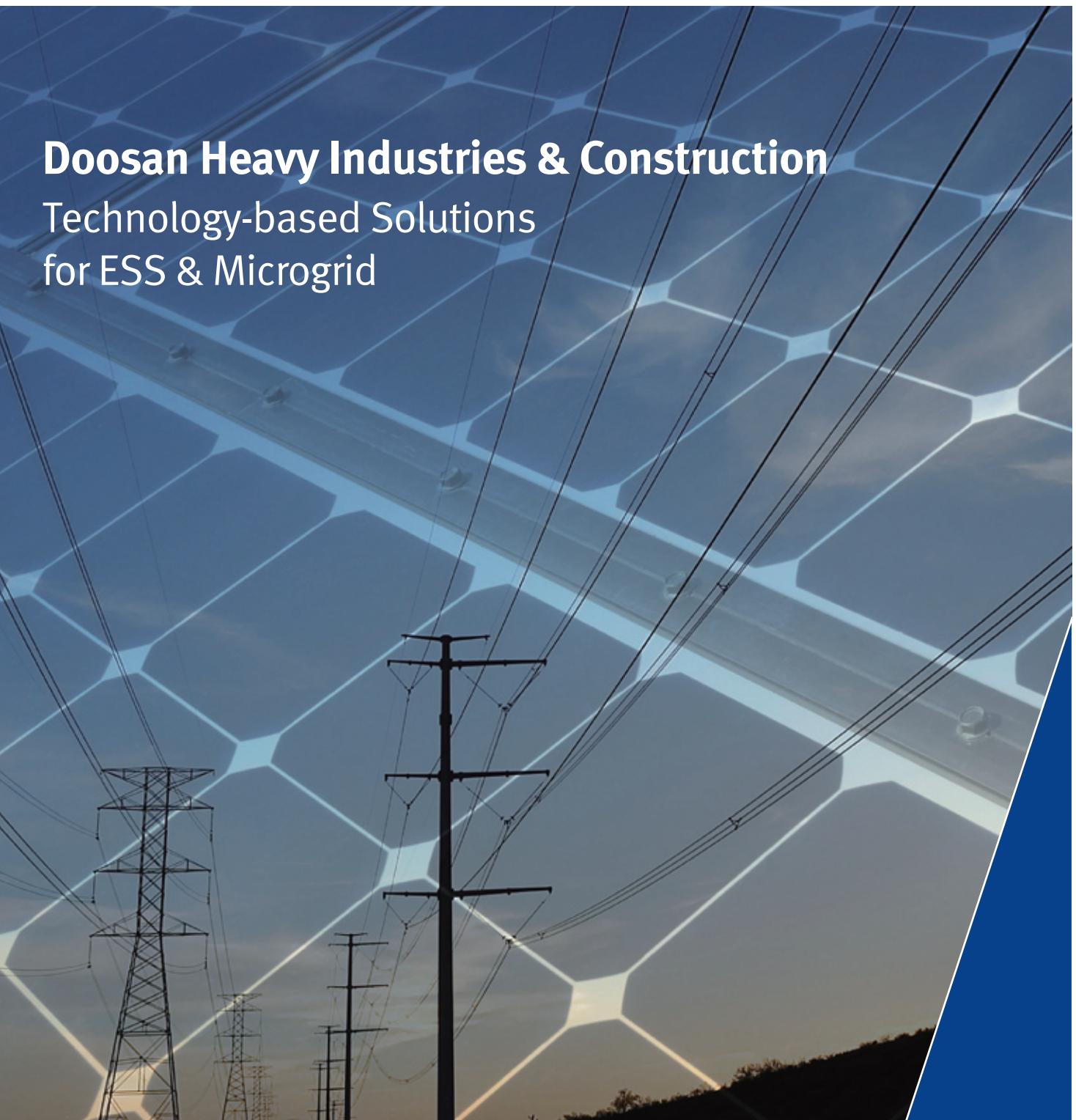


Doosan Heavy Industries & Construction

Technology-based Solutions
for ESS & Microgrid



Doosan Heavy Industries & Construction delivers innovative technology-based solutions that meet the challenges of change in the energy industry, embarking on an initiative to open new markets with its customers

The energy sector has traditionally relied on centralized generation stations that deliver a one-way supply of electric power to customers. But with the recent advancement of renewable energy technology, distributed generation that uses renewable energy resources such as solar and wind energy has been increasingly gaining attraction as a means to create a sustainable environment.

