

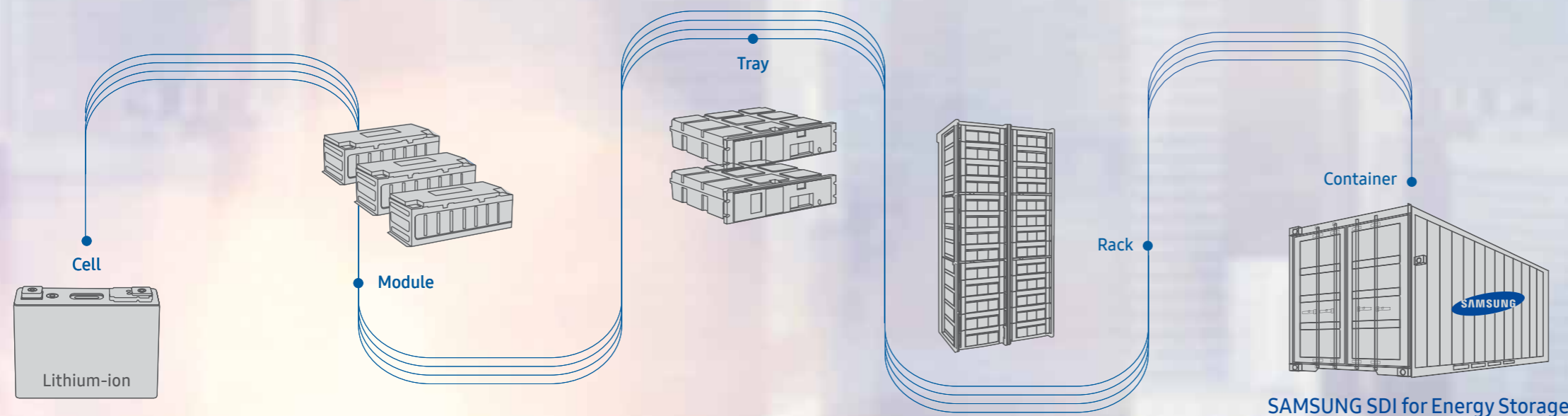
Smart Battery Systems

for Energy Storage







Creative Energy & Materials Solution Leader

Samsung SDI is creating a future energy world on the foundation of technology and innovation. As a global leading provider of lithium-ion batteries and electronic materials, Samsung SDI's innovation and excellence is part of our customers' lives around the world



Samsung SDI businesses

	Small-Sized Li-ion Battery	IT devices / Power devices Transportation devices
	Automotive Battery	Pure Electric Vehicle (EV) Hybrid Electric Vehicle (HEV) Plug-in HEV Micro-/Mild HEV
	Energy Storage Systems (ESS)	Utility-Scale Energy Storage Commercial Energy Storage Residential Energy Storage UPS battery Telecom battery
	Electronic Materials	Semiconductor LCD · OLED / Photovoltaic

ESS history

- 1970 ○ Established Samsung SDI
- 2000 ○ Started LIB (Lithium-ion battery) business
- 2008 ○ Started LIB business for automotives
- 2010 ○ Started LIB business for ESS
- 2011 ○ Entered residential ESS market in Japan
- 2012 ○ Supplied UPS batteries to bank data centers
- 2013 ○ Residential ESS achievements
- No.1 market share in Japan
- Obtain VDE certifications
- 2014.5 ○ 2014 Frost & Sullivan award for ESS in Europe
- 2014.9 ○ Supplied utility-scale energy storage to Schwerin project in Germany
- 2014.12 ○ No. 1 global market share in batteries for ESS (B3 research, 2014)
- 2015.5 ○ Hybrid UPS system (UPS+ESS) started operation in Uiwang, Korea
- 2015.6 ○ Supplied batteries to 1st frequency regulation ESS project in Korea
- 2015.12 ○ No. 1 global market share in batteries for ESS for two years in a row (B3 research, 2015)
- 2016.8 ○ Awarded the world's largest ESS project in USA

