

# Smart Battery Systems

for Energy Storage



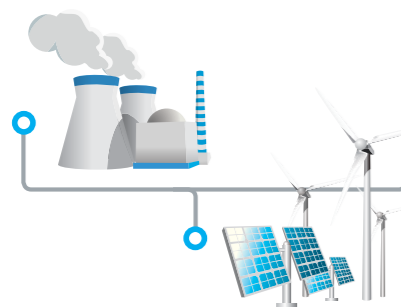
# Optimized Battery Solutions for ESS Applications

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



## Applications

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



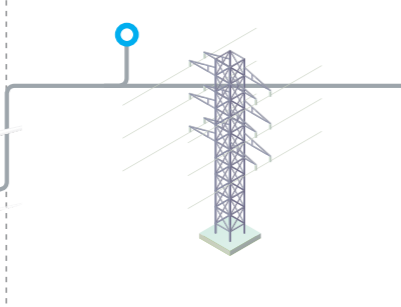
### Generation

#### Ancillary Services

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

#### Bulk Energy Services

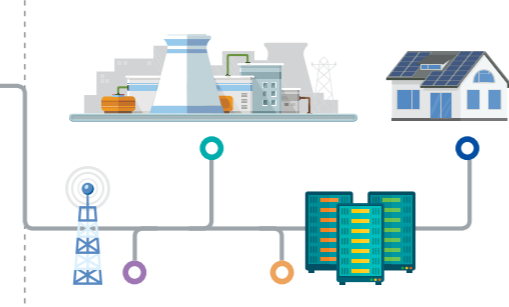
- Electric energy time-shift (Arbitrage)
- Electric supply capacity



### 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

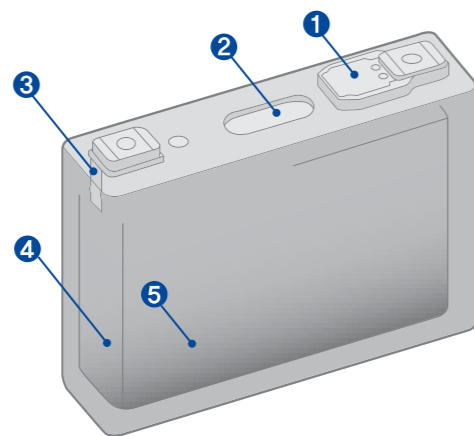


# Reliable Samsung SDI Continuous Innovation

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



## Safety First



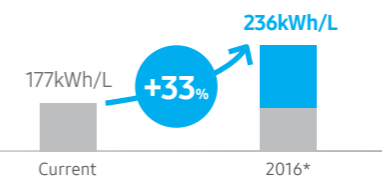
### Multi-layered protection on cell

- 1 OSD (Overcharge Safety Device)
- 2 Vent
- 3 Fuse
- 4 SFL (Safety Functional Layer)
- 5 NSD (Nail Safety Device)\*

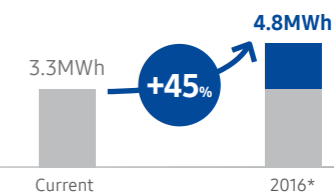
\* In case of 94Ah cell

## Higher Energy Density

[Module]



[Max 40ft ISO Container]



\* Energy line-up('16.3Q mass production)

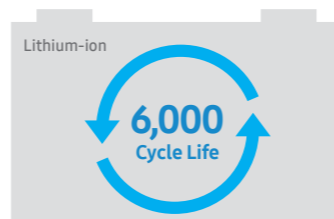
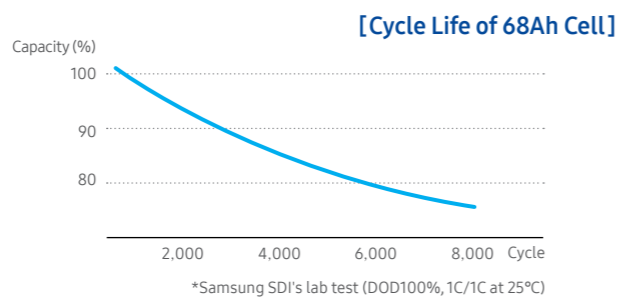
### Innovative Changes for 2016

