DER Integrated Operation Solution for Virtual Power Plant

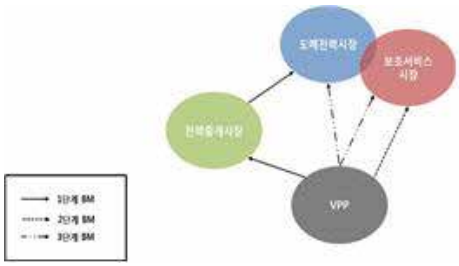
Green, flexible and smart distributed energy system

01. Summary

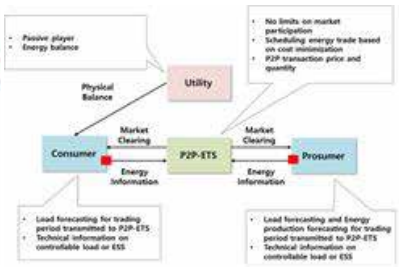
Distributed EMS design, its core solution development and related business model proposal as the core of VPP implementation that can utilized various types of DERs in connection with electricity market and power system operation

02. Character

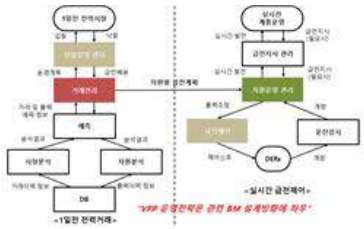
- ▶ Proposal of various VPP business models that can be implemented
- ▶ VPP architecture and key functions design for implementing a market-based VPP control strategy
- ▶ Development of optimal resource scheduling program for strategic electricity market participation of VPP



▲ Proposal of VPP business models for wholesale electricity market



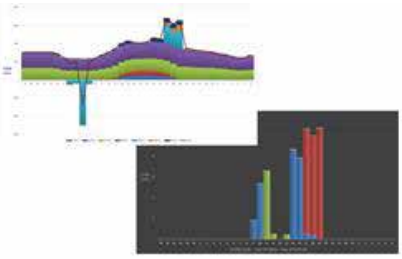
▲ Proposal of VPP-based P2P energy trading model



▲ Market-based VPP control strategy and required functions

▲ Proposed VPP architecture

▲ Procedure for developing VPP bidding strategy



▲ Example of VPP optimal resource scheduling

03. Expected Effect

- ▶ Procure VPP development strategy and fundamental technologies for VPP commercialization
- ▶ Enhance VPP availability for the power system volatility management
- ▶ Promote sustainable DER deployment by establishing VPP operating system
- ▶ Establish the foundation for promoting energy new business focused on energy prosumers

04. Applied Field

- ▶ Provide business opportunities in small-scale energy brokerage/wholesale electricity market
- ▶ Provide generic technologies for developing and commercializing VPP solution

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AC-DC Hybrid Microgrid Pilot Plant

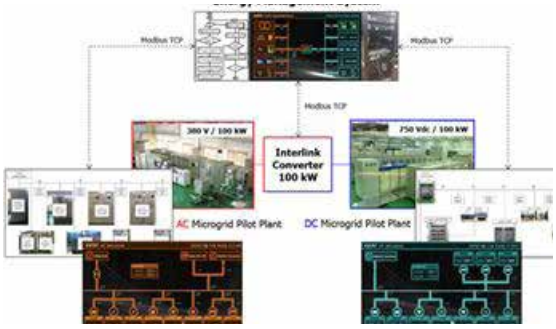
D3+DC grid technology for next power system

01. Summary

- Power system technology for sustainable operation of essential facilities due to the increase of natural disasters and power system fault
- Next power industry technology for increasing stability and efficiency of various renewable sources following the RE3020 national energy policy and the Fourth Industrial Revolution

02. Character

- Implementation of key characteristics of AC, DC, and multi-microgrid
- Verification of performance of low voltage power system key component
- Test of microgrid operation algorithm using real and simulated renewable sources and load
- Controllable load simulators with various load characteristics and a real building load
- System transient testing using a fault simulator



▲ AC-DC Hybrid Microgrid Pilot Plant

▲ Energy Management System Platform

03. Expected Effect

- Improved grid acceptance of renewable sources according to RE3020 national energy policy
- Improving efficiency and expanding of DC type DERs, such as electric vehicles, renewable sources, and BESS
- Verification of new energy platform technology for spreading the Fourth Industrial Revolution
- An effective emergency power system development for disaster and relief facilities, such as emergency shelter

