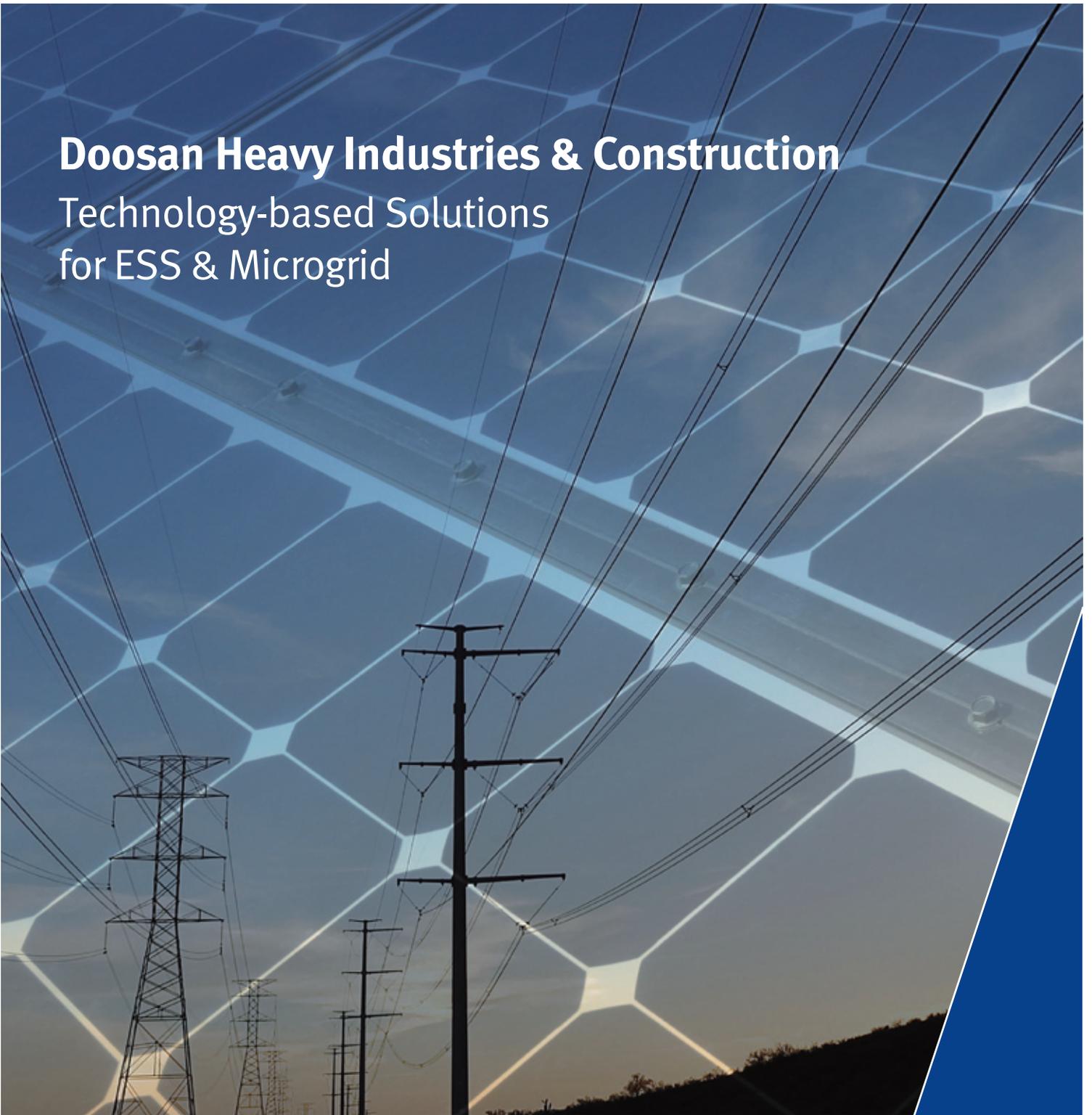


# Doosan Heavy Industries & Construction

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.).

