Global Leader

Introduction of Hyundai Electric

2019

Hyundai Electric & Energy Systems

HYUNDAI ELECTRIC

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Part1. Introduction

1. Introduction of Hyundai Electric and Energy Systems(H.E)
2. Competitiveness of H.E

Hyundai Overview

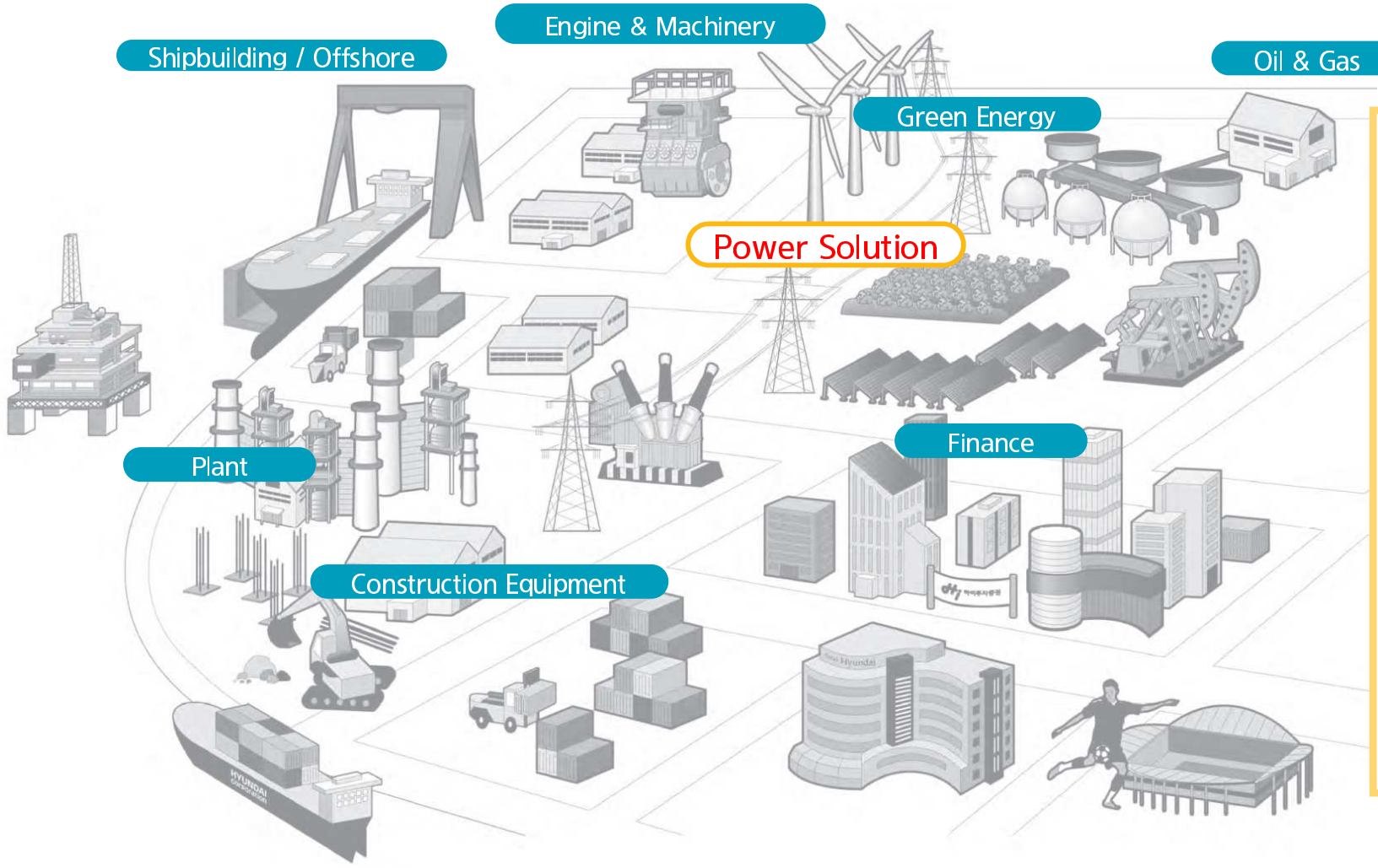
Hyundai
Motors Group

HYUNDAI ELECTRIC

Hyundai
Heavy Industries
Group

Hyundai
Engineering &
Construction

Overview of Hyundai Heavy Industries Group



Seven Business Divisions

- Shipbuilding
- Offshore & Engineering
- Industrial Plant
- Engine & Machinery
- Construction Equipment
- Electric Electro Systems
- Green Energy (PV + Wind)

1. Introduction of HE

History

+ 1973, HHI Corp.
+ 1977, HHE Corp.
+ 1993, HHI Corp. merged
+ 2017, HE Corp. separated
  Revenue :20 billion /
  Workers : 2,700

ESS Solution

Renewable Energy Solution

▶ Wide range of power energy business areas related to T/D system, and renewable energy
▶ EPC Capability in Energy Solutions such as ESS, FEMS, BEMS and Microgrid

Transmission and Distribution Equipment *FULL LINE-UP for Energy Infra*


GIS


Switchboard


Rotor


Transmission TR


Distribution TR


Switchgear

Energy Solutions


FEMS solution


BEMS solution


SEMS solution


Asset M'gmt


Micro Grid


Smart Farm

2. Competitiveness of HE

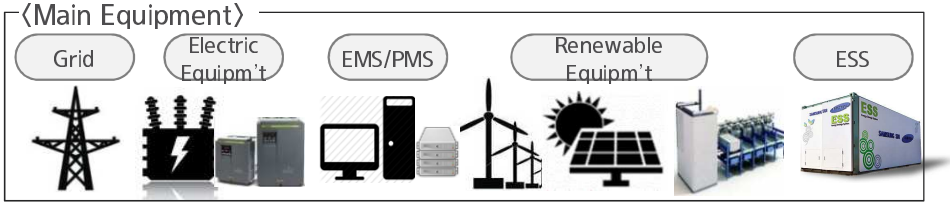
- Hyundai is a Top ranker of ESS Solution Provider in Asia region(around 1,000MWh)
- Wide range of power energy business areas related to T/D system, and renewable energy over 40 years

Base

1 Expert Design Ability and Business Experience

- Power equipment manufacturing such as TR, breakers, SWBD, and inverters for T/D and power generation systems
- Specialized Design and Business Experience of Renewable Energy such as Wind Power and Solar Power

〈Main Equipment〉



Competitiveness of ESS solution

3 Integrated engineering capabilities with power equipment design, manufacturing and maintenance

Feasibility Study	- In-house Simulation Design Tool - Optimal design for each application	Financing	- Provide customized financial models
Integrated Engineering	- Integrated Engineering Capacity of Gird/Load/ESS/Power Equipm't/Renewable	Business Expansion	- Provide scalability for EMS platform based FEMS, BEMS, AMS and TOC
Grid Design	- Design Capacity of High Power and High Voltage System	Reliability	- Korea's largest ESS and battery supply record (approximately 1GWh) and EPC competitiveness
Battery Design	- Experience of R&D of Various Batteries		

Part2. Engineering Capabilities

1. **Design Solution for Optimization**

   - Optimal Sizing and Availability Design for PV & ESS

2. **HE in-house Simulation Tool for Feasibility Study**

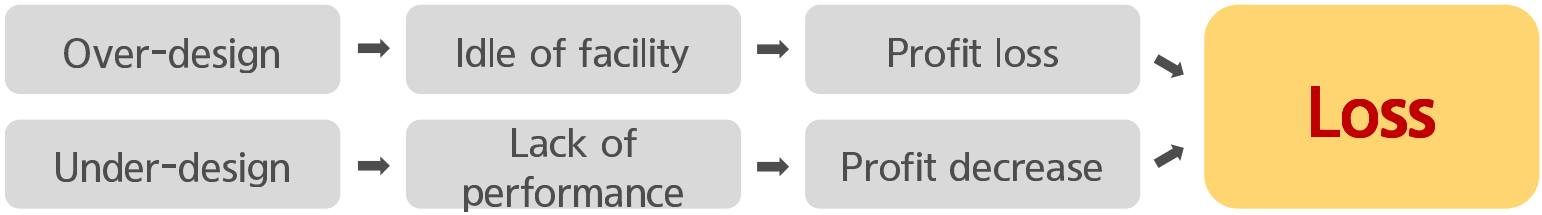
   - Feasibility Study Sample

3. **Site & Design Engineering(Drawings) Sample**

1. Design solution for Optimization

■ Philosophy for the Optimal Design

- Capacity, output, and efficiency are designed to ensure maximum profitability (B/C ratio, IRR) or maximum sales (revenue, NPV) within the optimal investment range from the facility utilization rate and performance point of view

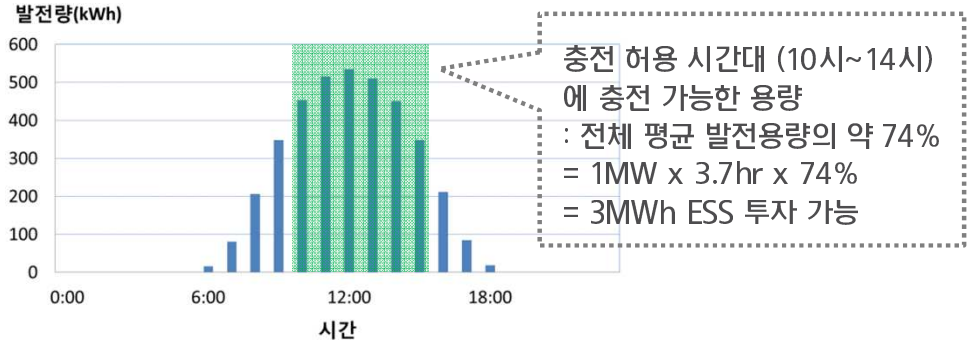


■ Basic Design for the PV ESS Capacity

- Rough design (Over-design risk)

  - Power generation time x System Capacity x
    Power generation rate within charge-allowed time zone
    = ESS system Capacity

(예시: 실제 1MW PV 발전소의 연평균 발전 프로파일)



- Detail design
  - It is important to design to avoid loss of profit in a daily and hourly unit through PV profile analysis and prediction.

1.1 Optimal Sizing and Availability Design for PV & ESS

■ Optimal Design Capacity for ESS

- Maximizing investment revenue
  - By analyzing the annual PV profile, we select the appropriate capacity to maximize the profit compared to the investment cost.
  - The annual ESS utilization rate is derived by predicting various PV profiles generated throughout the year through probabilistic methods.

