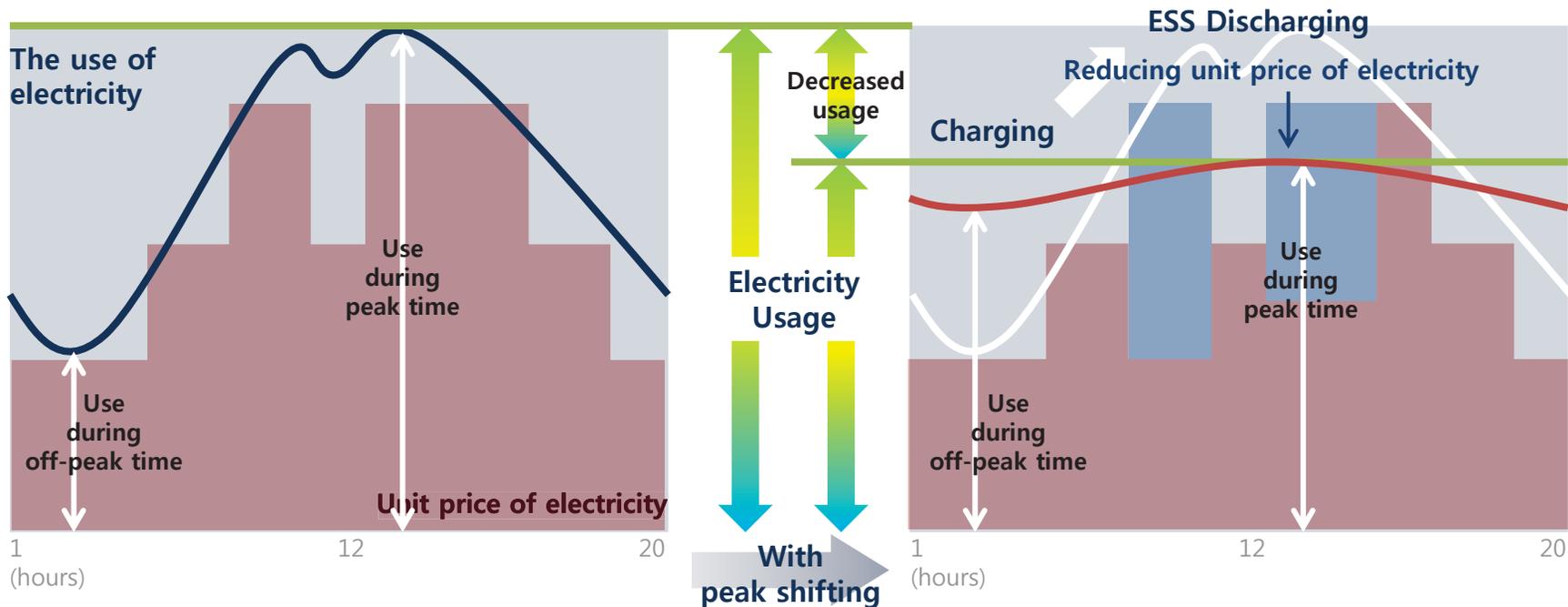
“ESS frequency regulation service enables replacing conventional generators”



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

As-is (without ESS)

To-be (with ESS)



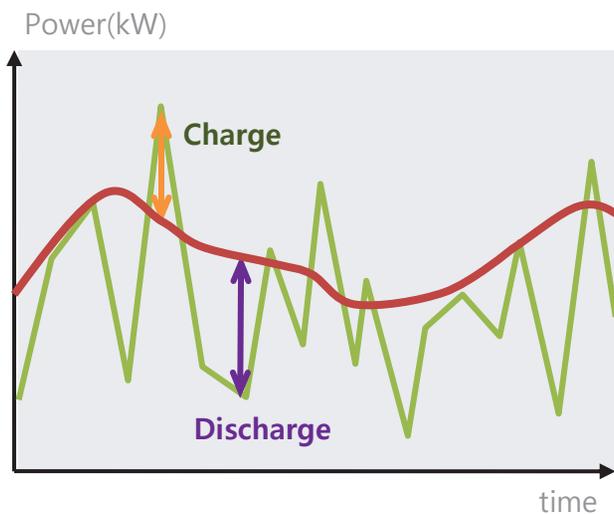
- Total generation capacity should be larger than sum of peak load and reserves.
- Massive investments to power plants for peak load are required in conventional ways.

- 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.