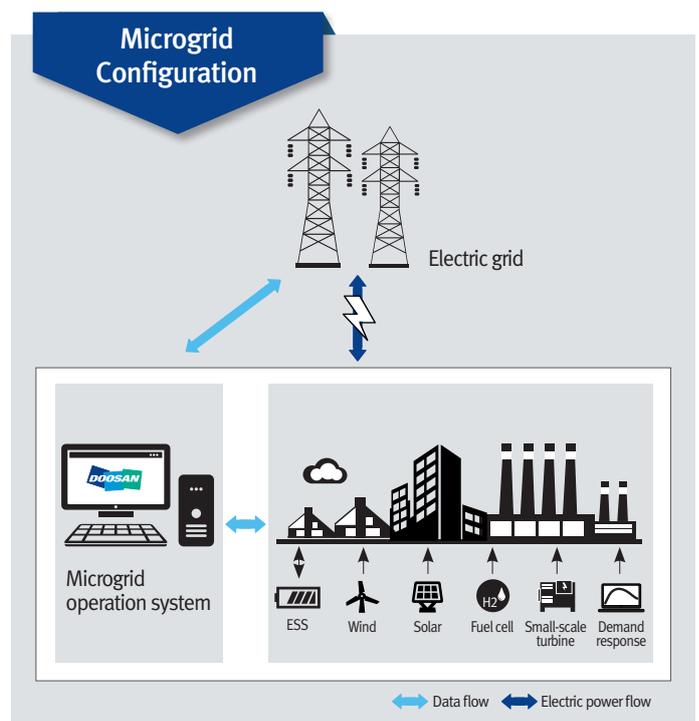
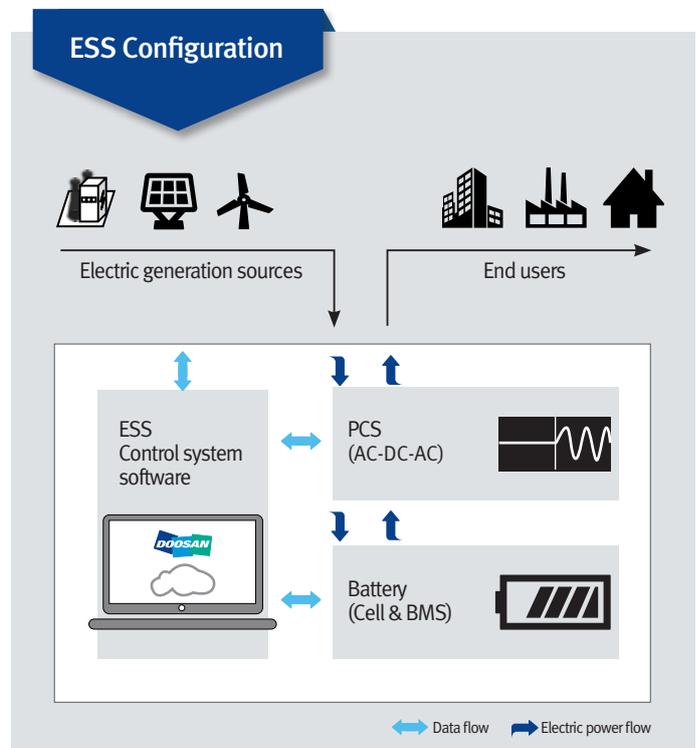
The ESS is used for managing peak demand, providing frequency regulation, stabilizing renewable energy electric output, enhancing electric power quality, electricity bill saving and many more applications. Based on its proprietary technology in control system software, Doosan Heavy Industries & Construction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