■ Availability

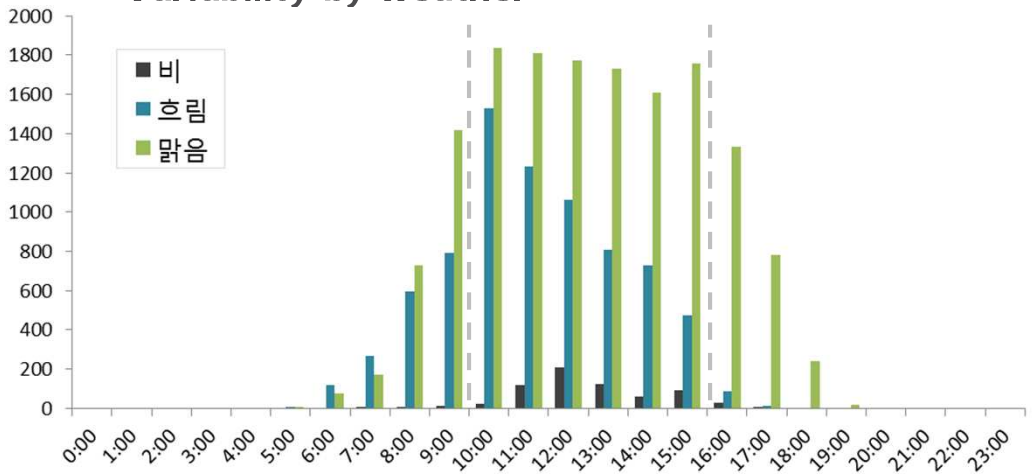
$$\text{ESS utilization rate} = \frac{\text{ESS } \textit{Power sales amount}}{\text{ESS } \textit{Capacity}} \times 100\%$$

* ESS power sales amount : The amount of the electricity charged between 10:00 and 16:00, was discharged at the other times and transferred to the power grid

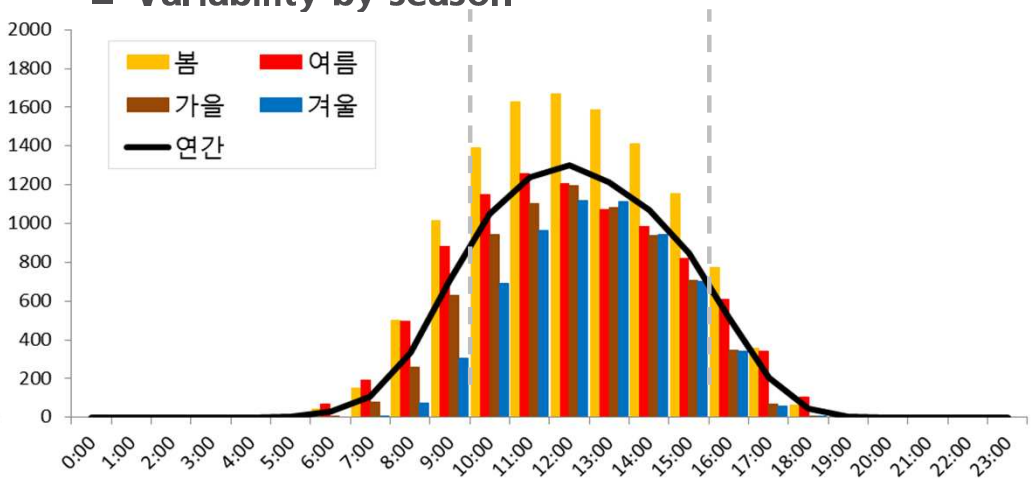
- Factors affecting ESS utilization rate ESS
  - PV profile (seasonal, weather)
  - Efficiency of charge/discharge

■ Example for the PV profile

■ Variability by weather



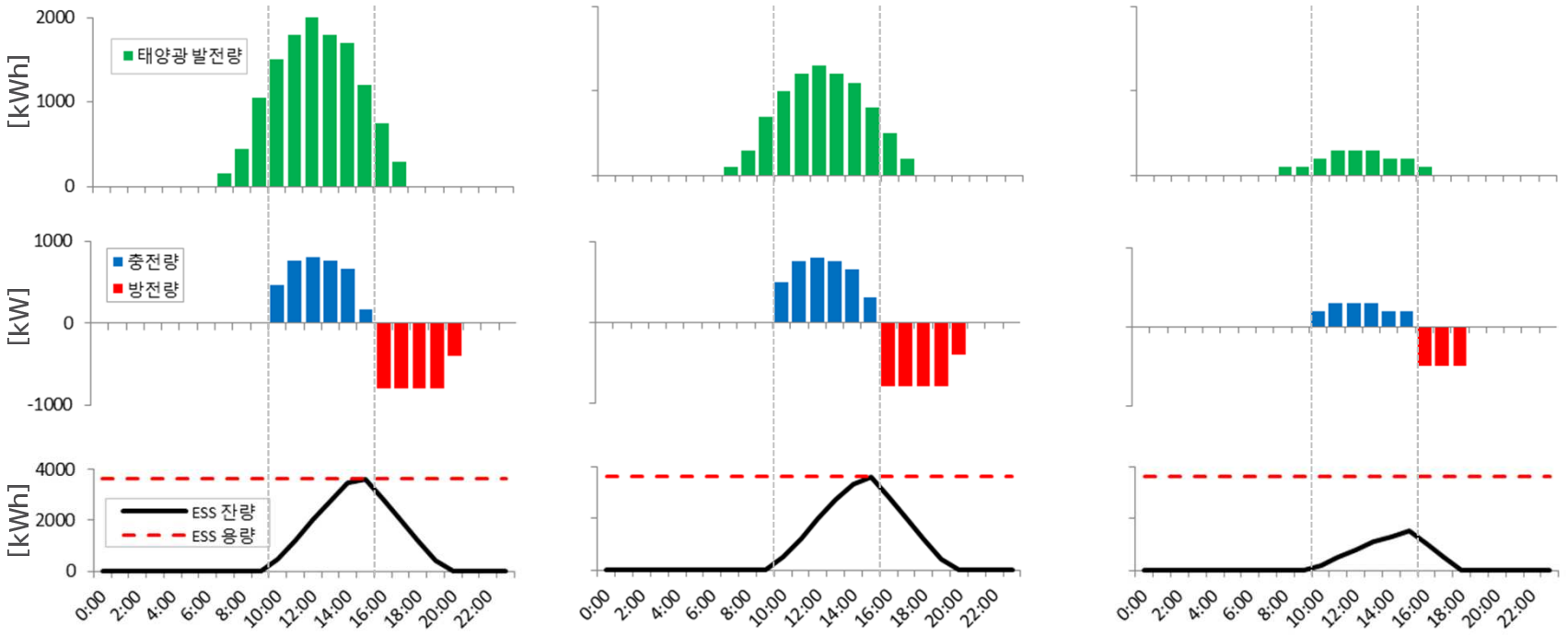
■ Variability by season



1.1 Optimal Sizing and Availability Design for PV & ESS

■ Impact of the PV profile pattern on the ESS Availability

※ Example. **1.0MW/3.6MWh ESS**

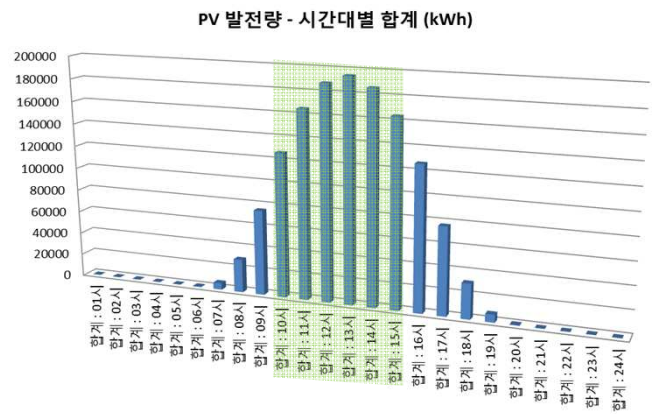


	CASE 1	CASE 2	CASE 3
Availability (daily)	100% (3,600kWh char/disch)	100% (3,600kWh char/disch)	42% (1,500kWh char/disch)
Comments	Scarcity	Optimum	Over-design

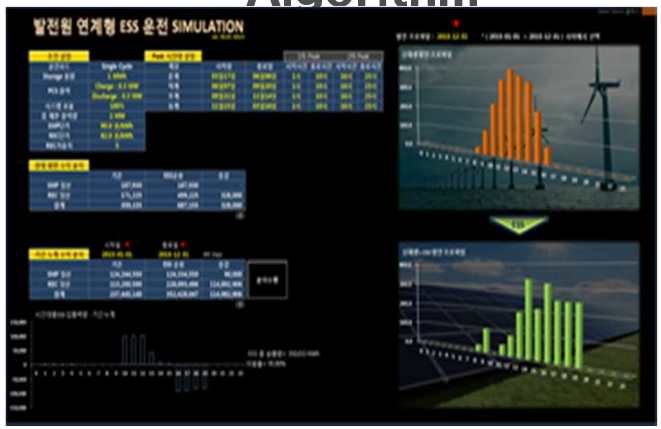
※ 본 페이지는 설명을 위한 예시자료로서, 본 자료에서 사용한 수치는 실제값과 상이함.

2. HE in-house Simulation Tool for Feasibility Study

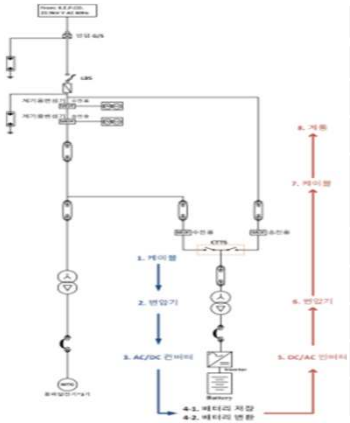
1 Analysis: PV profile



2 Design: Spec. & Op Algorithm

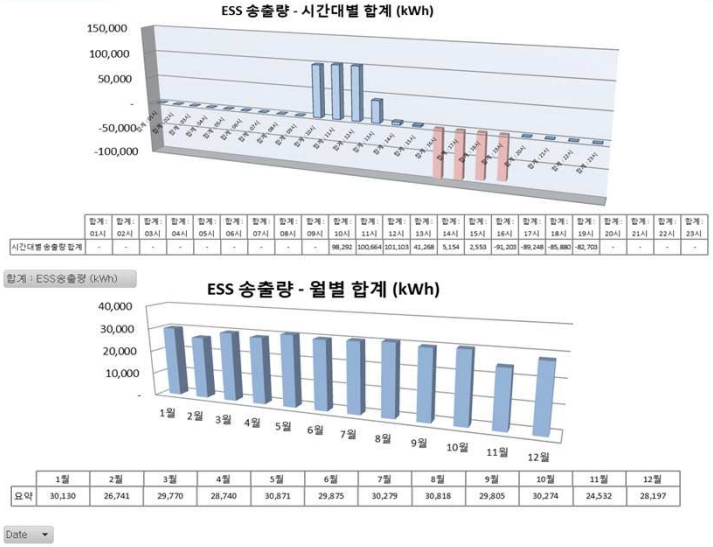


3 System Effic. Design



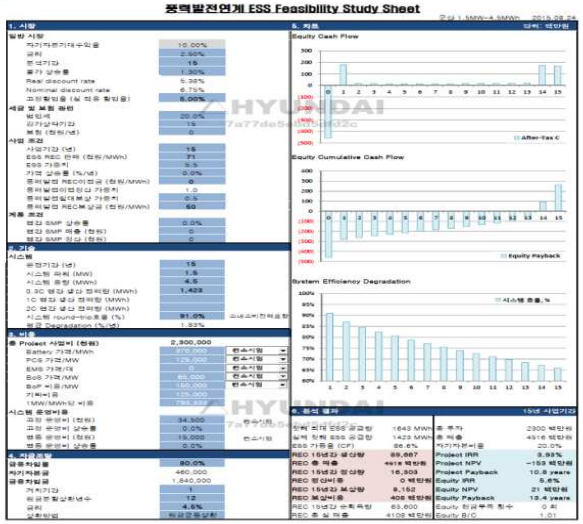
순번	세부 설비	효율
1	케이블	99.50%
2	TR_ESS용	99.00%
3	AC/DC 컨버터	98.80%
4	배터리 (저장)	99.75%
	배터리 (변환)	97.00%
5	DC/AC 인버터	98.80%
6	TR_ESS용	99.00%
7	케이블	99.50%
8	계통	100.00%
시스템 실질 효율		91.65%