However, electric output from renewable energy resources is highly fluctuated as it is influenced by environmental factors such as the weather or season, making it challengeable for electric utilities to maintain a steady supply of high quality electric power. Such intermittent nature of renewable energy also makes it difficult for “energy prosumers”, end users who produce energy themselves by using energy resources (e.g., solar) to save electricity bills, to produce and consume electric power efficiently.

Doosan Heavy Industries & Construction serves its customers by delivering total technology solutions that include platform-based control system software for ESS and distributed generation, helping customers turn crisis into opportunity and generate profit as the energy sector undergoes a great deal of change. Doosan Heavy Industries & Construction’s technology-based solutions provide the integration/ management/ control of ESS and various distributed generation types, enabling electric utilities to embrace more various types of distributed generation and energy prosumers to produce and consume electric power in a more effective manner.

DOOSAN HEAVY INDUSTRIES & CONSTRUCTION’S VISION FOR THE ESS & MICROGRID BUSINESS

***"Technology solutions for
the digital distributed electric grid"***



Intelligence where you need it

Our multi-tiered software platform enables decision making as dynamic as the resources it's controlling.

Open, interoperable solutions

Our solutions eliminate technology silos by embracing open standards so our customers can reduce costs and preserve choice as they adopt distributed energy resources as an interoperable part of their system.

Full service supplier

We are experienced power system engineers and offer the full suite of services and guarantees that our customers' projects require.

WHAT IS AN ESS & MICROGRID?

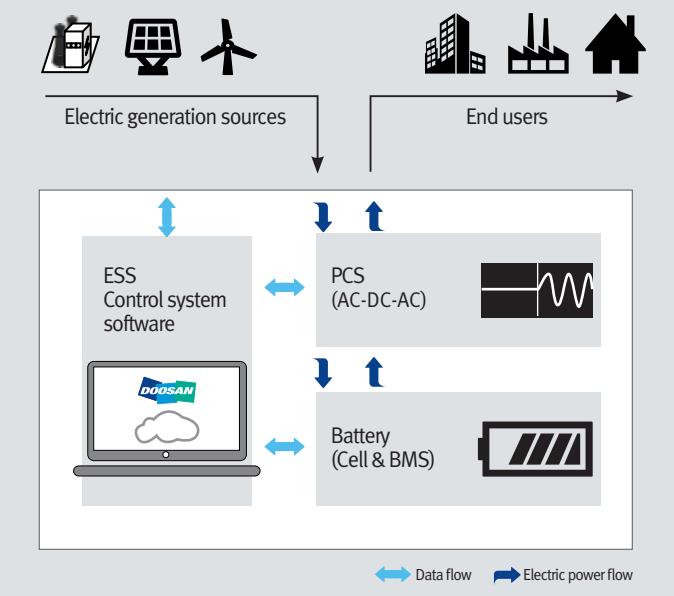
ESS (Energy Storage System)

ESS is a system that stores electrical energy produced from distributed generation or from the existing electric power system in a battery and discharges it for later use when necessary. It is comprised of a battery, i.e., the hardware, a power conversion system (PCS) and the control system software that coordinates the charging and discharging of electric power.

The battery is a device made up of multiple battery cells and a battery management system (BMS) that provides full protection and control of the cells. The PCS is a device that converts DC power that is stored in a battery to AC to deliver to the electric power system, or converts AC power from the electric power system to DC and stores the electric power in a battery. The control system software acts as the ‘brain’ of the ESS, providing real-time integration/management/control of all aspects of the overall system (e.g., time of charging and discharging, response speed, and etc.).

The ESS is used for managing peak demand, providing frequency regulation, stabilizing renewable energy electric output, enhancing electric power quality, electricity bill saving and many more applications. Based on its proprietary technology in control system software, Doosan Heavy Industries & Construction serves its customers by delivering total solutions that provide optimization of ESS.