## 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.

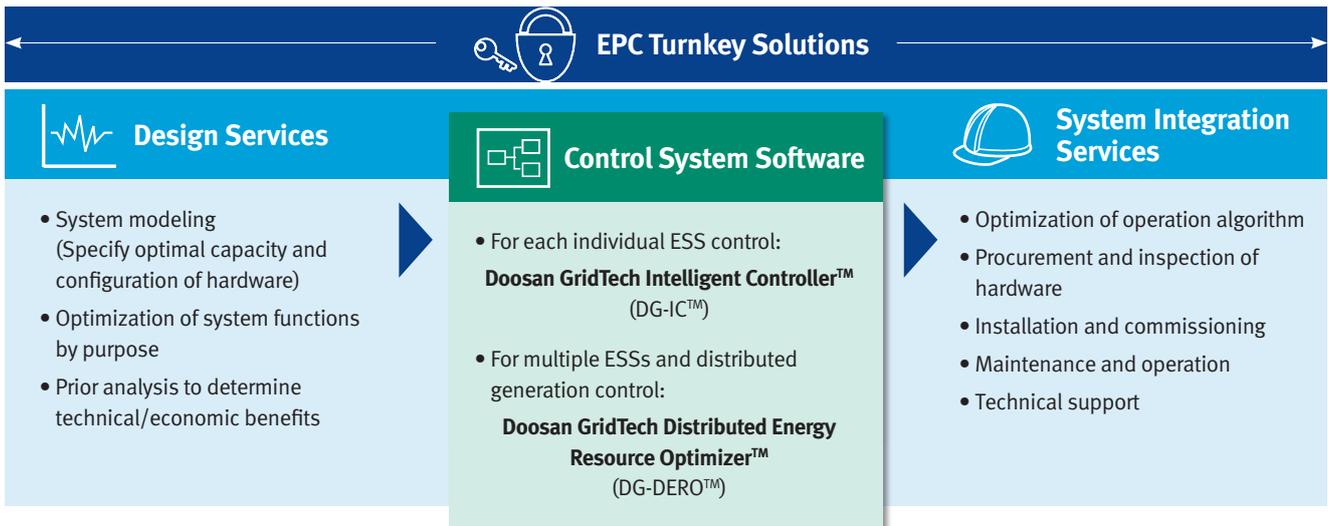
The system can be widely deployed in islands with electric power transmission difficulties, public facilities that require stable electric power supply, and commercial buildings and industrial sites that need to reduce demand charges.

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.



# 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.

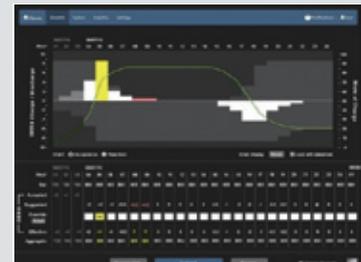
### Intelligent Controller™ (DG-ICT™)

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.



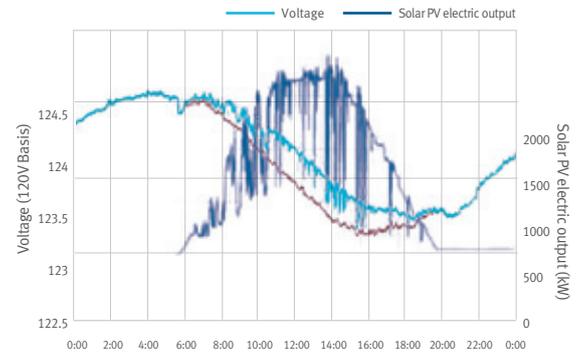
Both the DG-ICT™ and DG-DERO™ are platform-based designed, using open standards. When combined, the two products work together as a team, complementing each other.