4 Simul'n: ESS Discharge Capacity



	1월	2월	3월	4월	5월	6월	7월	8월	9월	10월	11월	12월
요약	30,130	26,741	29,770	28,740	30,871	29,875	30,279	30,818	29,805	30,274	24,532	28,197

5 Pre-FS



6 Design Optimization

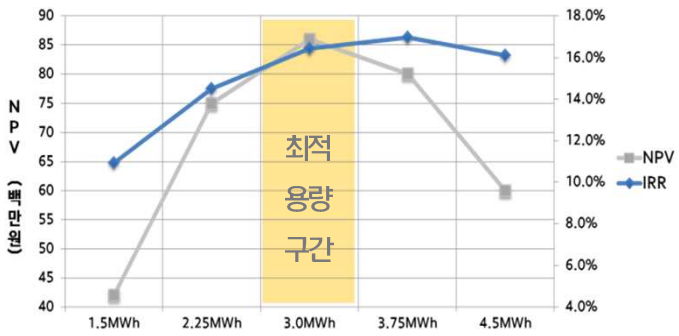


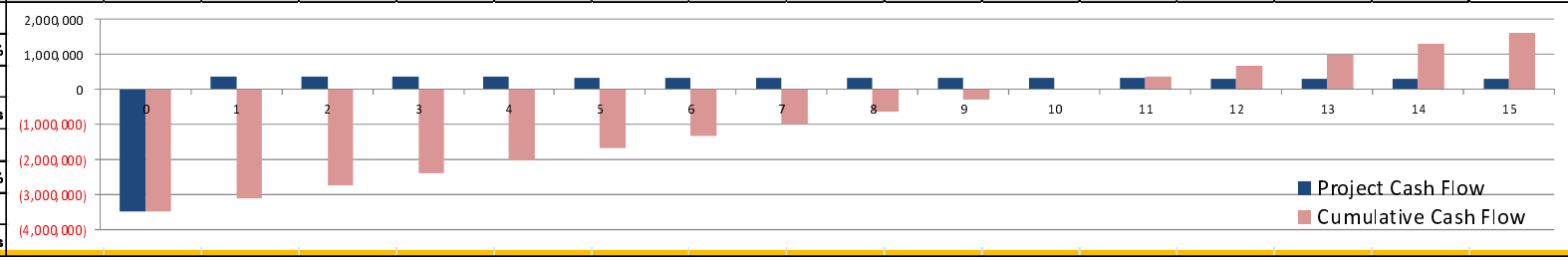
표 7. 사양별 연간 ESS 송전량 및 이용률

사양	1.2MW/3.6MWh	1.5MW/4.5MWh	1.6MW/4.8MWh
연간 ESS 송전량	1093.98 MWh	1308.01 MWh	1374.32 MWh
연간 ESS 이용률	83.3%	79.6%	78.4%

2.1 Feasibility Sample: 1MW PV connected with 1MW/3.5MWh ESS

기간 (연도)	n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
	year		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	연 평균
일반	**REC 총 생산, 개**		3,779	3,714	3,648	3,583	3,518	3,452	3,387	3,322	3,256	3,191	3,126	3,060	2,995	2,929	2,864	3,322
	REC ESS 생산, 개		3,779	3,714	3,648	3,583	3,518	3,452	3,387	3,322	3,256	3,191	3,126	3,060	2,995	2,929	2,864	3,322
	REC PV 이전, 개		771	758	744	731	718	704	691	678	664	651	638	624	611	598	584	678
	REC 효율손실보전, 개		115	113	111	109	107	105	103	101	99	97	95	93	91	89	87	101
	REC 순획득, 개		4,152	4,096	4,040	3,983	3,927	3,871	3,814	3,758	3,702	3,645	3,589	3,532	3,476	3,420	3,363	**3,758**
수입	**C_{IN}**		481,199	475,557	469,914	464,272	458,630	452,988	447,346	441,703	436,061	430,419	424,777	419,135	413,492	407,850	402,208	**441,703**
	REC 매출 (ESS 가중치 분량만)		355,232	349,089	342,945	336,802	330,658	324,515	318,372	312,228	306,085	299,942	293,798	287,655	281,511	275,368	269,225	
	SMP 매출	0	29,650	30,364	31,078	31,793	32,507	33,221	33,936	34,650	35,364	36,079	36,793	37,507	38,222	38,936	39,651	
지출	**C_{OUT}**	3,116,326	211,032	368,685	368,659	368,633	368,607	368,581	368,555	368,529	368,502	368,476	368,450	368,424	368,398	368,372	368,841	**358,050**
	태양광발전 이전정산, C_{REC}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	태양광발전 임대보상, C_{LEASE_REC}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	태양광발전 효율손실보전, C_{EFF}		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	태양광발전 효율손실보전, C_{CON}		1,512	1,485	1,459	1,433	1,407	1,381	1,355	1,329	1,302	1,276	1,250	1,224	1,198	1,172	1,146	**1,329**
	보험금, C_{INS}		14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	**14,000**
	SMP 정산, C_{SMP_OUT}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	$C_{O\&M}$		49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	49,000	**49,000**
	고정 운영비 (인건비)		24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	
	변동 운영비 (대수선비)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Debt, D		146,520	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,200	304,696	
	대출이자 상환		146,520	143,020	135,290	127,180	118,670	109,760	100,430	90,640	80,380	69,640	58,360	46,570	34,180	21,220	7,630	
	대출금 상환		0	161,180	168,910	177,020	185,530	194,440	203,770	213,560	223,820	234,560	245,840	257,630	270,020	282,980	297,066	
세금	감가상각기간		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	
	감가상각액		201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964	201,964
	법인세 차감전 영업이익		214,723	209,107	203,491	197,875	192,259	186,643	181,027	175,411	169,795	164,179	158,563	152,947	147,331	141,715	136,098	175,411
	T_n		47,239	46,004	44,768	43,533	42,297	41,061	39,826	38,590	37,355	36,119	34,884	33,648	32,413	31,177	29,942	**38,590**
Project (자기자본 100%) 현금흐름	**순 현금흐름_$C_{n_project}$**	(3,462,584)	369,448	365,068	360,687	356,307	351,926	347,545	343,165	338,784	334,404	330,023	325,643	321,262	316,882	312,501	308,121	
	누적 현금흐름_$C_{cn_project}$	(3,462,584)	(3,093,136)	(2,728,068)	(2,367,381)	(2,011,075)	(1,659,149)	(1,311,603)	(968,438)	(629,654)	(295,250)	34,773	360,416	681,678	998,560	1,311,061	1,619,182	
Equity (자기자본 10%) 현금흐름	**순 현금흐름_C_{n_equity}**	(346,258)	255,162	92,332	86,251	80,086	73,833	67,493	61,060	54,525	47,887	41,144	34,282	27,308	20,201	12,970	5,104	
	누적 현금흐름_C_{c_equity}	(346,258)	(91,096)	1,236	87,487	167,573	241,406	308,899	369,959	424,484	472,371	513,515	547,797	575,105	595,306	608,276	613,380	

Project	**NPV**	**395,913**
	IRR	**6.52%**
	B-C	1.11
	Payback Period	**9.9 years**
Equity	**NPV**	**721,491**
	IRR	**35.64%**
	B-C	1.21
	Payback Period	**2.0 years**



3. Site and Drawing Sample

(Hyundai Heavy Industries : PCS 24MW / Battery 51.5MWh)

ESS Center

Oil Transfomer(7200kVA)

SWGR(MV, LV)