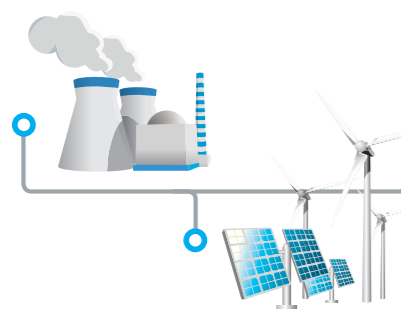
Optimized Battery Solutions for ESS Applications

Samsung SDI provides a variety of solutions from residential to utility-scale energy storage



Applications

ESS category ● Utility-Scale ● Commercial ● UPS ● Residential ● Telecom



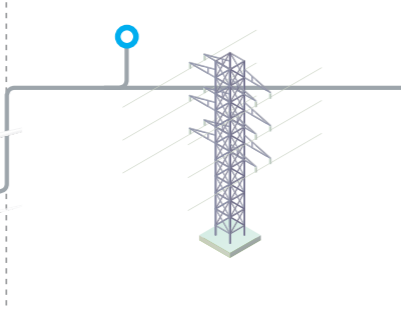
Generation

Ancillary Services

- Spinning reserves
- Non-spinning reserves
- Voltage support
- Black start

Bulk Energy Services

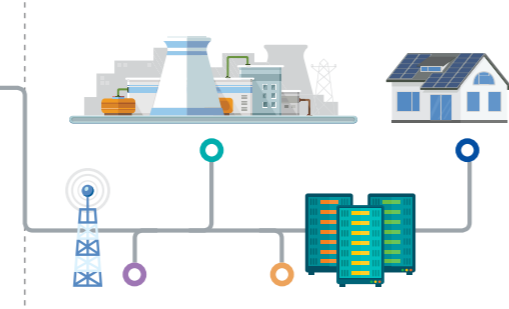
- Electric energy time-shift (Arbitrage)
- Electric supply capacity



T&D (Transmission & Distribution)

T&D Infrastructure Services

- Frequency regulation
- Transmission upgrade deferral
- Transmission congestion relief
- Distribution upgrade deferral
- Voltage support



Demand

Customer Energy Management Services

- Power quality
- Power reliability
- Retail electric energy time-shift
- Demand charge management

Product Line-up



Prismatic Lithium-ion Cells



Battery Modules & Trays



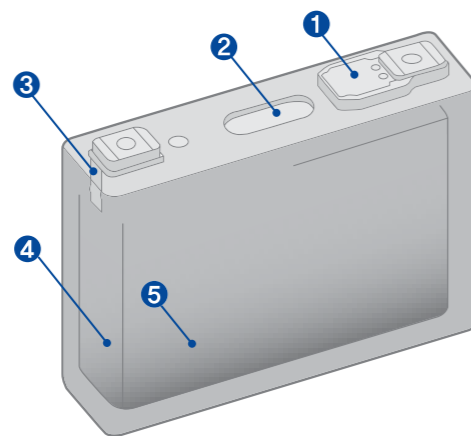
Battery Systems for Utility-Scale, Commercial and UPS

Reliable Samsung SDI Continuous Innovation

Based on excellent cell technology, our innovations make your ESS more enhanced and valuable



Safety First



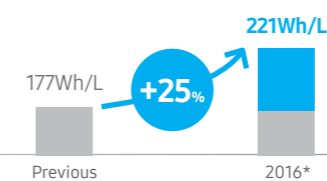
Multi-layered protection on cell

- ❶ OSD (Overcharge Safety Device)
- ❷ Vent
- ❸ Fuse
- ❹ SFL (Safety Functional Layer)
- ❺ NSD (Nail Safety Device)*

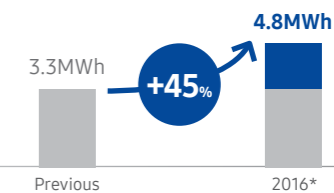
* In case of 94Ah cell

Higher Energy Density

[Module]



[Max 40ft ISO Container]