## 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-IC™ 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

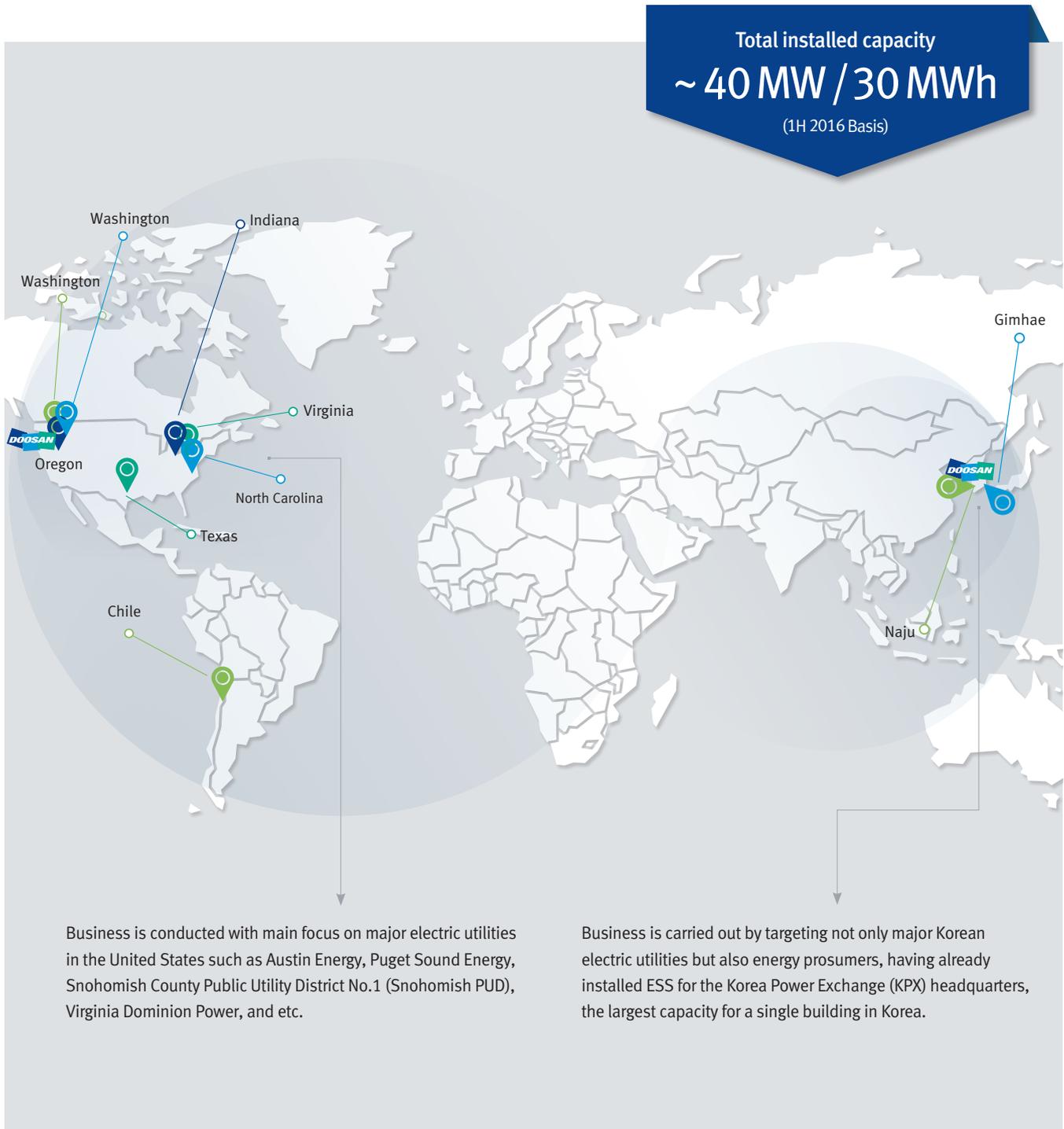
Doosan Heavy Industries & Construction has an extensive track record of delivering coal-fired power plants and combined cycle power plants to its customers around the world. As a recognized EPC turnkey contractor, we are capable of offering the full range of activities and services that cover the entire 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.



# 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.

# GLOBAL NETWORK

## EUROPE

### Subsidiaries

**DOOSAN POWER SYSTEMS LTD.**  
Doosan House, Crawley Business Quarter,  
Manor Royal, Crawley, West Sussex,  
RH10 9AD, United Kingdom  
Tel 44 1293 612888  
Fax 44 1293 584321

**[DOOSAN BABCOCK]**  
Porterfield Road, Renfrew, PA4 8DJ,  
United Kingdom  
Tel 44 141 886 4141  
Fax 44 141 885 3338

**[DOOSAN ŠKODA POWER]**  
Tylova 1/57, 301 28 Plzen, Czech  
Tel 420 378 185 000  
Fax 420 378 185 910

**[DOOSAN LENTJES]**  
Daniel-Goldbach-Strasse, 19,  
40880 Ratingen, Germany  
Tel 49 2102 166 0  
Fax 49 2102 166 2500

**DOOSAN ENPURE**  
Doosan Enpure House,  
Parklands Business Park, Rubery,  
Birmingham, B45 9PZ, United Kingdom  
Tel 44 121 683 2801  
Fax 44 121 251 9111