PCS

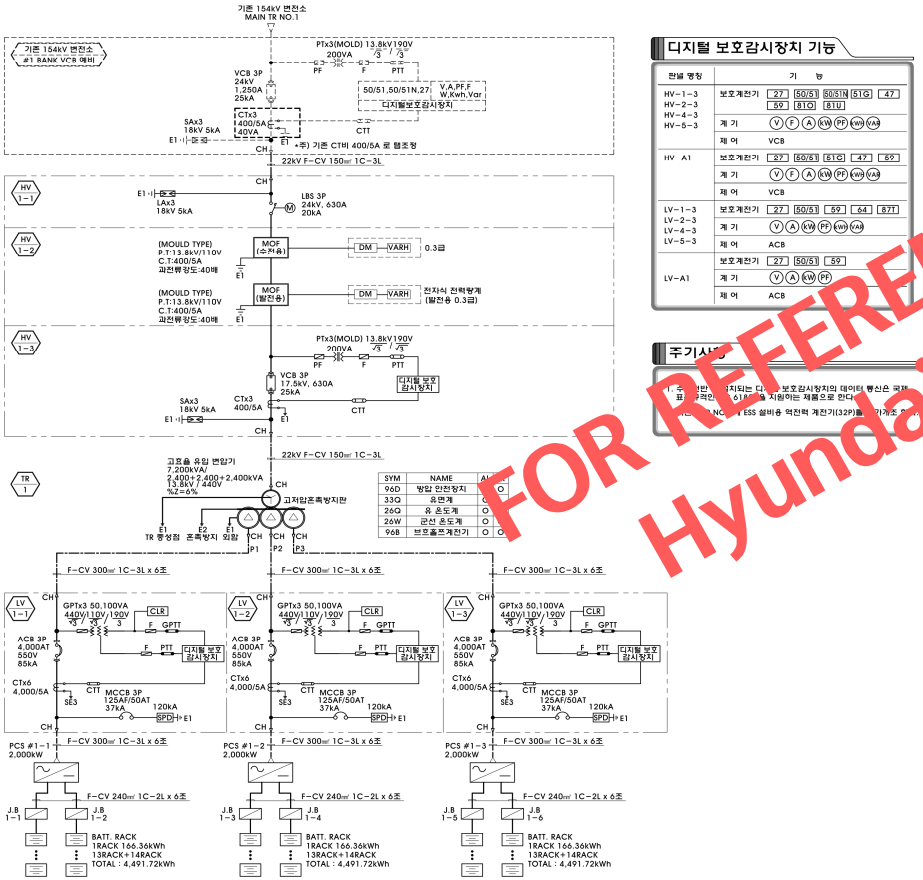
Battery

EMS

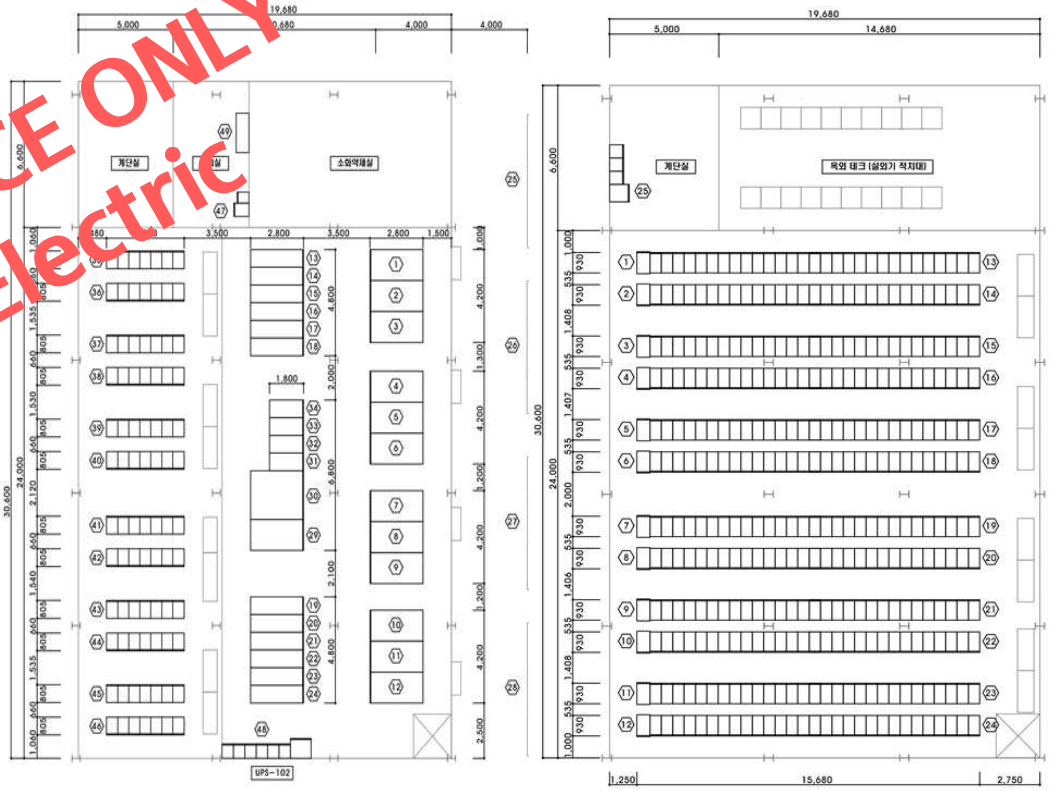
3. Site and Drawing Sample

(Hyundai Heavy Industries : PCS 24MW / Battery 51.5MWh)

〈Single Line Diagram〉



〈Layout〉



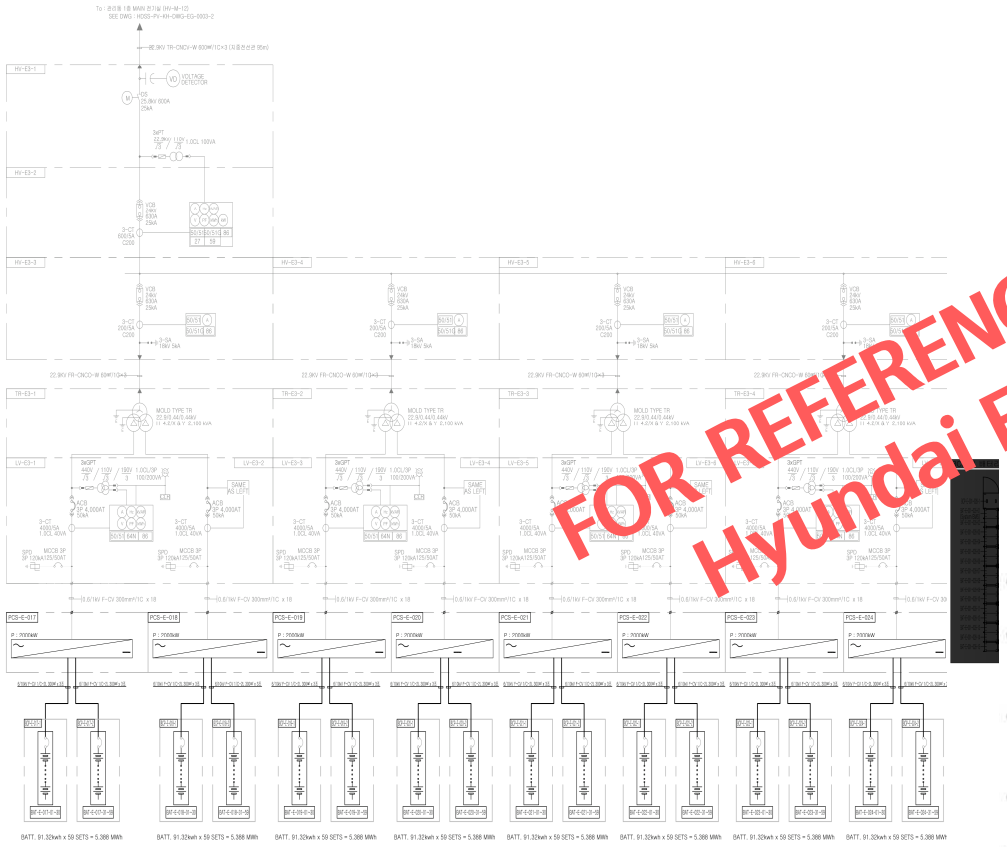
3. Site and Drawing Sample
(Seosan PV Farm 65MW: ESS 52MW – 140MWh)