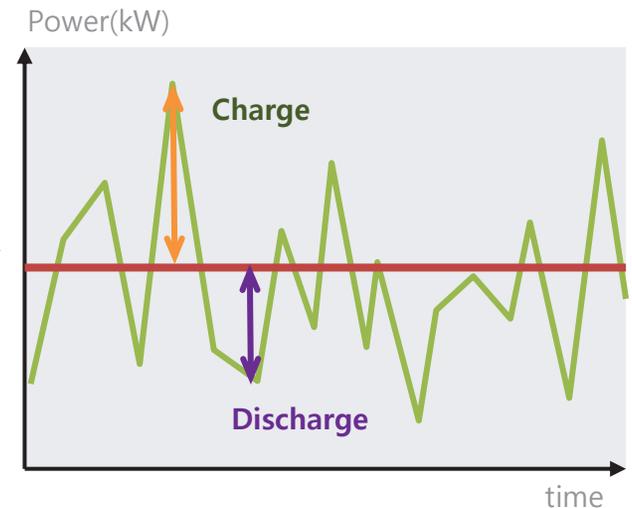
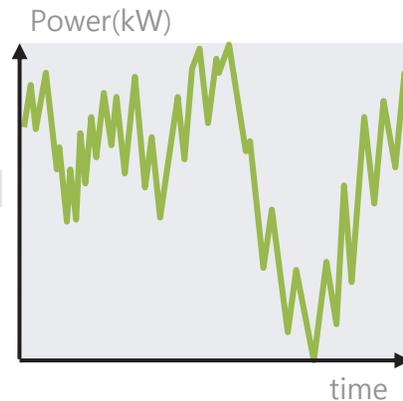
Intermittent power of renewable sources make power grid unstable. ESS is a solution for renewables integration by output smoothing and constant power control.

Output smoothing

Constant power control

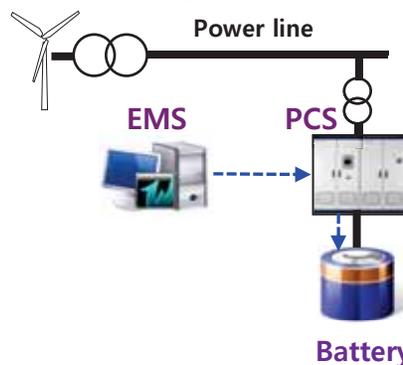


Output of renewables



- 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

Wind power



- 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

88GW of Power Plants are operating isolated. Semi conductors, Chemicals, Shipbuilding, Steel industries are strong. Korea has 494 islands occupied within 3,736 islands



* Map from DOE Global Energy Storage Database

<Key Statistics>

- Area: 100,210km²
- Population: 50 million

- # of Islands: 3,736
- Island occupied: 494

- Installed Capacity: 88GW
- Peak Demand: 76GW

- Nuclear: 20GW
- Coal: 25GW
- LNG: 27GW
- Renewable: 5.6GW
- PHES: 4.7GW

- Frequency: 60±0.2 Hz
- Voltage: 220V-380V-6.6kV-22.9kV-154kV-345kV-765kV

as of Apr 2014

Korean Government has a lot of interest for the ESS and enacted many ESS related policies.

Energy Storage System policies

ESS related policies in Korea	Policy name	Government department	Announcement Time	Main Content
	『Creative Korea Flagship Project』	 MSIP (Ministry of Science, ICT & Future Planning)	May 2014	<ul style="list-style-type: none"> ▪ Korean Government will support demonstration of 3 types(FR/RI/DR) of ESS Business.
	『2nd Energy Master Plan』	 MOTIE (Ministry Of Trade, Industry & Energy)	January 2014	<ul style="list-style-type: none"> ▪ Korean Government starts to focus on changing their energy policies from supply-side to demand-side management. ▪ For this reason, Korean ESS market will be expanded.
	『The sixth Electricity Supply Plan (2013~2027)』	 MOTIE (Ministry Of Trade, Industry & Energy)	February 2013	<ul style="list-style-type: none"> ▪ Target accumulated capacity of ESS is 500MW in 2015 ▪ Target accumulated capacity of ESS is 2,000MW in 2020
	『K-ESS 2020』	 MOTIE (Ministry Of Trade, Industry & Energy)	May 2011	<ul style="list-style-type: none"> ▪ Korean Government set the goal to occupy 30% of the world market and makes on effort to achieve Global Top3 ESS leading country by 2020 ▪ Supply 1,700MW ESS by 2020

Demonstration, R&D programs, smart grid promotion programs are major business opportunities in Korea. Nowadays KEPCO and large power users lead the ESS market.