**DOOSAN IMGB**  
104 Bercei Road, Bucharest 4, Romania  
Tel 40 21 301 2500  
Fax 40 21 301 2501

### Branches

**FRANKFURT OFFICE**  
7th Floor, Arabella Center, Lyoner Strasse  
44-48, 60528 Frankfurt am Main,  
Germany  
Tel 49 69 69 5004 0  
Fax 49 69 69 5004 10

**BIRMINGHAM WATER R&D CENTER**  
Doosan Enpure House, Parklands Business  
Park, Rubery, Birmingham, B45 9PZ,  
United Kingdom  
Tel 44 121 683 2800  
Fax 44 121 683 2888

## ASIA

### Subsidiaries

**DOOSAN POWER SYSTEMS INDIA PVT. LTD.**

**[CHENNAI OFFICE]**  
18/2A, Senneerkuppam,  
Bypass Road, Poonamallee, Chennai  
600 056, Tamil Nadu, India  
Tel 91 44 3303 5000  
Fax 91 44 3303 5001

### [MUMBAI OFFICE]

501,5th Floor, CNB Square Bldg.  
Sangam Complex, Near Sangam Cinema,  
Andheri-Kurla Road, Chakala, Andheri(East),  
Mumbai 400 059, India  
Tel 91 22 6177 0500  
Fax 91 22 6177 0599

### [NEW DELHI OFFICE]

16th Floor, DLF Square Building,  
Jacaranda Marg, Near NH-8, DLF Phase-II,  
Gurgaon, Haryana 122 002, India  
Tel 91 124 439 8200  
Fax 91 124 414 7006

### [KOLKATA OFFICE]

South City Pinnacle, Mangalam Business  
Center Suite No - 1214, 12th Floor, Salt Lake,  
Sector - V Kolkata - 700091  
Tel 91 33 4019 3425  
Fax 91 33 4019 3430

**DOOSAN HEAVY INDUSTRIES  
VIETNAM CO., LTD. (DOOSAN VINA)**  
Dung Quat Economic Zone, BinhThuan  
Commune Binh Son District,  
Quangngai Province, Vietnam  
Tel 84 55 3618 900  
Fax 84 55 713 950

**DOOSAN HEAVY INDUSTRIES JAPAN CORP.**  
Mita Kokusai Bldg, Room 2413, 1-4-28,  
Mita, Minato-Ku Tokyo 108-0073, Japan  
Tel 81 3 3452 5451-3  
Fax 81 3 3452 5624

### Branches

**BEIJING OFFICE**  
19th Floor, Gateway Plaza, Tower B, No. 18  
Xiaguangli, North Road, East Third Ring  
Chaoyang District, Beijing 100027, China  
Tel 86 10 8454 7122, 7136  
Fax 86 10 8484 7139

**BANGKOK OFFICE**  
10th Floor, M-Thai Tower, All Seasons Place,  
87 Wireless Road Phatumwan,  
Bangkok 10330, Thailand  
Tel 66 2 654 0690  
Fax 66 2 654 0693

**HANOI OFFICE**  
#1101, Daeha Business Center, 360 Kim Ma,  
Ba Dinh District Hanoi, Vietnam  
Tel 84 4 6273 0545-9  
Fax 84 4 6273 0550

**JAKARTA OFFICE**  
Plaza Bapindo, Mandiri Tower 20F,  
JlJendSudirman No 54-55, Jakarta, Indonesia  
Tel 62 21 2995 0101  
Fax 62 21 2995 0108

**MANILA OFFICE**  
Unit 1802, One World Place, 32nd street,  
Bonifacio Global City, Taguig City 1634,  
Philippines  
Tel 63 2 801 4619  
Fax 63 2 801 4616

### SHANGHAI OFFICE

Rm2903A, Gubei International Fortune  
Center, No.1438, Hong Qiao Road, Chang  
Ning District, Shanghai, 201103, China  
Tel 86 21 5877 8696  
Fax 86 21 5877 5938

### TAIPEI OFFICE

#704, No.51, Keelung Road Section 2,  
Taipei, Taiwan, R.O.C.  
Tel 886 2 2739 2255  
Fax 886 2 2739 2266

## AMERICAS

### Subsidiaries

**DOOSAN HEAVY INDUSTRIES AMERICA CORP.**  
10th Floor, Parker Plaza, 400 Kelby Street,  
Fort Lee, NJ 07024, USA  
Tel 1 201 944 4554 31, 24  
Fax 1 201 944 5022