ESS Building

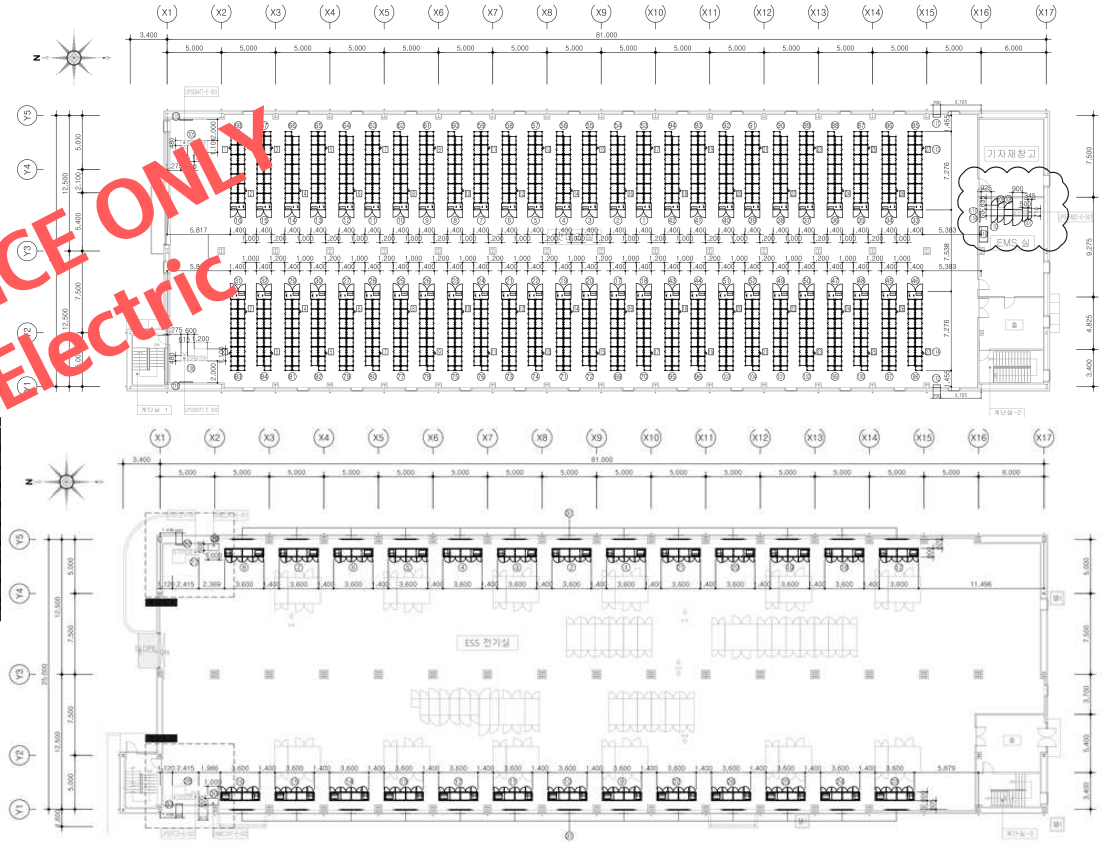
TR, GIS, Control Building

3. Site and Drawing Sample
(Seosan PV Farm 65MW: ESS 52MW – 140MWh)

〈Single Line Diagram〉



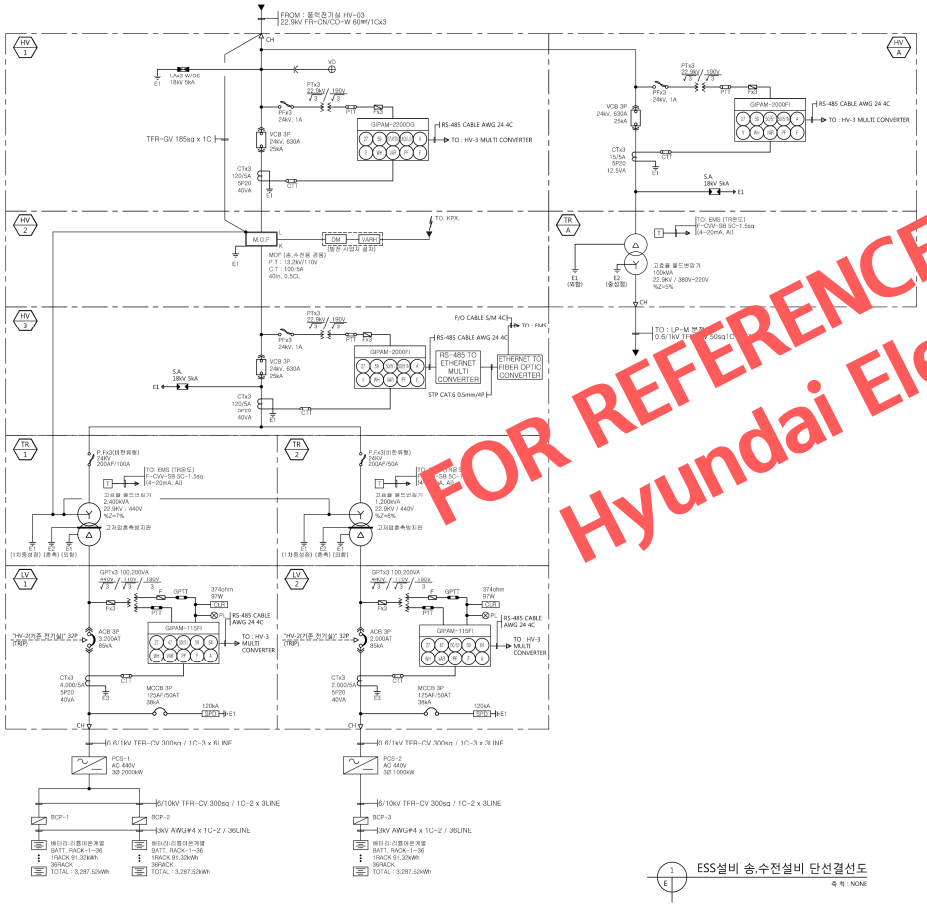
〈Layout〉



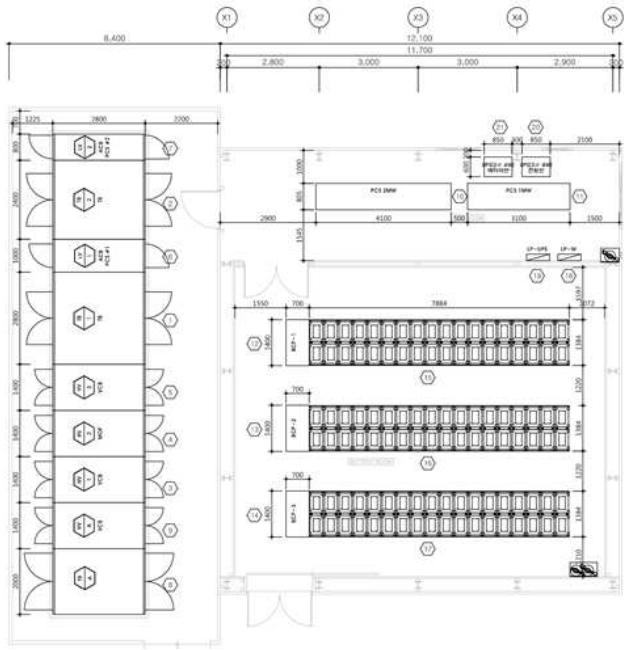
3. Site and Drawing Sample
(Honam Wind Farm 20MW: ESS 3MW – 10MWh)

3. Site and Drawing Sample
(Honam Wind Farm 20MW: ESS 3MW – 10MWh)

〈Single Line Diagram〉



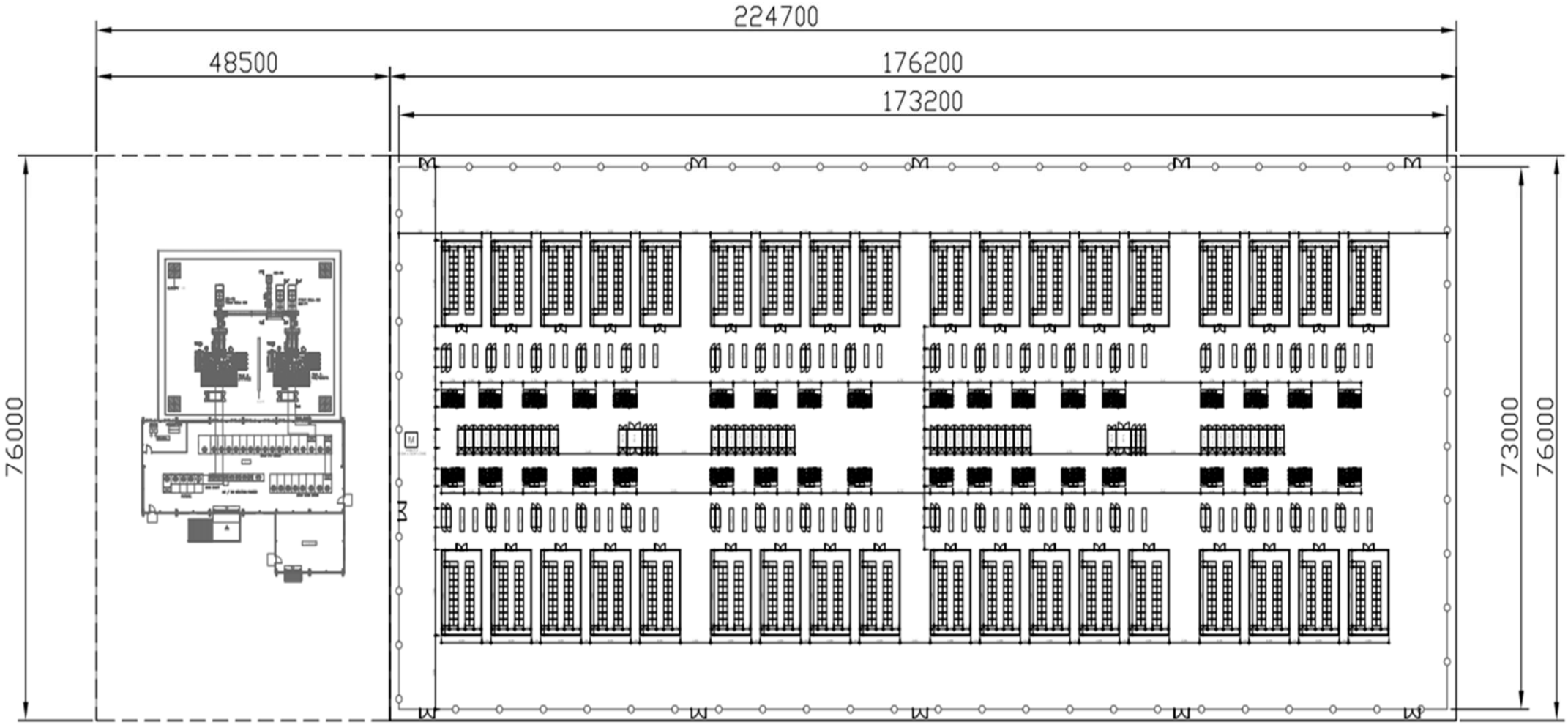
〈Layout〉



3. Site and Drawing Sample (World Largest PV ESS)

(Solasido PV Farm 100MW : PCS 72MW / Battery 305MWh)

〈Layout〉



(C.O.D : Dec. 2019)

Part3. Appendix

1. Reference List
2. Site Photo
3. Hyundai All In One ESS
4. Fuel Cell Solution
5. Certificates

1. Reference List

- Large scale(more than 50MWh) EPC Capabilities in ESS solution business
- Verified deep understanding in ESS operation and maintenance based on the numerous sites operating

Reference Record of ESS/FEMS/BEMS/PV(Solar) Project

Hyundai Electric & Energy Systems — 1-Apr-19

No.	Project	Purpose	Customer	Location	Solar PV Capa. (MW)	PCS Capa. (MW)	Battery Capa. (MWh)	Completion Date	Remarks
1	Solasido PV ESS	(Solar) ESS	Hanyang construction	Jeonnam, Korea		72	287	31-Dec-19	Preferred Bidder
2	ENTehcnology PV ESS	(Solar) ESS	ENTechnology	Geonbuk, Korea		10	29.8	30-Apr-19	Operating
3	Whanam PV & ESS(Inc. O&M)	(Solar) PV + ESS	Chilgok Whanam Solar	Chilgok, Korea	8.0	8.0	23.4	30-Jun-19	Under Construction
4	PV ESS (Total 6 Sites Inc. Gunwi)	(Solar) PV ESS	Hyundai Energy System	Gyeongbuk (Inc. Gunwi), Korea		4.3	14.2	28-Feb-19	Operating
5	ESS (Total 6 Sites Inc. Samil Spinning)	Industry ESS	Hyundai Energy System	Gyeongbuk (Inc. Gyeongsan), Korea		4.5	16.5	31-Dec-18	Operating
6	Emergency Operations Center ESS	Industry ESS	Hyundai Construction Co., Ltd.	Seoul, Korea		0.5	1.1	31-Dec-18	Operating
7	Seosan PV ESS	(Solar) PV ESS	Hyundai Construction Co., Ltd.	Seosan, Korea		52.0	140.0	31-Dec-18	Operating
8	Hyundai Samho Heavy Industries ESS	Industry ESS	Hyundai Samho Heavy Industries Co., Ltd.	Yeongam, Korea		4.0	10.0	30-Nov-18	Operating
9	Chunilpaper ESS (Main Equipment)	Industry ESS	Daegun Energy Co.	Jeonju, Korea		1.6	8.4	30-Sep-18	Operating