R&D

Demonstration and Promotion

Projects	Period	Contents
Jeju smart grid Demonstration	'09~'11	Smart Renewable, Smart Place, Smart Transportation with ESS, AMI, EVCI, etc
Daegu PV connected ESS for 100 household	'10~'14	PV connected ESS for Household
Chochun S/S Renewable Integration(4MW)	'11~'14	Substation level renewable integrated ESS
Industrial Energy Management ESS(1MW)	'13~'16	Factory energy management with ESS
Frequency Regulation with ESS(8MW)	'13~'16	Develop frequency regulation market

Projects	Period	Organization	Contents
Smart grid Promotion	'12~	KSGI	ESS, AMI, EMS 75% subsidy for end user 2012 ₩3B > 2013 ₩20B > 2014 ₩17B
Hybrid Renewable Energy	'13~	KEMCO	50% from KEMCO, Renewable Energy with ESS for island
KEPCO FR	'14~	KEPCO	500MW, ~2017
Large Power User Energy Management	'13~	Samsung SDI LG Chemical	Kiheung/Ulsan Plant Ochang/Iksan Plant
Jeju Wind Power	'14~	SK, Hanwha, GS, etc	Jeju province are reviewing wind power regulation 10%/min variation
Smart grid City Projects	'15~'17	KSGI	8 Consortiums are being evaluated for EVCI, AMI, ESS, EMS

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

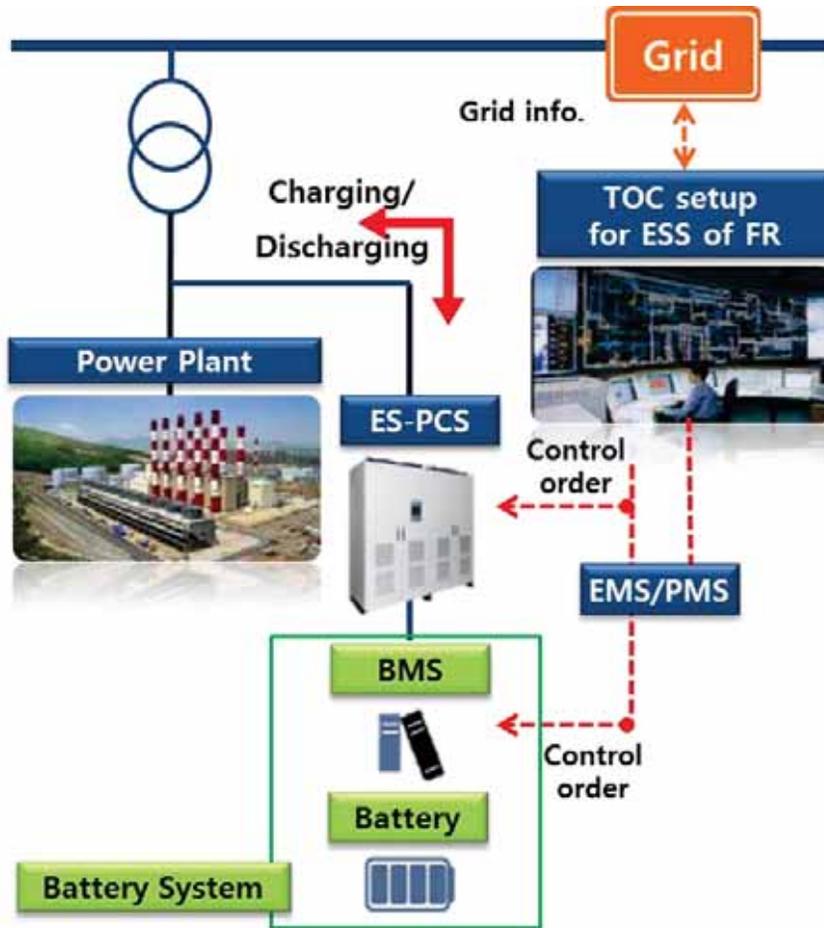
Jocheon Substation (4MW/8MWh)



- Period: 2011.07~2014.06
- End-customer: KEPCO
- Description: ESS is linked with substation for
 - ✓ Renewables output smoothing
 - ✓ Active & Reactive power Controlling
 - ✓ Black start
- Integrator: HYOSUNG
- Rated power: 4MW (4 units of 1MW PCS, HYOSUNG)
- Energy: 8MWh (Li-ion Battery, Samsung SDI)

ESS for Frequency Regulation

Hyosung participated in a study project determining how to adapt ESS for frequency regulation with KPX to reform market regulation and operational schemes.