04. Applied Field

- Technical Verification of design, control, and operation of AC, DC, and multi-microgrids
- Development and verification of microgrid and DER system.
- Performance test and commissioning of AC, DC, and multi microgrids
- Emergency power system for disasters such as emergency shelter and relief facilities

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Smart DER Coordinated Management Technology Based on IEC 61850 Standards

Smart distributed power management technology for efficient power management

01. Summary

KERI developed a novel way of efficient management technology for the large number of the renewable DERs that are installed in the distribution power system. And new technology has verified for its capability and applicability through the computer based simulations and laboratory scaled experimental tests as well
Developed Smart DERs Coordinated Management System is consist of IEC 61850 based information exchange system, Smart Inverters, and the Coordinated Management System

02. Character

- The IEC 61850-based integrated management system function design enables efficient management of power supply and demand
- Advanced grid-support functions such as Volt/Var, Frequency/Watt, and FRT (Fault-ride through) were implemented
- Optimization algorithm for Smart DERs was developed according to the various system situation scenario

▲ Smart Distributed Power Integrated Management System Configuration

▲ Smart Distributed Power and Integrated Management System Test Environments

03. Expected Effect

- Enable smart grid industry with distributed power integration and connectivity technologies such as energy storage systems and wind power generation systems
- Smart grid interface technology for energy service providers such as VPP and aggregators enables smart grid industry
- Securing technology for securing interoperability and strengthening competitiveness of distributed power supplies by pioneering domestic and foreign markets
- Contribution to establishment of smart grid national standard for distributed power supply and industry expansion of element technology
- Securing technologies related to linking and operating upper systems such as DMS of integrated power management technology and spreading smart grid related technologies

04. Applied Field

- Smart DER (Photovoltaic, Wind Turbine, Energy Storage System)
- DERMS (Distributed Energy Resources Management System), SCADA (Supervisory Control And Data Acquisition)
- DMS (Distribution Management System

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Reliability Test Technology for Large-scale Lithium-ion Battery Management System

BMS evaluation technology for safe use of Lithium-ion battery

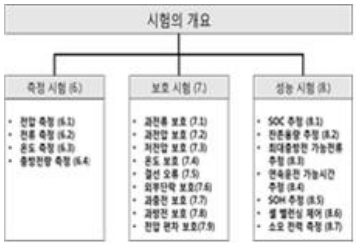
01. Summary

There is a need to verify the safety of a large-scale lithium-ion battery system because the demand for the system is increasing This technology is to evaluate the function and performance of the BMS in charge of the reliability and safety of the battery system

02. Character

- ▶ Ability to evaluate BMS functionality and performance through repetitive normal / abnormal signaling
- ▶ High precision through the use of equivalent circuit-based Li-ion battery model and its table parameters
- ▶ Development of BMS Evaluation Platform based on Hardware-In-the-Loop Simulation
- ▶ Development and domestic standard proposal of BMS performance evaluation procedure (measurement / protection / performance tests) for large-scale lithium-ion battery system

▲ BBMS evaluation platform



▲ BMS performance evaluation procedure

▲ Results of BMS evaluation software and performance test

03. Expected Effect

- ▶ Securing the foundation for the development of the mass battery system market and related infrastructure industries limited by safety, system operation, etc.
- ▶ Growth of related fields by enhancing reliability of electric propulsion systems such as EVs and electric ships
- ▶ Complement the domestic energy storage system test regulations through BMS performance evaluation and establishment of standards, and enhance the relevant technology level by applying the test evaluation technology

04. Applied Field

- ▶ Products that use BMS-equipped battery systems, such as EVs, electric ships, and ESS
- ▶ BMS and BMS evaluation system
- ▶ BMS Technology Related Companies

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Voltage-Sourced MMC Submodule Test System