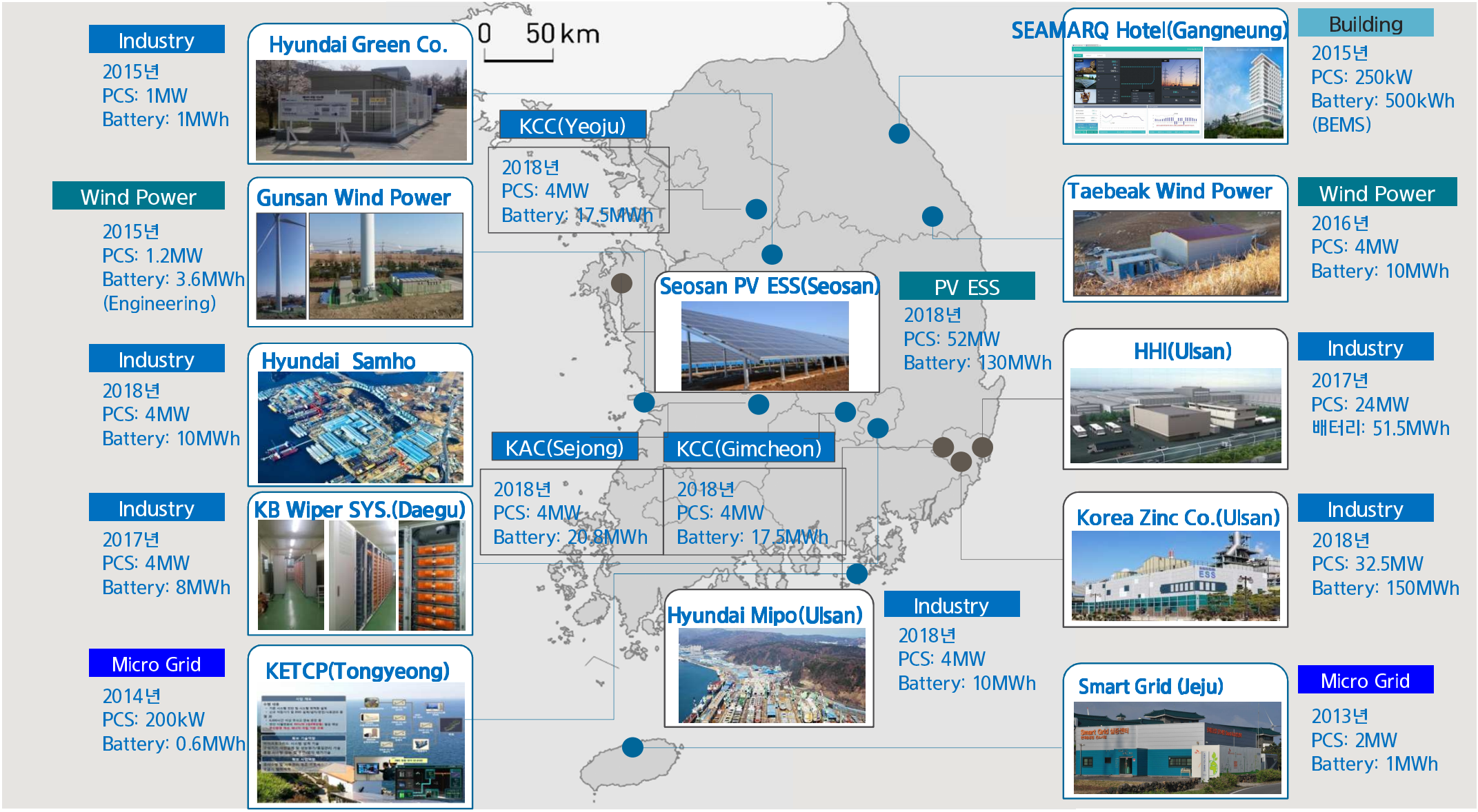
1. Reference List

10	BYC HighCity ESS	Industry ESS	DucSan Information Telecom Co., Ltd.	Seoul, Korea		0.8	3.3	31-Aug-18	Operating
11	Konka Green Solar PV (Inc. O&M)	(Solar) PV	Konka Green Solar	Seosan, Korea	3.4			15-Aug-18	Operating
12	Korea Solar ESS (Main Equipment)	(Solar) PV ESS	GaiaEnergy Co.			1.0	3.0	31-Jul-18	Operating
13	PV ESS (Total 8 Sites Inc. OSG Korea)	(Solar) PV ESS	Hyundai Electric Industrial System	Daegu, Korea		4.0	19.2	30-Jul-18	Operating
14	DSP PV ESS	(Solar) ESS	DSP ENG	Gangwon, Korea			44.2	30-Jun-18	Operating
15	Majeong Energy PV ESS (Main Equipment)	(Solar) PV ESS	YesEnerTech Co.	Majeong, Korea		2.0	6.2	30-Jun-18	Operating
16	Hyundai Mipo Dockyard ESS	Industry ESS	Hyundai Mipo Dockyard Co., Ltd.	Ulsan, Korea		4.0	10.0	30-Jun-18	Operating
17	Honam Wind Power ESS	Wind Power ESS	Honam Wind Power Co.	Yeonggwang, Korea		3.0	9.0	29-Jun-18	Operating
18	KCC ESS	Industry ESS	KCC	Yeoju, Korea		2.0	17.5	30-May-18	Operating
19	KCC ESS	Industry ESS	KCC	Gimcheon, Korea		2.0	17.5	30-May-18	Operating
20	Korea Autoglass Corporation ESS	Industry ESS	KAC	Sejong, Korea		2.0	20.8	30-May-18	Operating
21	Daegu Industrial Estate ESS	Industry ESS	KBWS, Ilshin Plastic Corp, Central DTS Corp.	Daegu, Korea		4.0	8.0	30-Nov-17	Operating

1. Reference List

22	KC Cottrell ESS	Industry ESS	KC Cottrell	Anseong, Korea		0.3	1.1	31-Dec-17	Operating
23	Korea Zinc ESS	Industry ESS	Korea Zinc Co., Ltd.	Ulsan, Korea		25.0	150.0	31-Dec-17	Operating
24	Hyundai Heavy Industries ESS/FEMS	Industry ESS/FEMS	Hyundai Heavy Industries Co., Ltd.	Ulsan, Korea		24.0	50.0	31-Oct-17	Operating
25	Taebaek Wind Power ESS	Wind Power ESS	Taebaek Wind Power IPP	Taebaek, Korea		3.0	9.0	20-Dec-16	Operating
26	Guk-do Micro Grid	Micro Grid	Tongyeong City	Tongyeong, Korea		0.1	0.6	30-Oct-16	Operating
27	SEAMARQ Hotel BEMS	BEMS	SEAMARQ Hotel	Gangneung, Korea				2015	Operating
28	L & F ESS (Engineering)	Industry ESS	L & F Co.	Daegu, Korea				2015	Operating
29	Gunsan Wind Power ESS (Engineering)	Wind Power ESS	Gunsan Wind Power Co.	Gunsan, Korea				2015	Operating
30	Hyundai Green Energy ESS (Korean National Project)	Industry ESS	Hyundai Green Co., Ltd.	Eumseong, Korea		1.0	1.0	31-May-14	Operating
31	Smart Grid (Korean National Project)	Micro Grid	KETEP	Jeju, Korea		0.3	1.1	31-Dec-10	Closed
Total					11.4	145.3	901.9		

2. Site Photo


0 50 km
Industry
2015년
PCS: 1MW
Battery: 1MWh
Hyundai Green Co.
Wind Power
2015년
PCS: 1.2MW
Battery: 3.6MWh
(Engineering)
Gunsan Wind Power
Industry
2018년
PCS: 4MW
Battery: 10MWh
Hyundai Samho
Industry
2017년
PCS: 4MW
Battery: 8MWh
KB Wiper SYS.(Daegu)
Micro Grid
2014년
PCS: 200kW
Battery: 0.6MWh
KETCP(Tongyeong)
KCC(Yeoju)
2018년
PCS: 4MW
Battery: 17.5MWh
Seosan PV ESS(Seosan)
KAC(Sejong)
2018년
PCS: 4MW
Battery: 20.8MWh
KCC(Gimcheon)
2018년
PCS: 4MW
Battery: 17.5MWh
Hyundai Mipo(Ulsan)
PV ESS
2018년
PCS: 52MW
Battery: 130MWh
Industry
2018년
PCS: 4MW
Battery: 10MWh
SEAMARQ Hotel(Gangneung)
Building
2015년
PCS: 250kW
Battery: 500kWh
(BEMS)
Taebeak Wind Power
Wind Power
2016년
PCS: 4MW
Battery: 10MWh
HHI(Ulsan)
Industry
2017년
PCS: 24MW
배터리: 51.5MWh
Korea Zinc Co.(Ulsan)
Industry
2018년
PCS: 32.5MW
Battery: 150MWh
Smart Grid (Jeju)
Micro Grid
2013년
PCS: 2MW
Battery: 1MWh

3. Hyundai All In One ESS

All-In-One
ESS

HYUNDAI ELECTRIC's AIO product has been designed as one package including Battery, PCS, Switchgear panel which are part of ESS, and AIO can be selected based on the capacity of batteries for PV or load.
AIO can be fabricated shortly better than order-made ESS, and responsibility for installation / O&M by HYUNDAI ELECTRIC global service network.

All-In-One ESS
- All-In-One package
- Optimized installation size below PV panel.

Cost Efficiency
- The best quotation based on standardization and optimization for customer satisfaction.

Easy Monitoring
- Cloud / Mobile service.

Warranty Service
- Based on the terms and conditions

Energy Efficiency
- Low powered HVAC system.
- Technical proposal for the best capacity & economic efficiency.

Exterior

HYUNDAI ELECTRIC
All-In-One ESS 100kW-250kWh

(Model : HI-AIO-100-250)
Battery capacity can be enlarged.

Interior

Incoming/ Distribution Panel

PCS

Battery

3. Hyundai All In One ESS

HI-AIO-100-250		HI-AIO-200-500	
Battery capacity	Operation : 264kWh Design : 278kWh	Battery capacity	Operation : 528Wh Design : 556kWh
AC Rated Output	100kW	AC Rated Output	200kW
Round Trip Efficiency	90%	Round Trip Efficiency	Same as "HI-AIO-100-250"
Guarantee	Based on the condition	Guarantee	
Operating Temp./ Humidity	-20~+50℃ / 95%(non-condensing)	Operating Temp./ Humidity	
IP Rating	Battery : IP54, IP55 PCS : IP44	IP Rating	
AC grid connection	3-phase 4-wire system 380V	AC grid connection	
Transformer	Not included	Transformer	
Size(WxDXH, mm)	3,900 x 1,400 x 1,400	Size(WxDXH, mm)	6,300 x 1,400 x 1,400
Weight	3,500~4,000kg	Weight	6,257~7,000kg
EMS	Based on Cloud	EMS	Same as "HI-AIO-100-250"
Security	Firewall, Server Access Control	Security	
PCS Requirement	SGSF-025-4 KS-C-IEC-62477-1	PCS Requirement	
Battery Requirement	KBIA-10104-01 KBIA-10104-02	Battery Requirement	

Cloud EMS Solution

This is HYUNDAI ELECTRIC's own solution to control the "All-In-One ESS" of multiple site

Main Service

Real time monitoring

- Real time ESS status (Charge/Discharge, Operation mode, Output, Frequency, Temperature of Battery and so on.)
- Real time PV and load status (Amount of generation, Voltage, Current, Temperature of Outside/Inside, Output(kW) and so on.)

Return analysis

- Management of FIT(Feed In Tariff) ; Cause of variation, History of price change and so on.)
- Management of Return; Return per site, Analysis the factor of return
- Return Forecast; Customer return simulation according to price variation

System control & Maintenance

- Time Based Management; SMS, Email notice, maintenance history
- Remote control for charging/discharging; Manual, Automatic, Schedule mode, Setting the condition of charging/discharging

Statistics & Efficiency analysis

- System performance, Efficiency of PCS/Battery, Failure rate, Operation rate, Battery SOH and so on.
- Supply the various efficiency indicators; Amount of solar radiation-generation, PV generation-PCS charging-efficiency and Amount of charging from grid and discharging to grid.

4. Fuel Cell Solution(Illustrative)

- Hyundai Electric provides the appropriate Fuel Cell solution for our valued customers.