Project	Frequency Regulation ESS (4MW/2MWh)
End-User	KPX
Rated Power	4MW (4 units of 1MW PCS, HYOSUNG)
Energy	2MWh (Li-ion Battery, SK Innovation)
Description	N/A
Construction	2013. 06 ~ 2016. 06

Hyosung supported multiple ESS projects for electricity users to reduce electricity charge.

Guri Agricultural Market (250kW/500kWh)



- Period: 2012.08~2012.12
- End-customer: KT, Korea Smart Grid Institute
- Description: ESS is installed for separate outdoor building and linked with KEPCO's 22.9kV Power grid
- Effect: Reduce power electricity demand charge (max \$23 mil/year) and power electricity rate charge (max \$12 mil/year) by peak reduction.
- Integrator: HYOSUNG
- Rated power: 250kW (HYOSUNG)
- Energy: 500kWh (Li-ion Battery, LG Chemical)

Hyosung supported multiple ESS projects for electricity users to reduce electricity charge.

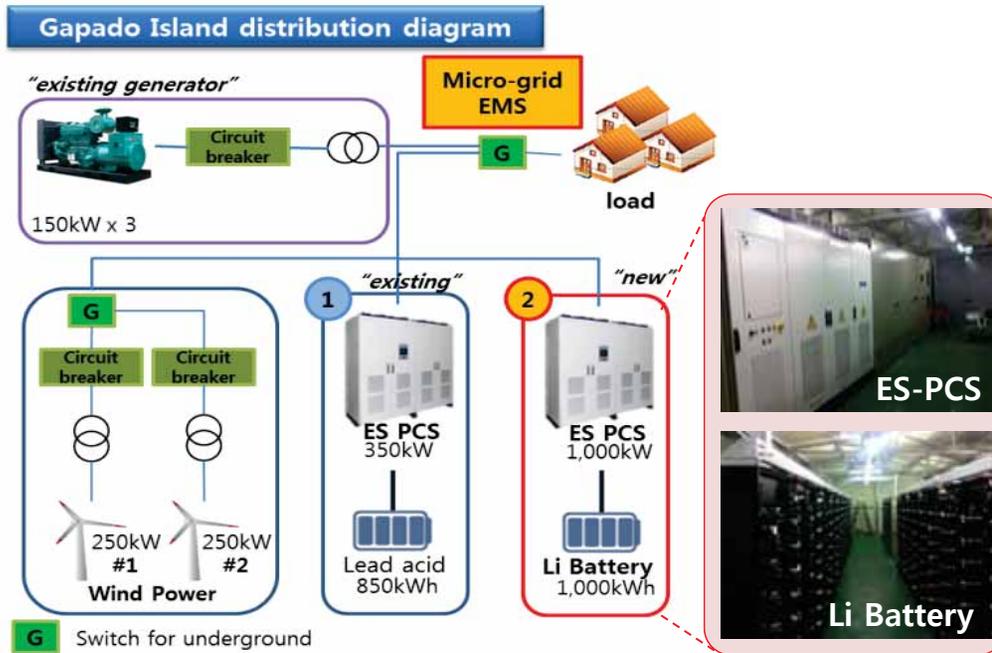
Duzon Bizon (500kW/1,600kWh)



- Period: 2013.08~2013.12
- End-customer: Duzon Bizon, Korea Smart Grid Institute
- Description: ESS is installed inside the building to reduce power electricity demand charge and power electricity rate charge by peak reduction.
- Integrator: HYOSUNG
- Rated power: 500kW(2 units of 250kW PCS, HYOSUNG)
- Energy: 1,600kWh(Li-ion Battery, Samsung SDI)