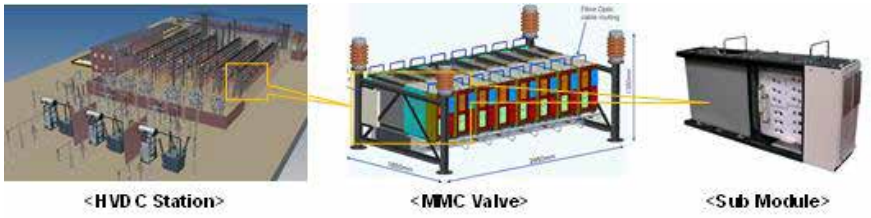
Submodule evaluation system for DC grid with reliability and stability

01. Summary

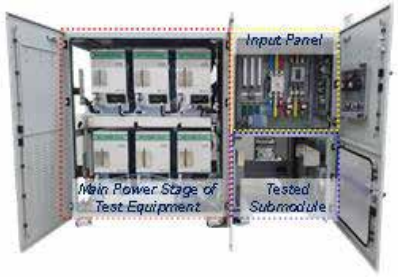
This technology is a system that can evaluate a submodule of a voltage-sourced (VSC) MMC. The evaluation system can test a single submodule of VSC MMC and its components upto 3kV / 1000A, by employing similar voltage and current with an actual operation of MMC in HVDC system. In particular, this system has advantage to improve the reliability of the submodule and to apply the accelerated lifetime test of the capacitor

02. Character

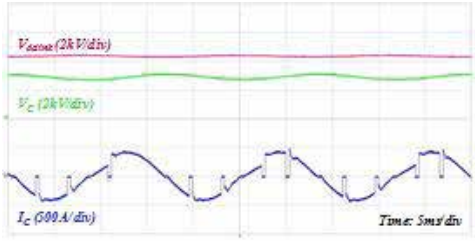
- ▶ Securing design and manufacturing technology for systems that can test and evaluate a single submodule
- ▶ Testing and Evaluating a single submodule regardless of its structure, which are half-bridge type and full-bridge type
- ▶ Securing high efficiency structure for supplying less than 100kW of system losses to evaluate single-capacity 3MW submodule
- ▶ Minimize size by applying small reactor with powder core
- ▶ Possible to apply complex control current generated in actual MMC operation such as 2nd harmonics, DC offset, AC pulse, etc



▲ Configuration of VSC HVDC system



▲ Implemented evaluation system



▲ Waveforms of system operation

03. Expected Effect

- ▶ Securing objective test results by providing test conditions similar with actual operation
- ▶ Diversification of MMC applications and technologies by providing testing for both half-bridge and full-bridge submodule
- ▶ Creating new business area based on large-capacity MMC and securing localizing manufacturing technology

04. Applied Field

- ▶ Offshore wind farm conneted VSC HVDC system.
- ▶ Korea-China-Russia-Japan Northeast power grid connected HVDC system.
- ▶ Future DC grid system connected with renewable energy such as HVDC & MVDC
- ▶ Reactive power compensation system using STATCOM
- ▶ Other large capacity grid connection system using MMC structure

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Design Engineering for MMC-HVDC Transmission System

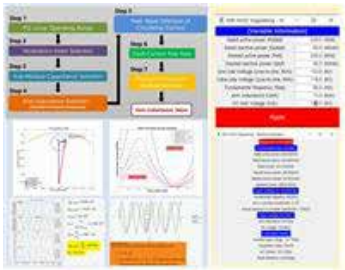
Reliable engineering services of MMC-HVDC system

01. Summary

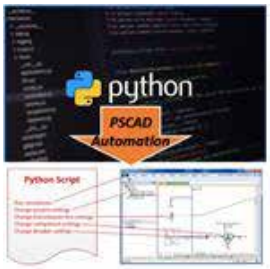
For the MMC, the engineering services offers reliable system design, automated power system analysis with python-PSCAD/EMTDC interface, efficient reduced EMT modeling including large power system and power electronic based generation system to evaluate variable of interconnection impacts

02. Character

- ▶ MMC-HVDC transmission system design
- ▶ Efficient reduced EMT modeling of large power system with power electronic interfaced converters
- ▶ Analysis of the electrical interconnection problems and validation of MMC-HVDC system parameters design with automated EMT simulation
- ▶ Real time digital simulation based design demonstration platform