PRODUCT SPECIFICATIONS

Type	PEM (Proton Exchange Membrane) Fuel Cell Power Generator[1]	
Performance	Electrical Output Continuous	1 MWe
	Electrical Efficiency	>50% LHV at BOL
	System Output Voltage	380 - 480 VAC
	System Output Frequency	50 - 60 Hz
	Package Design Life	20 years with LTSA
Physical Characteristics	Dimensions: (H) x (W) x (L)	9.6 x 8 x 40 feet (x2)
	Weight	32,000 kg
Fuel	Hydrogen[2]	99.99%
	Fuel Consumption[3]	250 Nm³/h per MW[3]
	Aux Electrical Input Power	35 kW continuous, 40 kW at start-up
Available Heat	Output Heat Load	< 1.5 MW
	Stack Temperature	Up to 70°C
	Exhaust Gas Temperature	70°C
Emissions	Noise level at 1m	Approx. 75 dB in open air
	Pollutants	Zero emissions (No GHG or local air pollutants)

[1] Conditions: Inlet air temperature: 15°C | Atmosphere pressure: 101.3 kPa
[2] Fuel type: Hydrogen according to ISO/TS 14687-2:2008(E)
[3] Cumulative average. Fuel consumption calculated for reference only. Actual fuel consumption may vary.

Maker: Hydrogenics

FCI Design, 120kW x2 확장형
(6kW 모듈 적용)

FCI Design, 500kW - 1MW 확장형 제품
(25kW LSM 스택 또는 활용)

Maker: FCI

5. Certificate (ISO 14001)

DNV·GL

MANAGEMENT SYSTEM CERTIFICATE

Certificate No:
215839-2017-AE-KOR-RvA

Initial certification date:
22 March, 2017

Valid:
20 May, 2018 - 22 March, 2020

This is to certify that the management system of

HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.

Head Quarters & Ulsan Factory(1): 700, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea
and the sites as mentioned in the appendix accompanying this certificate

has been found to conform to the Environmental Management System standard:
ISO 14001:2015, KS I ISO 14001:2015

This certificate is valid for the following scope:
Design and Manufacture of Transformers, Rotating Machinery, Switchgear, Navigation & Automation System, Low Voltage Circuit Breakers, High Voltage Circuit Breakers, Power Electronics

Place and date:
Seoul 21 May, 2018

MGMT. SYS.
RvA C 024

The RvA is a signatory to the IAF MLA

For the issuing office:
DNV GL – Business Assurance
18F, Kyobo Bldg., 1, Jong-ro, Jongno-gu,
Seoul, Korea

In-Kyoon Ahn
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV GL Business Assurance B.V., ZWOLSEWEG 1, 2994 LB, BARENDRECHT, NETHERLANDS. TEL: +31102922689. assurance.dnvgl.com

DNV·GL

Certificate No: 215839-2017-AE-KOR-RvA
Place and date: Seoul 21 May, 2018

Appendix to Certificate

HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.
Locations included in the certification are as follows:

Site Name	Site Address	Site Scope
HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.	Head Quarters & Ulsan Factory(1): 700, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea	Design and Manufacture of Transformers, Switchgear, Navigation & Automation System, Low Voltage Circuit Breakers, High Voltage Circuit Breakers, Power Electronics
HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.	Ulsan Factory (2): 1000, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea	Design and Manufacture of Rotating Machinery
HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.	Seonam Factory: 223, Sapyeong-ro, Nam-gu, Ulsan, Korea	Design and Manufacture of Transformers and Switchgear

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV GL Business Assurance B.V., ZWOLSEWEG 1, 2994 LB, BARENDRECHT, NETHERLANDS. TEL: +31102922689. assurance.dnvgl.com
Page 2 of 2

5. Certificate (OHSAS 18001)

DNV·GL

MANAGEMENT SYSTEM CERTIFICATE

Certificate No:
215840-2017-AE-KOR-DNV

Initial certification date:
22 March, 2017

Valid:
22 March, 2017 – 22 March, 2020

This is to certify that the management system of

HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.
700, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea
and the sites as mentioned in the appendix accompanying this certificate

has been found to conform to the Occupational Health and Safety Management System standard:
OHSAS 18001:2007

This certificate is valid for the following scope:
Design and Manufacture of Transformers, Rotating Machinery, Switchgear, Navigation & Automation System, Low Voltage Circuit Breakers, High Voltage Circuit Breakers, Power Electronics

Place and date:
Seoul 23 March, 2017

MANAGEMENT SYSTEM CERTIFICATION
DNV·GL

For the issuing office:
DNV GL – Business Assurance
18F, Kyobo Bldg., 1, Jong-ro, Jongno-gu, Seoul, Korea

In-Kyeon Ahn
Management Representative

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV GL Business Assurance Korea Ltd, 18F Kyobo Bldg., 1 Jong-ro, Jongno-gu, Seoul, Republic of Korea. TEL: +82 2 723 7593.
dnvgl.kr/assurance

DNV·GL

Certificate No: 215840-2017-AE-KOR-DNV
Place and date: Seoul 23 March, 2017

Appendix to Certificate

HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd.
Locations included in the certification are as follows:

Site Name	Site Address	Site Scope
HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd. Ulsan Factory	700, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea	Design and Manufacture of Transformers, Switchgear, Navigation & Automation System, Low Voltage Circuit Breakers, High Voltage Circuit Breakers, Power Electronics
	1000, Bangeojinsunhwando-ro, Dong-gu, Ulsan, Korea	Design and Manufacture of Rotating Machinery
HYUNDAI ELECTRIC AND ENERGY SYSTEMS Co., Ltd. Seonam Factory	223, Sapyeong-ro, Nam-gu, Ulsan, Korea	Design and Manufacture of Transformers and Switchgear

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.
ACCREDITED UNIT: DNV GL Business Assurance Korea Ltd, 18F Kyobo Bldg., 1 Jong-ro, Jongno-gu, Seoul, Republic of Korea. TEL: +82 2 723 7593.
dnvgl.kr/assurance

5. Certificate (UVDB)

Achilles UVDB

Certificate of Qualification

This is to certify that

Hyundai Electric & Energy Systems Co., Ltd

Supplier Number: 059041

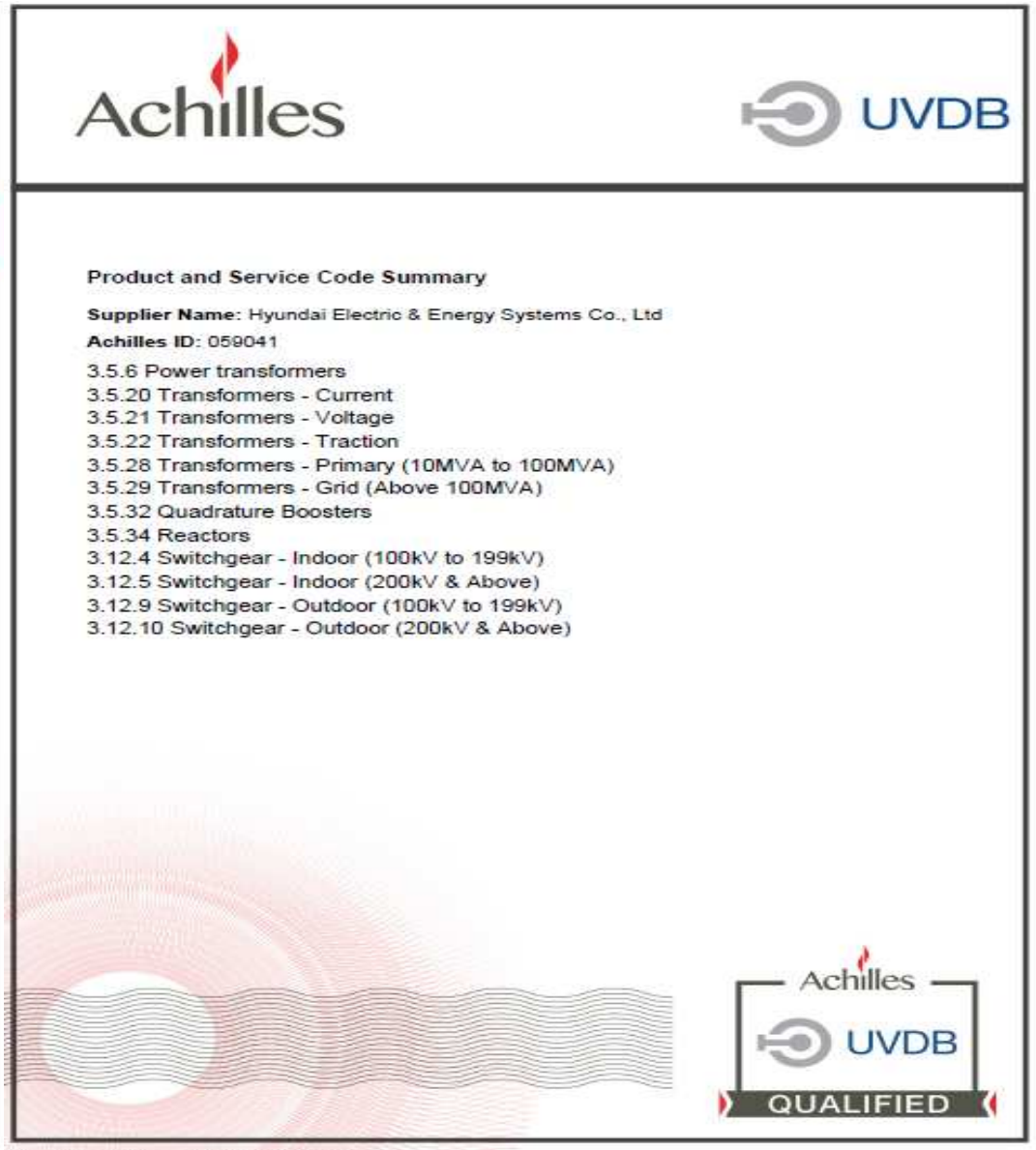
are now fully qualified as a supplier on Achilles UVDB.

Ian Bartle
Chair UVDB Steering Group

Tom Grand
UKI Regional Director, Achilles

Registration Expiry Date: 22 November 2019
This is not a legal document and cannot be used as such.

Achilles UVDB QUALIFIED



Achilles UVDB

Product and Service Code Summary

Supplier Name: Hyundai Electric & Energy Systems Co., Ltd
Achilles ID: 059041

3.5.6 Power transformers
3.5.20 Transformers - Current
3.5.21 Transformers - Voltage
3.5.22 Transformers - Traction
3.5.28 Transformers - Primary (10MVA to 100MVA)
3.5.29 Transformers - Grid (Above 100MVA)
3.5.32 Quadrature Boosters
3.5.34 Reactors
3.12.4 Switchgear - Indoor (100kV to 199kV)
3.12.5 Switchgear - Indoor (200kV & Above)
3.12.9 Switchgear - Outdoor (100kV to 199kV)
3.12.10 Switchgear - Outdoor (200kV & Above)

Achilles UVDB QUALIFIED

5. Certificate (UNCE)

Utilities NCE
Powered by Achilles

Certificate of Registration

Awarded to:

Hyundai Electric & Energy Systems Co., Ltd.