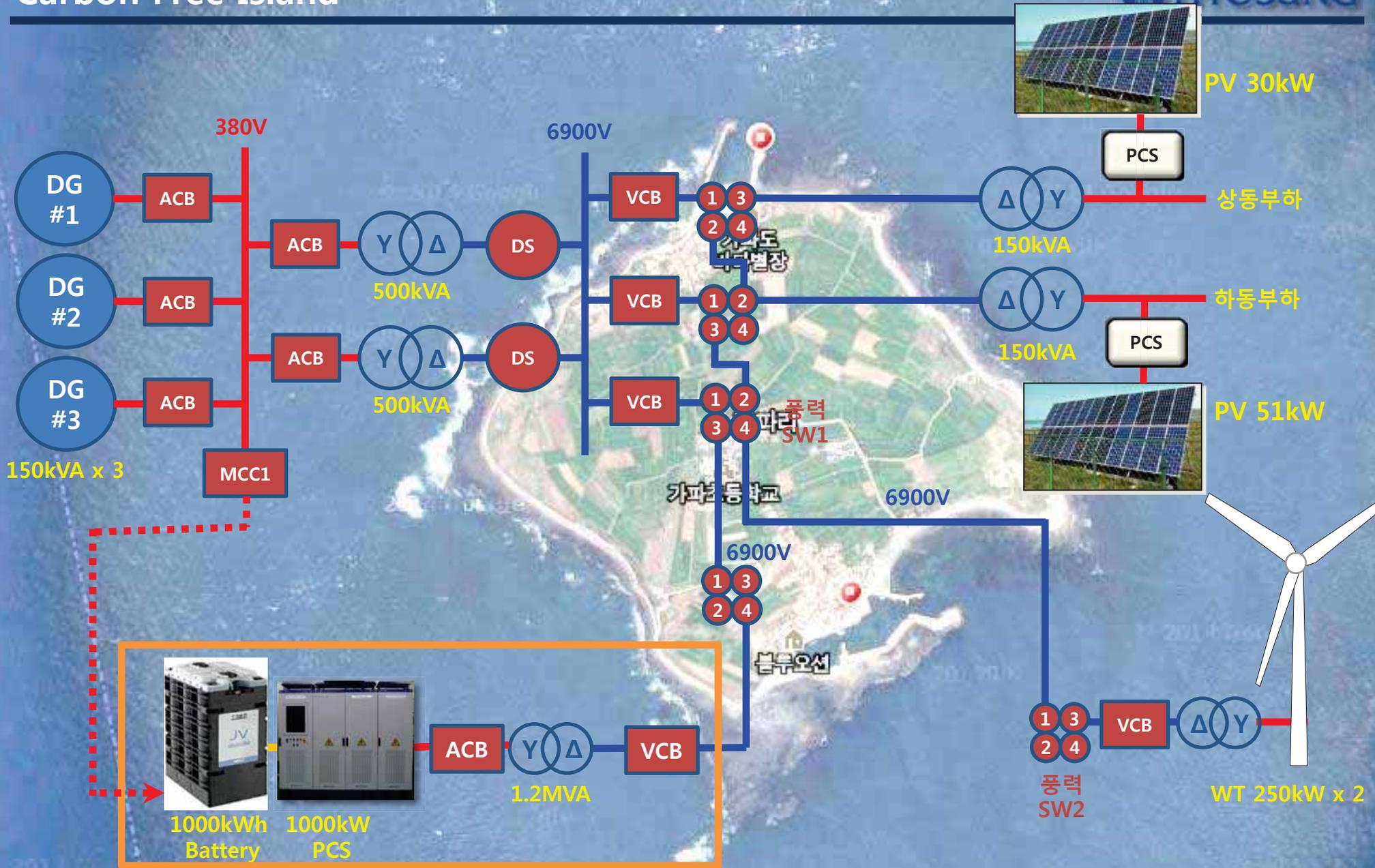
Hyosung constructed Carbon Free Island in Gapado island, Korea

Gapado Renewable & Off-grid Integration (1MW/1MWh)



- Period: 2013.08~2014.01
- End-customer: Government of Jeju Island
- Description: Electricity supply using wind power and ESS to over 200 residents in Gapado island
- Integrator: HYOSUNG
- Rated power: 1MW (HYOSUNG)
- Energy: 1MWh (Li-ion Battery, Samsung SDI)

Carbon Free Island



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

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

the Republic of Korea



Jindo-gun



- Period: 2014.03~2014.09
- End-customer: KEPRI
- Description: Carbon free island using Renewables and ESS for off-grid integration
- Integrator: HYOSUNG
- Rated power: 1,250kW (1 unit of 250kW and 2 units of 500kW, HYOSUNG)
- Energy: 3MWh (Li-ion Battery, Kokam)