▲ Design methodology



▲ EMT automation

▲ Real-Time Digital Simulation demonstration platform

03. Expected Effect

- ▶ Development of cost-effective and reliable power electronic based large electric system engineering solution
- ▶ Contribution of establishing world top technology in future energy system
- ▶ Applying in 200MW MMC-HVDC transmission system in Korea electric system
- ▶ Development of Grid-tied converter test system

04. Applied Field

- ▶ Renewable energy interfaced PCS system
- ▶ Grid-tied power electronic based conversion system
- ▶ Frequency regulation BESS(Battery Energy Storage System) converter system
- ▶ Modular multilevel converter based multi-terminal HVDC transmission system

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Power Electronic Based T&D System Design and Control Development with Medium Voltage DC technology

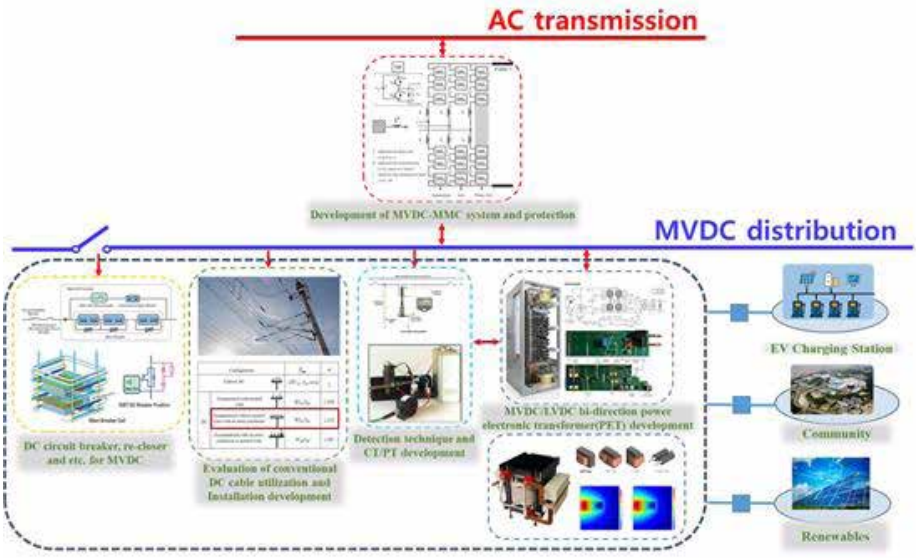
More smargrid and higher hosting capacity with MVDC

01. Summary

Medium voltage DC based transmission and distribution system could increase hosting capacity and system resiliency. For providing secure electric power to customer, DC/DC converter for MVDC to LVDC should be developed, which has 10 to 70kV for Medum voltage class to 1500V for LVDC side with high efficiency and performance

02. Character

- ▶ Development and fabrication of modular multilevel converter system and protection coordinated control platform
- ▶ MMC based hybrid topology with DC fault current limiting capability DC
- ▶ MVDC/LVDC bi-directional power conversion system, and design/fabrication of magnetic transformer for high capacity power electronic transformer(PET)
- ▶ Real-time digital simulation based distribution system demonstration with MVDC



▲ Development of main components for multi-terminal MVDC distribution

03. Expected Effect

- ▶ Challenge and exploration for electrical business world expansion with multi-terminal medium-voltage DC distribution system
- ▶ development of voltage and current detection with direct current system and of Improvement KOREA global competitiveness in electric power system
- ▶ Smartgrid realization and hosting capacity enhancement with smart inverter for 20% renewable energy by 2030
- ▶ development of MVDC main components test system and standard

04. Applied Field

- ▶ Renewable energy interfaced PCS system
- ▶ Grid-tied power electronic based conversion system
- ▶ Frequency regulation BESS(Battery Energy Storage System) converter system
- ▶ Modular multilevel converter based multi-terminal HVDC transmission system

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Smart PCS Technology in Grid-connected Application

Smart PCS for low carbon self-supporting microgrid

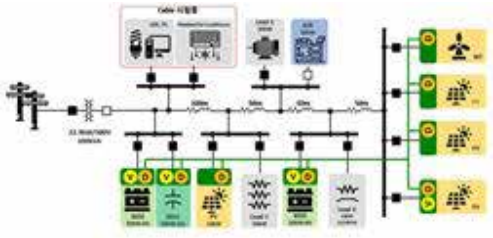
01. Summary

This technology is development of design, control and operating technique to have reliability and economics of a grid connected power conditioning system (PCS) in a self-supporting micro-grid based on renewable energy and energy storage system (ESS). This contributes to increasing the demand of renewable energy and reliability of grid for a low-carbon self-supporting micro-grid