*Energy Line-up

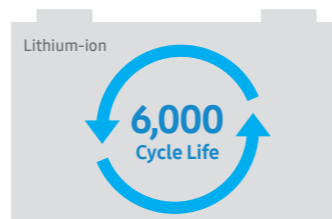
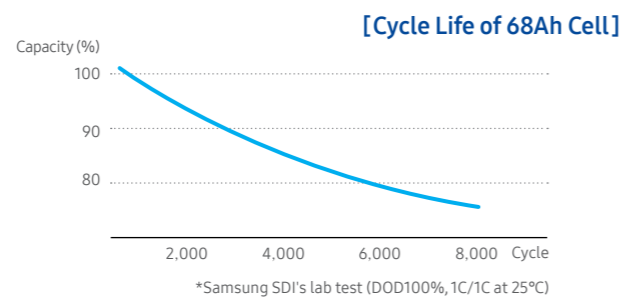
Innovative Changes for 2016

- High energy & high power cell
- Compact module
- Multiple arrangement

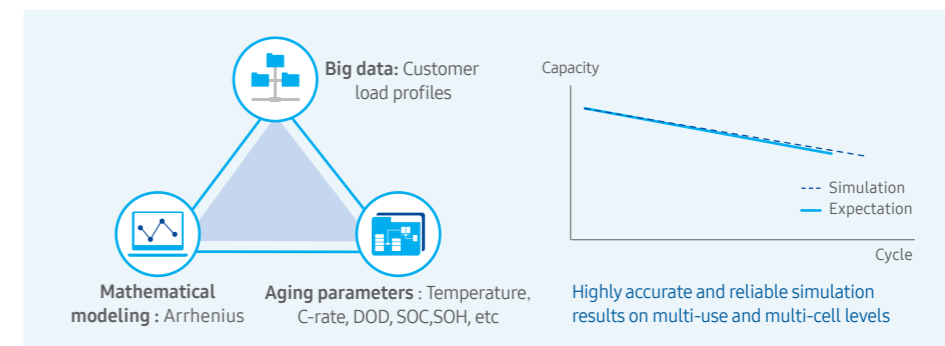
Long Cycle Life

Key Advantages of Samsung SDI's Cell

- Longer expected cycle life
- Slow, linear capacity degradation even for lower SOH levels
- Components design for longer durability (30years+)



Unique Samsung SDI's LTS (Life-Time Simulation) Technology



Battery Module & Tray

Module



Specification

Item		M2994	M2968	M2967
Cell type		Prismatic	Prismatic	Prismatic
Energy	kWh	2.8	2.0	2.0
Operating voltage	V	25.6 ~ 33.2	24.0 ~ 32.8	24.0~33.6
Peak discharge C-rate	C	0.5	4.0	6.0
Dimension (W x D x H)	mm	457 x 185 x 154	214 x 414 x 163	214 x 414 x 163
Weight	kg	22	17	17

2016 Module



Specification

Item		M8194 E2	M8194 M2	M8068 P2
C-rate	C	< 0.5	<1.0	1.0 ~ <2.5
Cell type		Prismatic	Prismatic	Prismatic
Cell capacity	Ah	94	94	68
Energy	kWh	7.6	7.6	5.5
Operating voltage	V	70.4 ~ 91.3	70.4 ~ 91.3	68.2 ~ 90.2
Dimension (W x D x H)	mm	370 x 588 x 160	370 x 650 x 160	370 x 650 x 160
Weight	kg	52.5	53	49

100V / 48V Solution

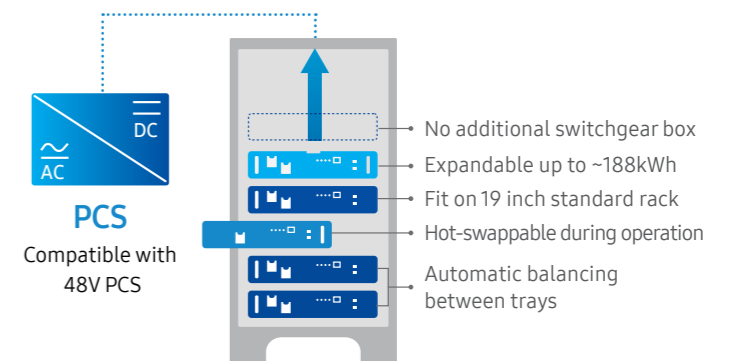
100V Solution _M10023

- Advanced cylindrical 21700 cell
- High conversion efficiency (DC to AC)
- Optimized for high voltage PCS
- Wide temperature range