ESS Configuration



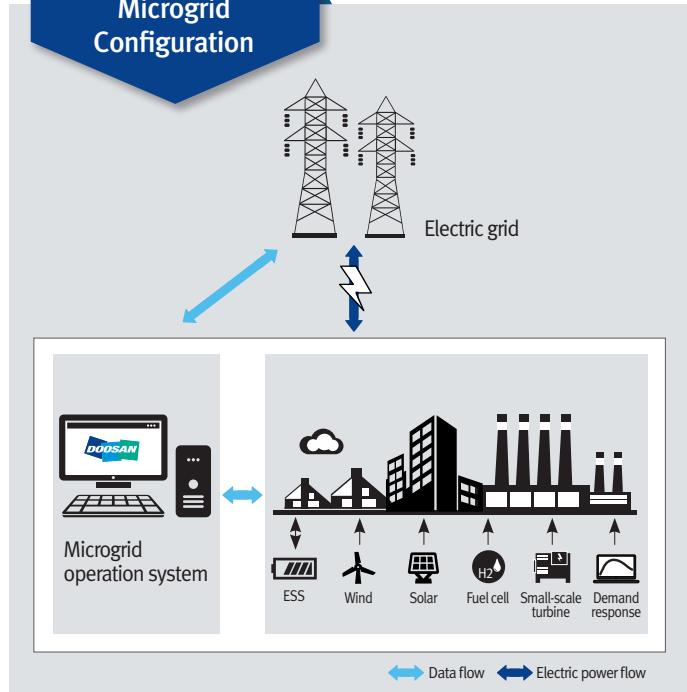
Microgrid

Microgrid is a small-scale electric power supply system that integrates distributed energy resources (e.g., wind, solar, and etc.) and ESS, capable of operating independently, or by being connected to the existing centralized electric grid.

The system can be widely deployed in islands with electric power transmission difficulties, public facilities that require stable electric power supply, and commercial buildings and industrial sites that need to reduce demand charges.

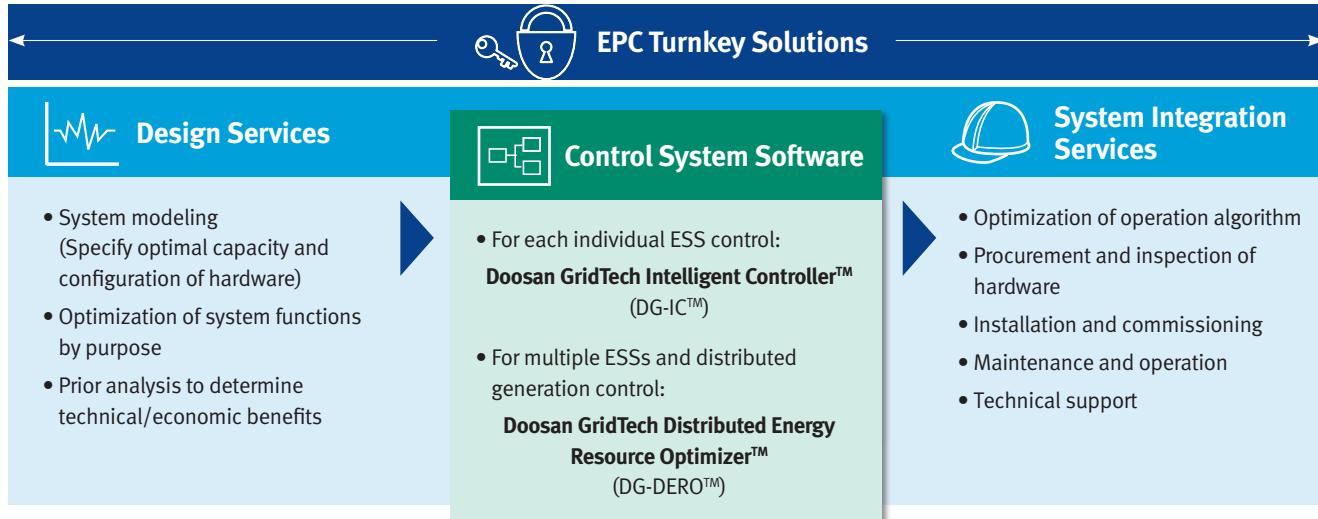
Aside from offering the ESS control system software, Doosan Heavy Industries & Construction delivers strongly competitive total solutions for the microgrid, based on its proprietary technology in the integration/management/ control of distributed generation, an integral part of the microgrid.