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

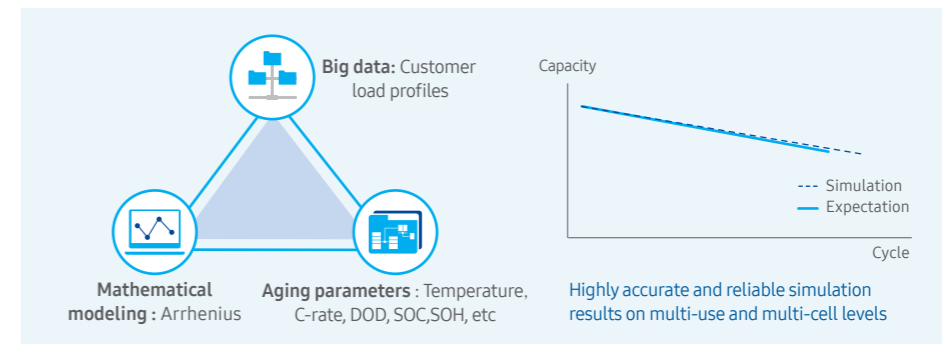
## Long Cycle Life

### 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

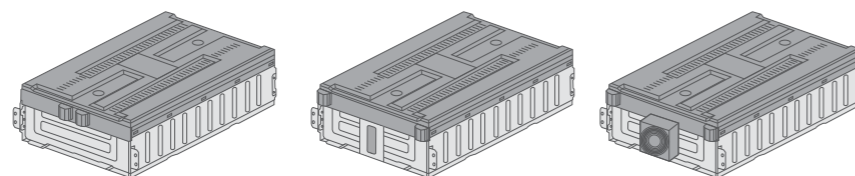
## Module



### Specification

Item		M2994	M2963 / M2968
Cell type		Prismatic	Prismatic
Energy	kWh	2.8	2.0
Nominal voltage	V	29.6	29.2
Operating voltage	V	25.6 ~ 33.2	24.0 ~ 32.8
Peak discharge C-rate	C	0.5	6 / 4
Dimension (W x D x H)	mm	457 x 185 x 154	214 x 414 x 163
Weight	kg	22	17

## 2016 Module\*



### Specification

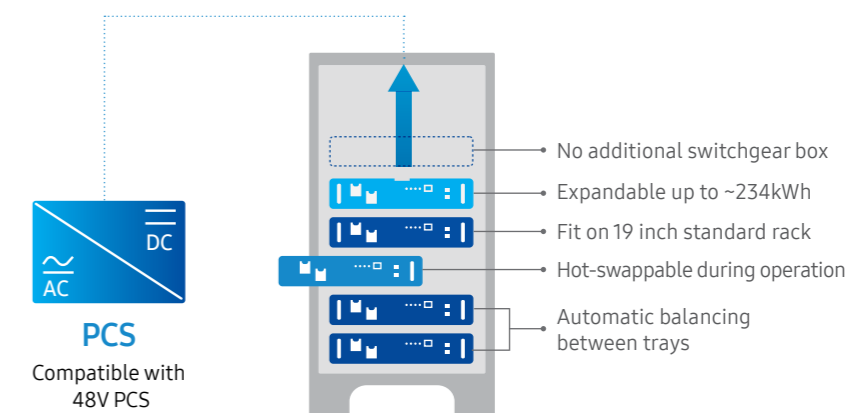
Item		M8994 E2	M8194 M2	M8068 P2
Cell type		Prismatic	Prismatic	Prismatic
Cell capacity	Ah	94	94	68
Energy	kWh	8.39	7.65	5.46
Nominal voltage	V	89.3	81.4	80.3
Operating voltage	V	76.8 ~ 99.6	70.4 ~ 91.3	68.2 ~ 90.2
Dimension (W x D x H)	mm	370 x 588 x 160	370 x 588 x 160**	370 x 650 x 160
Weight	kg	< 60	< 55	< 50

\*2016.3Q mass production \*\*Fan is optional, dimension with fan is equal to M8068 P2