48V Solution _M5194

- High energy prismatic 94Ah cell
- High energy density
- Long cycle life
- Available up to 1C-rate



Specification

Item		M10023	M5194
Component		Battery Module, BMS	Battery Module*, BMS
Cell type		Cylindrical	Prismatic
Energy (Rated/Usable)	kWh	2.3 / 2.0	4.84 / 4.84
Scalability (Usable)	kWh	32(16ea)	188 (39ea)
Operating voltage	V	84 ~ 112	44.8 ~ 58.1
Charging method		CC-CV	CC-CV
Dimension (W x D x H)	mm	454 x 200 x 173	484 x 450 x 163
Weight	kg	20	40
Operating temperature	°C	-10 ~ 60	-10 ~ 50
Life cycle **	Cycle	4,000	5,000

*Module base, tray type is optional **Under the condition at 25°C, EOL 80%

Battery System for Utility-Scale & Commercial

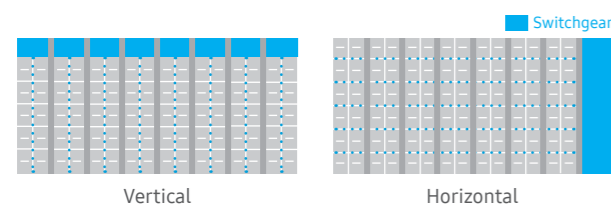
2016 Innovations

- High energy and high power in the same form factor
- All line-up based on single module with compact size
- Multiple arrangement for space optimization

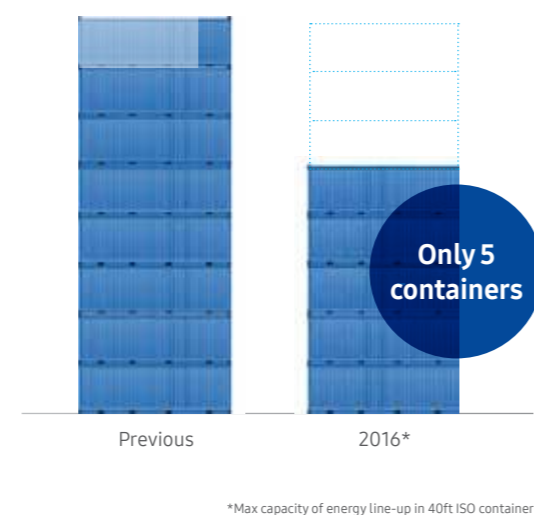
Customized combination for optimized ESS

Cell	Module	Arrangement
94 Ah	22S1P	Vertical
68 Ah		Horizontal

Multiple arrangement



24MWh case



Product Line-up

Energy	Medium	Power
<p>Power output</p> <p>Duration</p> <p>Energy shift, Peak Cut Curtailement</p>	<p>Power output</p> <p>Duration</p> <p>Peak cut Peak shift</p>	<p>Power output</p> <p>Duration</p> <p>Ancillary services Frequency regulation, Voltage support</p>
<p>Configuration</p>		<p>Cell ■ 94Ah ■ 68Ah</p>
<p>Max 40ft ISO container</p> <p>4.8MWh</p>	<p>4.8MWh</p>	<p>3.4MWh</p>

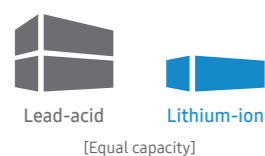
Specification

Item		Energy	Medium	Power
Module		M8194 E2	M8194 M2	M8068 P2
Configuration of rack		242S1P	264S1P	242S1P
Cell capacity	Ah	94	94	68
Energy	kWh	83.7	91.3	60.0
Operating voltage	V	774 ~ 1,004	845 ~ 1,096	750 ~ 992
Dimension (WxDxH)	mm	442 x 640 x 2,124	442 x 640 x 2,290	442 x 702 x 2,124
Weight	kg	659	718	618

Battery System for UPS (Uninterruptible Power Supply)

Benefits of Lithium-ion Battery for UPS

Less Space/Weight



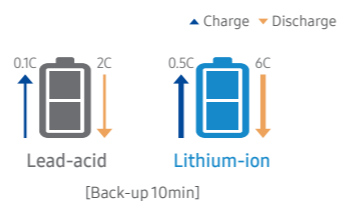
- Less space for battery room
- No structure reinforcement required