Hyosung constructed the Off-Grid system based on PV generator in Mozambique



Project	Mozambique Off-grid PV generator ESS (900kW/20MWh)
End-User	FUNAE
Rated Power	900kW (single phase 5kW x 180, SMA)
Energy	20MWh (2V, 2,000Ah x 5,105, SEBANG Battery)
Description	<p>Electricity supply using PV generator and ESS in Mozambique under contemplation of grid-connected photovoltaic system</p> <ul style="list-style-type: none"> - Mavago(550kW) - Mecula(400kW) - Muembe(350kW)
Construction	2013. 01 ~ 2013. 12

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

Hong Kong CLP (CLP, 500kW/350kWh)



- Period: 2013.09~2014.08
- End-customer: CLP
- Description: ESS is linked with substation for
 - ✓ Load leveling
 - ✓ Peak shifting
 - ✓ PV power generation quality improving
- Integrator: HYOSUNG
- Rated power: 500kW (2 units of 250kW PCS, HYOSUNG)
- Energy: 350kWh (Li-ion Battery, Samsung SDI)



Hyosung has excellent performance records in Korean wind farm business, with total Installed capacity of 100MW

Haengwon Wind Farm



- Jeju Island, Korea
- 1.2MW
- Commissioned in 1997

Daegwanryung Wind Farm



- Gangwon, Korea
- 2.64MW
- Commissioned in 2004

Maebong Wind Farm



- Gangwon, Korea
- 6.8MW
- Commissioned in 2006

Gashiri Wind Farm



- Jeju Island, Korea
- 15MW
- Commissioned in 2011

Taebaek Maebong Wind Farm



- Gangwon, Korea
- 2MW
- Commissioned in 2012

Taebaek Wind Farm



- Gangwon, Korea
- 18MW
- Commissioned in 2012

Pyeongchang Wind Farm



- Gangwon, Korea
- 30MW
- Commissioning in 2015

Daegiri Wind Farm



- Gangwon, Korea
- 26MW
- Commissioning in 2016

Hyosung has been providing total solutions for solar power plants, serving customers across the Globe (Total Installed capacity 176MW).

Italy



- Trivento
- 3.0MW
- Commissioned in 2012

Romania



- Satu Mare and 5 Sites
- 115MW
- Commissioned in 2013

Mozambique



- Muembe and 2 Sites
- 1.35MW
- Commissioned in 2014

Korea



- Yeongam F1 and many
- 56MW

Hyosung provides Bio Mass power plant solutions. Currently, a 4.8MW Biomass Power Plant is under construction in Wellingborough, England.

Daegu Woodchip Renewable Energy



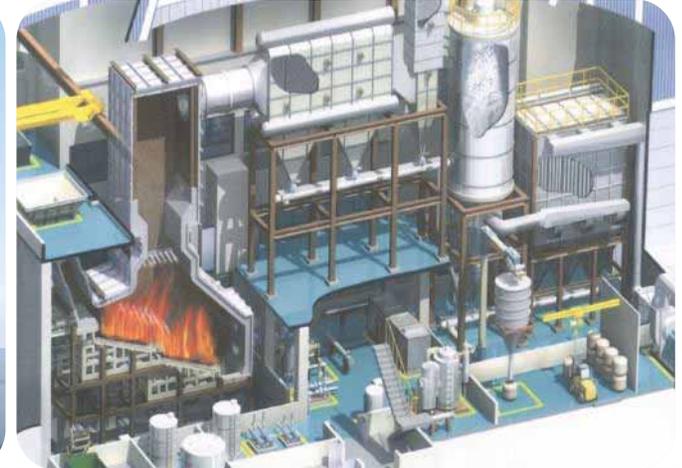
- Fuel : Woodchip
- Capacity : 150 ton/day
- Energy Capacity :
 Steam 27 ton/hr
 Electricity 3 MW
- Technology : Traveling Stoker
- Construction Period :
 2009 ~ 2010

Eagon Energy Bio-SRF Cogeneration



- Fuel : Woodchip
- Capacity : 345 ton/day
- Energy Capacity :
 Steam 62 ton/hr
 Electricity 3 MW
- Technology : Traveling Stoker
- Construction Period :
 2014 ~ 2015

Jeonju Cogeneration



- Fuel : SRF(Solid Refuse Fuel)
- Capacity : 350 ton/day
- Energy Capacity :
 Steam 21 ton/hr
 Electricity 7.9 MW
- Technology :
 Step Grating Stoker
- Construction Period : 2015 ~