**[NEWINGTON OFFICE]**  
178 Shattuck Way, Newington, NH 03801,  
USA  
Tel 1 603 433 5507  
Fax 1 603 433 1060

**[PITTSBURGH OFFICE]**  
1000 Westinghouse Drive, Building 2,  
239D, Cranberry Township, PA 16066, USA  
Tel 1 412 374 6071  
Fax 1 724 720 0903

**DOOSAN ENGINEERING & SERVICES LLC**  
5 Paragon Drive, Montvale, NJ 07645, USA  
Tel 1 201 746 8200  
Fax 1 201 746 8210

**DOOSAN HYDRO TECHNOLOGY, INC.**  
912 Chad Lane, Tampa, FL 33619, USA  
Tel 1 813 549 0182  
Fax 1 813 623 6666

**DOOSAN ATS AMERICA, LLC**  
11360 N. Jog Road, Palm Beach Gardens,  
FL 33418, USA  
Tel 1 561 572 9100  
Fax 1 561 572 9101

**DOOSAN GRIDTECH, INC.**  
615 2nd Avenue, Suite 620 Seattle,  
WA 98104, USA  
Tel 1 888 452 7715  
DoosanGridTech.com

### Branches

**SANTIAGO OFFICE**  
Av. Nueva Tajamar 481, Torre Sur,  
Piso 11, Oficina 1103, Las Condes,  
Santiago, Chile  
Tel 56 2 2657 3333  
Fax 56 2 2657 3343

### TAMPA OFFICE

912 Chad Lane, Tampa, FL 33619, USA  
Tel 1 813 549 0182  
Fax 1 813 623 6666

**TAMPA WATER R&D CENTER**  
912 Chad Lane, Tampa, FL 33619, USA  
Tel 1 813 549 0182  
Fax 1 813 623 6666

## MIDDLE EAST & AFRICA

### Branches

**ABU DHABI OFFICE**  
# 508, Al Ghaith Tower, Hamdan Street,  
P.O. Box 27767, Abu Dhabi, UAE  
Tel 971 2 627 6273  
Fax 971 2 627 6274

**CAIRO OFFICE**  
2nd Floor, Land Mark Building 1, 67 El  
Teseen St., 5th Settlement, New Cairo  
Tel 20 2 2537 1040  
Fax 20 2 2537 1041

**DUBAI OFFICE**  
30th Floor, H HotelOffice Tower, Sheikh Zayed  
Road, P.O.Box 11859, Dubai, UAE  
Tel 971 4 327 5545  
Fax 971 4 327 5529

**DAMMAM WATER R&D CENTER**  
Al Turki Business Park 9th Floor, Al Khobar 31952,  
Eastern Province, Kingdom of Saudi Arabia  
Tel 966 3 868 6951  
Fax 966 3 868 7100

**KUWAIT OFFICE**  
7B, Block 49, Plot 35, Laila Commercial  
Tower, Salmiya, P.O Box 2031 Kuwait  
Tel 965 6001 3075  
Fax 965 2575 2001

**MIDDLE EAST OPERATION CENTER**  
30th Floor, H HotelOffice Tower, Sheikh Zayed  
Road, P.O.Box 11859, Dubai, UAE  
Tel 971 4 327 5545  
Fax 971 4 327 5592

**RIYADH OFFICE**  
# 205-206, The Plaza Building (Akariya No. 4),  
Olaya Street, P.O.Box 9656, Riyadh 11423,  
Kingdom of Saudi Arabia  
Tel 966 1 419 1696  
Fax 966 1 419 1995

## AFRICA

### Branches

**JOHANNESBURG OFFICE**  
12F, The Forum, 2 Maude Street, Sandton,  
Johannesburg, South Africa  
+27 113 265 790 (Landline)  
Tel 27 113 265 790  
Fax 966 1 419 1995



**Doosan Heavy Industries & Construction** DoosanHeavy.com

Seoul Office (06611) 465 Gangnam-daero, Seocho-gu, Seoul, Korea (T) 82 2 513 6114, (F) 82 2 513 6200