Longer Life



- Battery replacement deferral
- Enhanced reliability

Fast Charge/Discharge Rate

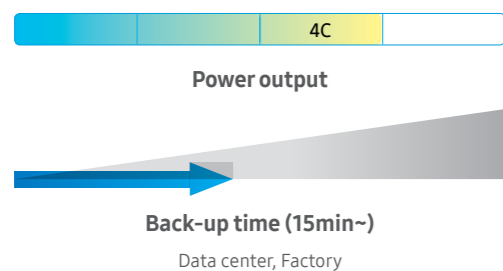


- No oversizing required
- Shorter charging time

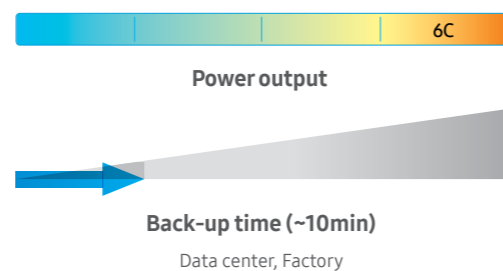
*This comparison above is based on each material's characteristic

Product Line-up

AC UPS : 4C



AC UPS : 6C



Specification

Item	UPS 4C (600V)	UPS 6C (600V)
Module	M2968	M2967
Configuration of rack	144S1P	136S1P
Cell capacity	Ah	
	68	67
Energy	kWh	
	35.7	34.6
Operating voltage	V	
	432 ~ 590	408 ~ 571
Dimension (WxDxH)	mm	
	650 x 600 x 2,000	650 x 600 x 2,055
Weight	kg	
	500	480

Battery System for Hybrid UPS

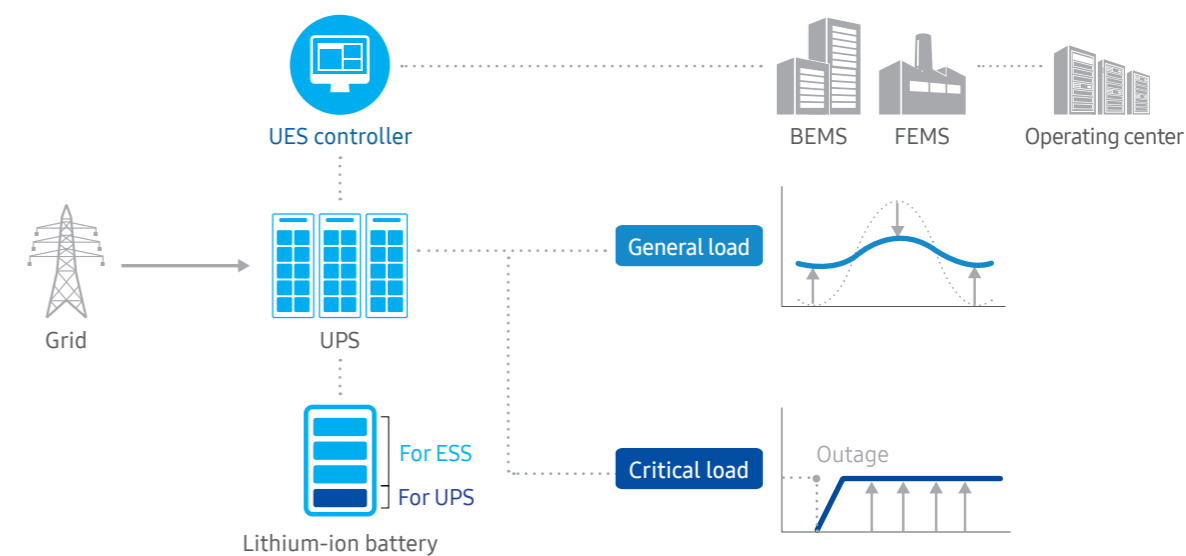
New Business Model: Samsung SDI's UES(UPS+ESS)

UES solution provides both UPS and ESS function. It works as backup power in the event of power outage, while it functions as ESS for energy saving.