Company Registration number: 266-86-00531

Achilles Utilities Nordics & Central Europe hereby confirms that Hyundai Electric & Energy Systems Co., Ltd. is now fully registered as a supplier in Achilles Nordics & Central Europe Pre-Qualification System for the products/service codes listed in the appendix.

Supplier Id: 108181
Issued Date: 13/11/2018
Expiry Date: 23/11/2019

Anja Thorsdalen
European Operations Manager
Achilles Information Limited

Klaus Kræmer
Head of Utilities, Nordics & Central Europe
Achilles Information Limited

Achilles
Utilities NCE
QUALIFIED

participating utilities may use UNCE as the basis for preparation of bidder lists directly or together with additional qualification criteria established by the individual utility. Other ification stages may be added by the individual utility if more information is found necessary to complete the preparation of bidders lists.

Utilities NCE
Powered by Achilles

Registered Products & Services

Hyundai Electric & Energy Systems Co., Ltd.

has registered the following products and services in the Achilles Utilities Nordics & Central Europe Community:

- 3.5.28 Transformers - Primary (10MVA to 100MVA)
- 3.5.29 Transformers - Grid (Above 100MVA)
- 3.5.34 Reactors
- 3.12.4 Switchgear - Indoor (100kV to 199kV)
- 3.12.5 Switchgear - Indoor (200kV & Above)

(*) The UNCE qualification does not apply to codes marked with an asterisk. The company's role is 'Agent' for these codes, and as such it is not selling the product itself but acting on behalf of others.

5. Certificate (Power & Tech)

Achilles

Power & Tech Global

Certificate of Registration

This is to certify that

HYUNDAI ELECTRIC & ENERGY SYSTEMS CO. LTD

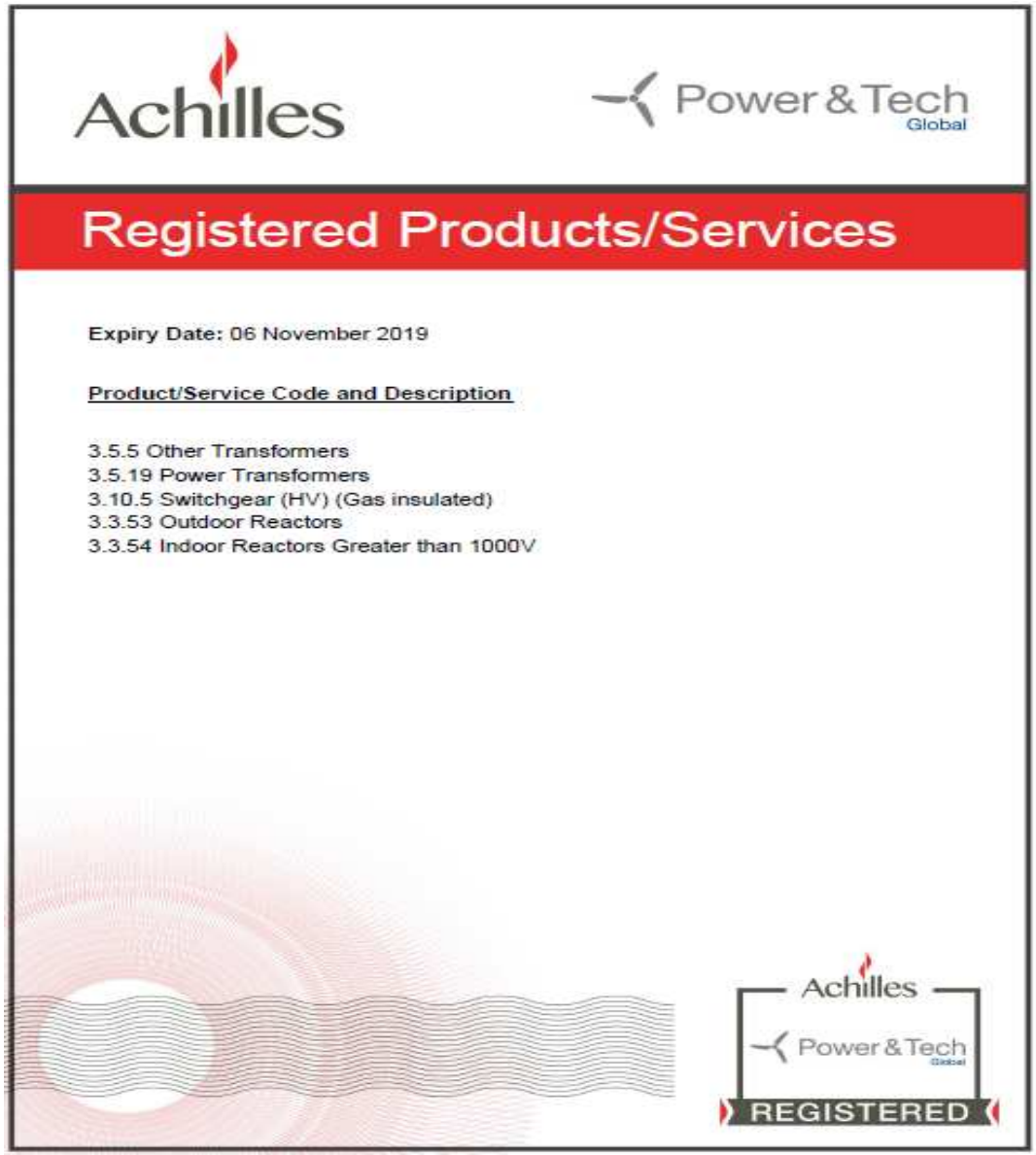
Is now a registered supplier in the Achilles Power & Tech Community, and that company information related to the following criteria has been checked and validated by Achilles Information Limited, an independent third party:

- Supply Chain Management
- Corporate Social Responsibility
- Health & Safety Management
- Quality Management
- Environmental Management
- Carbon Management
- Financial & Insurance
- Information Security & Data Protection

Supplier ID: 270616

Francisco Lopez
Power & Tech Community Director
Achilles Information Limited

Achilles Power & Tech REGISTERED



Achilles

Power & Tech Global

Registered Products/Services

Expiry Date: 06 November 2019

Product/Service Code and Description

3.5.5 Other Transformers
3.5.19 Power Transformers
3.10.5 Switchgear (HV) (Gas insulated)
3.3.53 Outdoor Reactors
3.3.54 Indoor Reactors Greater than 1000V

Achilles Power & Tech REGISTERED

5. Certificate (Supply-Line, FPAL)

Achilles Supply-Line

Certificate of Registration

This is to certify that

Hyundai Electric & Energy Systems Co., L

Supplier Number: 714072

are now fully registered as a supplier on Supply-Line for the following product codes:

1.07.28	Transformers - Primary (10MVA to 100MVA)
1.07.29	Transformers - Grid (Above 100MVA)
1.07.34	Reactors
1.24.04	Switchgear - Indoor (100kV to 199kV)
1.24.05	Switchgear - Indoor (200kV & Above)

Last Financial Year: 2017

Last Update of Questionnaire: 21 September 2018

This is not a legal document and cannot be used as such.

Achilles Supply-Line Registered

Achilles FPAL

Certificate of Registration

Achilles First Point Assessment (FPAL)
for suppliers to the Oil & Gas Industry

This is to certify that

HYUNDAI ELECTRIC & ENERGY SYSTEMS CO., LTD

Company Registration Number: 266-81-00531

Supplier Number: 10054480

is now fully registered as a supplier on
the Achilles First Point Assessment Database
for suppliers to the Oil & Gas Industry
for the provision of products and services as detailed
in their membership listing on www.fpal.com

Malcolm Wilson
FPAL Director

Issued Date: 2018-02-08

Expiry Date: 2019-01-13

Achilles First Point Assessment (FPAL)
7 Burnbank Business Centre Souterhead Road Aberdeen Scotland AB12 3LF UK
T: +44 (0)1224 337 533 F:+44 (0)1224 337 544 E:fpal@fpal.com W:www.fpal.com

5. Certificate (RePro)

Nº RePro: 325785

HYUNDAI ELECTRIC & ENERGY SYSTEMS CO.,LTD.

RePro empowered by Achilles

Una vez superado el proceso de registro, se extrae la siguiente información puntual de la documentación depositada:

Constitución
Año: **2017**

Situación con la Seguridad Social
Al corriente: **SÍ** — Último Certificado disponible: **02/07/2018**

Situación con la AEAT
Al corriente: **SÍ** — Vencimiento del último Certificado: **01/08/2019**

Seguro de Responsabilidad Civil
Nombre de la Cía. Aseguradora: **The Insurance Company of the State of Pennsylvania**
Límite Anual: **2.404.144** — Vencimiento de la Póliza: **01/02/2019**

Datos Financieros
Últimos datos financieros disponibles: **2016**
Observaciones:
Nota Achilles: cuentas por validar porque la empresa se constituyó en abril de 2017 y no tenía cuentas individuales hasta 2016. Aguardamos envío del balance de cuentas de 2017.

Sistema de Gestión de Calidad
¿Certificado por un tercero? **SÍ**

Norma de Referencia: **ISO 9001: 2015**
Certificador: **DNV GL**
Fecha de Certificación: **22/03/2017** — Fecha de Vencimiento: **22/03/2020**

Sistema de Gestión Medioambiental
Situación: **SISTEMAS DE GESTIÓN MEDIOAMBIENTAL**

Norma de Referencia: **ISO 14001:2015**
Certificador: **DNV GL**
Fecha de Certificación: **22/03/2017** — Fecha de Vencimiento: **22/03/2020**

Sistema de Gestión de Prevención de Riesgos Laborales
¿Dispone de un SGPRL documentado? **SÍ**
¿Sistema Certificado por un tercero? **SÍ**

Alcance del Certificado
RePro España, Portugal e Italia

Estado General de la Documentación:

Nº RePro: 325785

HYUNDAI ELECTRIC & ENERGY SYSTEMS CO.,LTD.

RePro empowered by Achilles

1.06.01 Transformadores de potencia
1.06.09 Motores eléctricos de media-alta tensión
1.06.10 Motores eléctricos de baja tensión
1.06.15 Interruptores de interior de media tensión
1.06.28 Celdas y cabinas

Certificado válido hasta el día: 17/11/2019

Este certificado indica que el Proveedor en cuestión está registrado en RePro en los productos y/o servicios señalados para las empresas participantes en el Registro de Proveedores. RePro podrá ser utilizado por las Empresas Participantes, bien como base para realizar la selección de proveedores que serán invitados a presentar ofertas, o bien como requisito previo para poder acceder a sus propios sistemas de clasificación.

Nº RePro: 325785

HYUNDAI ELECTRIC & ENERGY SYSTEMS CO.,LTD.

RePro empowered by Achilles

Eva Lezcano
Director de Operaciones
Achilles South Europe, S.L.U.

Agustín Amores
Presidente del Comité
En representación de las Empresas Participantes.