Microgrid Configuration



PRODUCTS & SERVICES PORTFOLIO

Doosan Heavy Industries & Construction delivers total solutions that include works that extend across the entire ESS and microgrid value chain. Such works start from design services (e.g., system modeling and function optimization of the ESS and microgrid) to providing EPC turnkey solutions (e.g., installation, commissioning and maintenance).



Control System Software

Doosan Heavy Industries & Construction provides an array of products and services and at the core of its offerings is the DG-ICT™, the ESS control system software, and DG-DERO™, the software that integrates and manages multiple ESSs and other distributed generation. Both of the software has been developed by Doosan GridTech, the company's Seattle-based subsidiary.

Intelligent Controller™ (DG-ICT™)

DG-ICT™ provides real-time optimization and automatic control of ESS for electric power to be managed in a stable and efficient manner, based alongside the ESS hardware in locations such as the existing electric grid, utility-owned distributed energy resources, or factories and commercial buildings of energy prosumers. The DG-ICT™ offers a suite of operating modes (a total of 12) that make it possible to integrate ESS into the electric grid which transmits and distributes the electric power generated to end users. The operating modes include peak demand management, frequency regulation, stabilizing renewable energy electric output, maintenance of high electric power quality, electricity bill saving, and etc. If necessary, multiple operating modes can be engaged at the same time to address the needs of electric utilities and energy prosumers.



Distributed Energy Resource Optimizer™ (DG-DERO™)

The DG-DERO™ is the software that complements the DG-ICT™ by providing integrated management of multiple ESSs and other distributed generation. Based in either the electric utilities' control center or in facilities run by energy prosumers with microgrids, the DG-DERO™ manages a diverse ESS fleet and distributed generation to operate smoothly. Furthermore, the DG-DERO™ function that offers real-time analysis and forecasting of the supply and demand curves, electricity prices, and more in the electricity market has been upgraded in order to deliver maximum economic value to our customers.



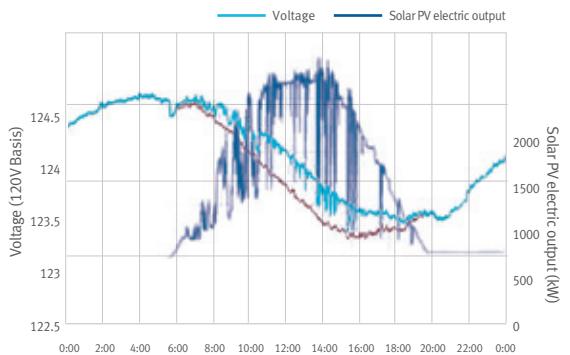
Both the DG-ICT™ and DG-DERO™ are platform-based designed, using open standards. When combined, the two products work together as a team, complementing each other.

Design Services

Doosan Heavy Industries & Construction's design services are focused on helping its customers generate maximum economic value through the optimization of ESS and microgrid, designed to fully consider customer's requirements, currently owned assets (hardware and software), and operating environment.

Our team of power systems engineers is responsible for determining the optimal ESS size and configuration of distributed energy resources through system modeling whereas our software experts focus on function optimization to effectively bring the expected results of modeling into actual results.

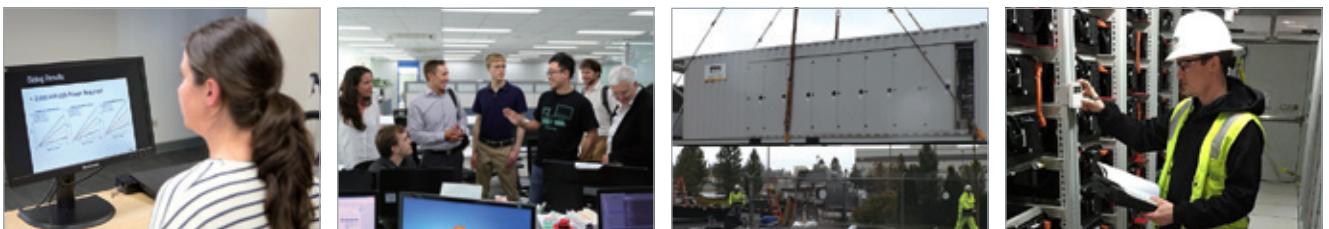
Such services enable our customers to verify the benefits of installing ESS and microgrid beforehand, assisting them in the rational decision-making process to make the right investment.