02. Character

- ▶ It is possible to increasing demand of distributed generation based on renewable energy and ESS by improving reliability and stability of grid using PCS
- ▶ In micro-grid, by decreasing use of diesel generator, alleviating greenhouse effect, increasing energy efficiency and decreasing cost for operating will be provided
- ▶ By stand-alone operation of PCS, stable operating under failure on diesel generator or line
- ▶ Developing high reliability and high band-width communication system for increasing capacity, reliability and economics
- ▶ Output passive filter design technique for high power grid-connected PCS
- ▶ Developing evaluation unit for reactor for output filter for high power grid-connected PCS

▲ Smart PCS concept



▲ Micro-grid based on distributed generation

03. Expected Effect

- ▶ New markets for not only domestic ESS but also overseas with poor power system will be opened by the proposed smart PCS. (for 7,000 islands in Southeast Asia)
- ▶ Contribute to market activation by securing competitiveness of domestic PCS-related companies
- ▶ It can contribute to social problem solving such as momentary power failure due to the failure of aging dieselgenerators, low power quality, smoke pollution, noise and maintenance costs by operation
- ▶ Critical technical indicators for PCS optimal capacity design, stability design and system operation
- ▶ Contributes to the dynamic stability enhance of micro-grid through various distributed generation and ESS based PCS operation in case of power failure caused by disaster
- ▶ Contribute to the government's renewable energy policy by increasing the demand of distributed generation based on renewable energy and ESS

04. Applied Field

- ▶ A self-supporting micro-grid based
- ▶ PCS for ESS for grid power stabilizer
- ▶ Parallel operating PCS for high power system
- ▶ Grid-connected PCS for various renewable energy
- ▶ Grid-connected hybrid UPS

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Control Platform Technique for Power Electronics Systems

Control your data quickly and accurately !

01. Summary

The power conversion system must be able to convert AC to DC or DC to AC to transmit low-capacity or large-capacity power. According to its voltage level, it is divided into three stages (Low-Voltage, Middle-Voltage, and High-Voltage), and the controllers are designed for each stage based on efficiency and reliability considering cost and control specifications

02. Character

- Controllers have communication speed considering the control period from minimum 10Mbps to maximum 5Gbps
- Network standardization using industrial communication protocol
- High-capacity converter with fast control cycle performs high-speed parallel operation processing with logic
- Various applications can be implemented through the interface between DSP and FPGA

▲ DSP-FPGA Structure

▲ DSP-Ethernet Structure

▲ SOC-FPAG Structure

▲ Control Platform Technology and HILS Application

03. Expected Effect

- It is possible to design a high-reliability controller considering economical efficiency
- Hardware-in-the-loop (HILS) verification is possible through linkage with Real-Time Digital Simulator
- Floating point operation using DSP and high-speed parallel operation using FPGA can maximize performance of communication system and control algorithm
- Demand for modular medium and large capacity power converters for solar and wind power generation of several tens of GW is expected to increase according to 3020 renewable energy development plan

04. Applied Field

- STACOM
- PCS for ESS
- Power Electronic Transformer
- Power Converter for LVDC-to-MVDC and MVDC-to-HVDC
- MMC HVDC
- Multi-Terminal DC Transmission

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Modeling and Design Program of Distributed Energy Resources