Start operation from April, 2015 in Uiwang, Korea

Concept



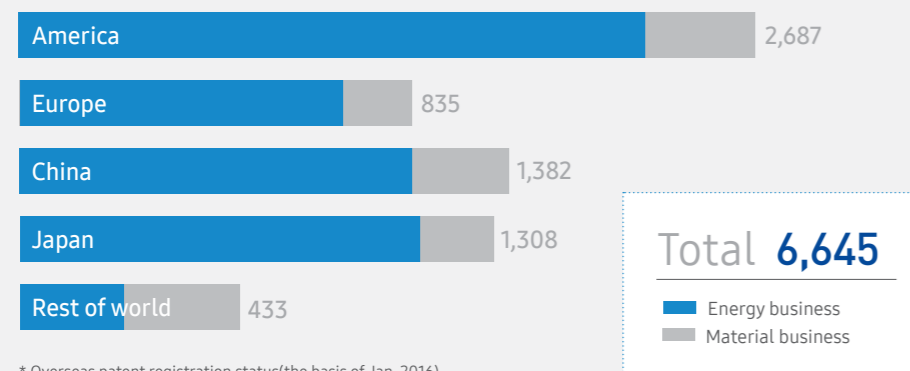
Battery Solutions, Opening the Future Energy World



Technology Leadership

Samsung SDI having 6,645 patents in total leads future business energy market based on world-class technology leadership. As a lithium-ion battery solution provider, Samsung SDI has acquired a number of safety-related certifications from unit cell to battery system in Korea, USA, Europe, Japan, Australia, etc.

Patent status*

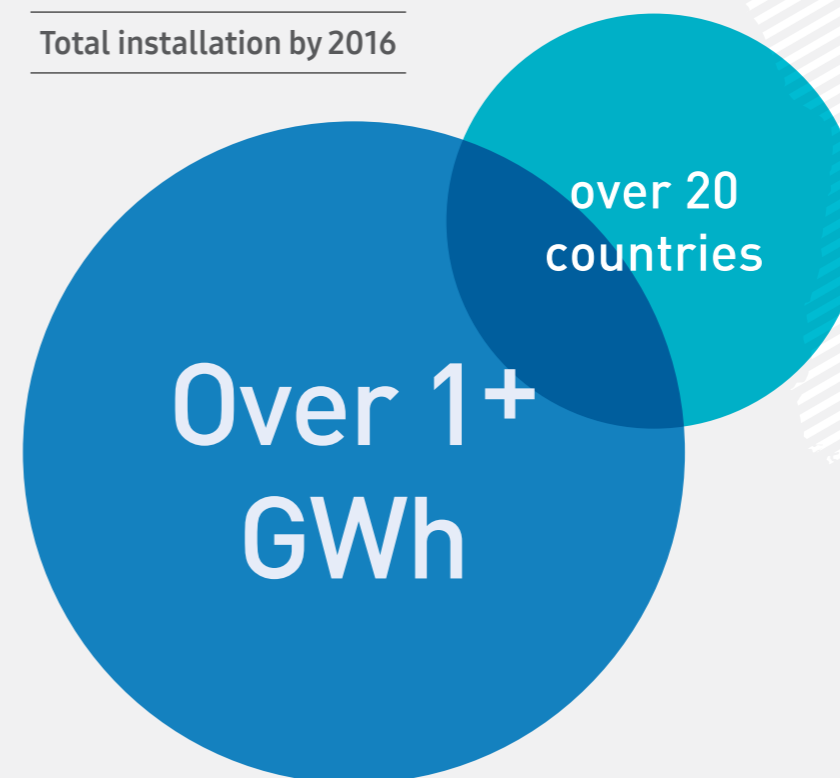


* Overseas patent registration status(the basis of Jan, 2016)

Global Track Record

Since 2010, Samsung SDI's lithium-ion battery systems are being successfully operated in over 20 countries worldwide.

Total installation by 2016



- Australia
- Austria
- Canada
- China
- Germany
- Hong Kong
- India
- Israel
- Italy
- Japan
- Kenya
- Korea
- Malaysia
- Netherland
- Philippines
- Switzerland
- UAE
- UK
- USA
- Vietnam

SAMSUNG SDI

Energy Storage System

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