System Integration Services

Doosan Heavy Industries & Construction's system integration services include the smooth integration of the battery and PCS of the ESS, and distributed energy resources of the microgrid with the control system software consisting of DG-ICT™ and DG-DERO™. Services including the selection and procurement of the hardware, installation and commissioning that best addresses our customer's needs are offered as well.

Doosan Heavy Industries & Construction's control system software is platform-based designed, using open standards. As a result, interoperability is allowed with a variety of hardware types or software that customers are currently deploying, offering solutions at a competitive price to customers.



EPC Turnkey Solutions

Doosan Heavy Industries & Construction has an extensive track record of delivering coal-fired power plants and combined cycle power plants to its customers around the world. As a recognized EPC turnkey contractor, we are capable of offering the full range of activities and services that cover the entire value chain of the EPC turnkey business from the design stage to procurement, construction and quality assurance. Backed by the wealth of experience and know-how built up over the past 40 years in this industry, Doosan Heavy Industries & Construction delivers competitive EPC turnkey solutions for ESS and microgrid customers.

Such solutions not only provide system integration but also guarantee the quality of the overall system. The team, consisting of power system engineers, software experts, and skilled managements who have extensive experience in the power sector, offers solutions that focus on meeting the various business needs of customers in terms of safety, efficiency, economic feasibility, and being environment-friendly.



CUSTOMERS & TRACK RECORDS

Doosan Heavy Industries & Construction has been conducting business, mainly in South Korea and the United States where the ESS and microgrid markets are showing rapid growth, targeting electric utilities and energy prosumers. We have already successfully delivered many projects that call for a variety of battery chemistries (e.g., li-ion battery, vanadium redox flow battery, and etc.) with capacity ranging from 0.5MW up to 20MW. Today, Doosan Heavy Industries & Construction goes global by expanding its business internationally, proactively leveraging Doosan Group's established presence in the global market and financial support, and overseas subsidiaries and offices, along with the existing customer relationship that has been built by providing power solutions.

Total installed capacity
~40 MW / 30 MWh
(1H 2016 Basis)



Business is conducted with main focus on major electric utilities in the United States such as Austin Energy, Puget Sound Energy, Snohomish County Public Utility District No.1 (Snohomish PUD), Virginia Dominion Power, and etc.

Business is carried out by targeting not only major Korean electric utilities but also energy prosumers, having already installed ESS for the Korea Power Exchange (KPX) headquarters, the largest capacity for a single building in Korea.

CASE STUDY:



Snohomish County Public Utility District No. 1 (Snohomish PUD), located in Everett, Washington, United States, is committed to meeting load growth first with conservation, and then with clean renewable resources. After growing its wind generation from 0 to 8% in just two years, the utility realized it would not be able to keep adding wind generation to the system without help managing its intermittency. They turned to energy storage as the answer, both to address renewable intermittency and to more broadly support the transmission and distribution grid.

Snohomish PUD recognized the advantage of deploying different battery chemistries to address different use cases, and also realized that, for them to cost-effectively deploy more than one ESS, energy storage had to become more scalable and replicable. Economies of scale require standardized components and publicly available software interfaces for connecting them together.



To address this need, Doosan GridTech partnered with Snohomish PUD to bootstrap the development of the MESA standard – a set of open standards that enable utilities to assemble ESSs from interchangeable components and integrate those systems into their existing software systems for managing the grid, without requiring expensive, one-off engineering for each system. Today, the MESA Alliance is a standalone organization with 30+ members from across the electric utility and energy storage industries. MESA members include some of the largest utilities in the country – such as Duke Energy, Florida Power & Light, Austin Energy, Sacramento Municipal Utility District, and Puget Sound Energy – as well as leading clean energy technology suppliers delivering batteries, power conversion, and software.





Doosan GridTech, a subsidiary of Doosan Heavy Industries & Construction that secures proprietary technology in ESS control system software, has been awarded the Grid Edge Awards by Greentech Media (GTM) for "Building the 21st-Century Energy System" with its unparalleled technological capabilities.

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