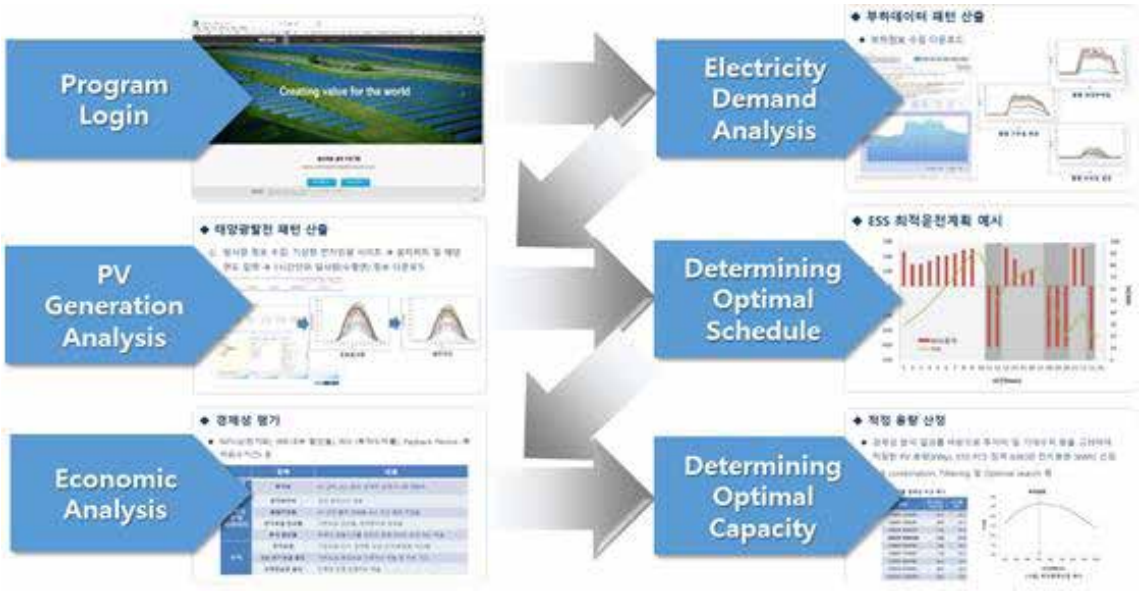
Determining optimal capacity of distributed energy resources considering various business models

01. Summary

MODDER(Modeling and Desing of Distributed Energy Resources) is a program that supports optimal capacity determination and economic analysis for the new designs of distributed energy resources, taking into account various business models

02. Character

- ▶ Development of distributed energy resource design program considering various business models
- ▶ Improving the convergence stability and the global optimum accuracy for several scheduling algorithms used in the MODDER program
- ▶ Helping investors make more efficient decisions by providing various economic analysis results, such as NPV(Net Present Value), payback period



▲ Procedure for using MODDER program

03. Expected Effect

- ▶ Recognizing the necessity of renewable energy resources
- ▶ Reducing the risk of investing in distributed energy resources
- ▶ Contribution to expanding the market for distributed energy resources

04. Applied Field

- ▶ Used in case studies to reduce the risk of investing in distributed energy resources
- ▶ Preventing the inefficient investments of distributed energy resource investors
- ▶ Used as an objective economic analysis data of distributed energy resources for related product or service companies

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Eco-Friendly Electric Vehicle Charging Station Operation System

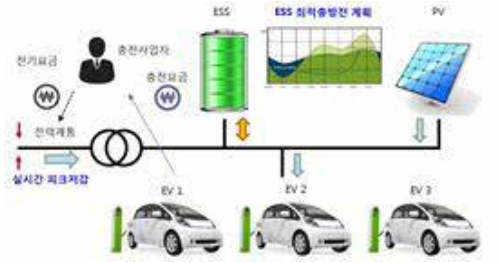
Put nature in a car

01. Summary

- Operation system of the electric vehicle charging station that charges with eco-friendly energy by using renewable energy sources and energy storage devices
- Automatic charging station operation according to the output of renewable energy sources and the charge of electric vehicles
- techniques for improving profits of charging station operators

02. Character

- Charging electric vehicles by storing or directly supplying renewable energy
- Forecasting the generation pattern of renewable energy sources and the charging pattern of electric vehicles
- Electricity rate reduction using load shifting
- Real-time peak reduction and power factor control
- Applicable to both rapid and normal chargers, especially for rapid chargers



▲ Concept of Eco-Friendly Charging Station

▲ Monitoring screen

▲ Control panel

▲ Daily operation result

03. Expected Effect

- Improved renewable energy penetration
- Minimize the influence of neighboring systems due to rapid charging power
- Maximize revenue
- Advancement of energy storage device operation technology
- Expansion of electric vehicle charging infrastructure

04. Applied Field

- Expandable to VxG electric vehicle charging station energy management system
- Expandable to electric vehicle aggregator business model
- Expandable to Microgrid with renewable energy resources and energy storage devices

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Operation Technology of Energy Storage System for Demand Management

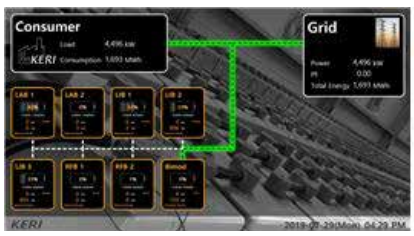
Manage your power consumption economically and conveniently with the energy storage system

01. Summary

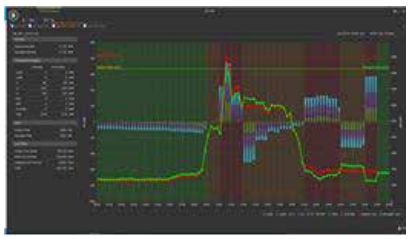
- Technology to maximize profits through efficient operation when installing and operating ESS
- Technology that saves energy charges by optimizing and ESS charging and discharging scheduling, and reduces basic charges by reducing peak load according to real-time logic

02. Character

- Include load forecasting technology
- Development of technology for optimizing operation plan of power storage device according to time-based rate
- Real-time peak load reduction algorithm implementation and verification
- Reflects charging and discharging efficiency characteristics according to battery type such as lithium ion battery or lead acid battery
- Life cycle estimation by calculating cycle count and available capacity



▲ ESS EMS Monitoring screen



▲ ESS EMS Operation Result screen

▲ Lithium polymer battery ESS

▲ Lead acid battery ESS

03. Expected Effect

- Contribute to stable supply expansion of ESS
- Expect to expand domestic smart grid market by synergy effect of IT industry and electric power industry
- Possible to generate national economic benefits by reducing power peak, and reducing investment in power generation and transmission facilities through efficient operation of ESS EMS

04. Applied Field

- Operation system for Energy Storage System or Microgrid
- Industrial EMS, building EMS, campus EMS and, home EMS
- Business model of agency for operating ESS for demand management
- Possible to operate by integrating several energy storage systems with various battery types

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W-Energy Management System(EMS) for Wind Power Plant

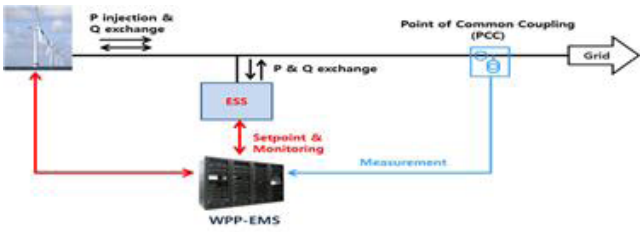
Operate a wind power plant like a conventional power plant

01. Summary

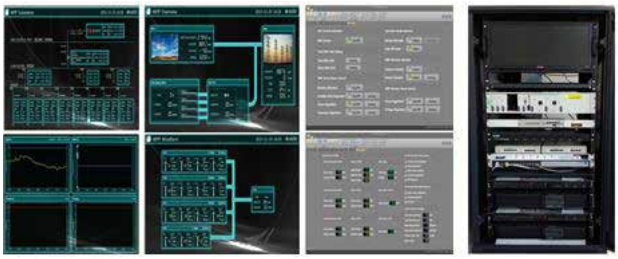
- The first case of development and field application of W-EMS in Korea
- Supervisory operation and control technology for wind power plant
- Essential technology for high penetration of wind energy
- Grid support services by integrated operation with diverse DER including ESS

02. Character

- Wind power control of wind power plant to comply with dispatch command from grid operator
- Grid frequency and voltage droop control
- Regulating wind power fluctuation by ESS
- Daily wind energy shift by ESS based on REC incentive program
- RTU function for communication with grid operator system
- Effective visualization of wind power plant operating status
- Secure high reliability and performance of W-EMS through field experiment



▲ Concept diagram of W-EMS



▲ Feature of W-EMS

03. Expected Effect

- Maximize settlement benefits of wind power plant owner
- Contribute to stable power system operation through smoothing wind power fluctuation
- Increase wind penetration ratio through power control function
- Enhance RES plant operation and control technology in Korea

04. Applied Field

- Cluster of RES (Wind, PV)
- VPP(Virtual Power Plant) with various types of small scale DER

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