## 48V Tray

### Special Benefits

- Investment cost down
- Operation & maintenance convenience
- Lead-acid battery replacement



### Specification

Item		T4835	T4894
Component		Battery Module, BMS, Switchgear	Battery Module*, BMS, Switchgear
Cell type		Cylindrical	Prismatic
Energy (Rated/Usable)	kWh	2.2 / 1.7	4.5 / 4.5
Scalability (Usable)	kWh	28.3 (16ea)	234 (52ea)
Nominal voltage	V	50.4	47.8
Operating voltage	V	42.0 ~ 56.0	40.3 ~ 53.9
Charging method		CC-CV, Floating	CC-CV, Floating
Dimension (W x D x H)	mm	482 x 433 x 96	482 x 510 x 161
Weight	kg	18.5	45
Operating temperature	°C	-20 ~ 60	0 ~ 40
Life cycle **	Cycle	3,150	3,500

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

# Battery System for Utility-Scale & Commercial

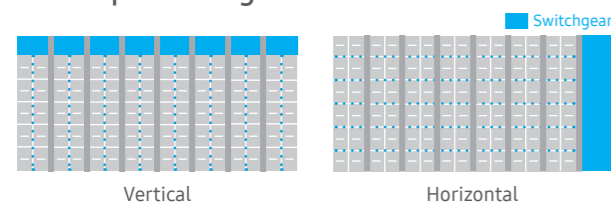
## 2016 Innovations

- 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

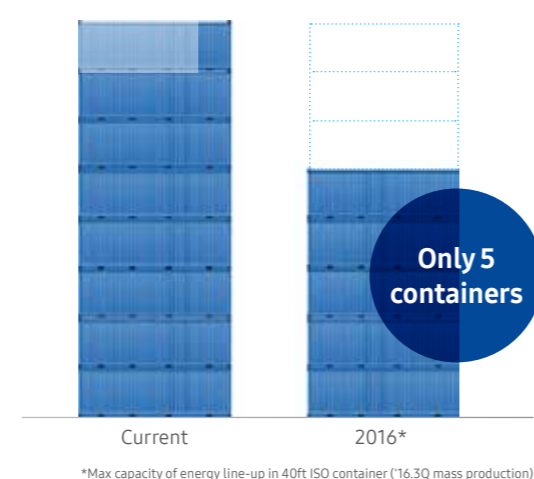
### I Customized combination for optimized ESS

Cell	Module	Arrangement
94 Ah	24S1P	Vertical
68 Ah	22S1P	Horizontal

### I Multiple arrangement



### I 24MWh case



\*Max capacity of energy line-up in 40ft ISO container (\*16.3Q mass production)

## Product Line-up

Energy	Medium	Power
<p>Power output</p> <p>Duration</p> <p>Energy shift, Peak Cut Curtailment</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 <span style="color: blue;">■</span> 94Ah <span style="color: orange;">■</span> 68Ah   Module <span style="color: blue;">■</span> 24S1P <span style="color: orange;">■</span> 22S1P</p>
<p>Max 40ft ISO container</p>		

## Specification (Rack@1,000V)

Item		Energy		Medium		Power	
Module		M8994 E2		M8194 M2		M8068 P2	
Arrangement type		Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
Configuration of rack		240S2P	48S13P	242S2P	44S13P	242S2P	44S13P
Cell capacity	Ah	94	94	94	94	68	68
Energy	kWh	168	218	168	199	120	142
Continuous power	kW	83.9	109	168	199	360	426
Nominal voltage	V	893	179	896	163	884	161
Operating voltage	V	768 – 996	154 – 200	774 – 1,004	141 – 183	750 – 992	136 – 180
Dimension (WxDxH)	mm	890 x 680 x 1,970	890 x 680 x 2,290	890 x 680 x 2,130	890 x 680 x 2,290	890 x 680 x 2,130	890 x 680 x 2,290
Rack energy density	Wh/L	140	157	131	144	93.2	102

Horizontal type rack is configured for electrical series expansion to horizontal direction. This model is optimized in 40ft container.

# Battery System for UPS (Uninterruptible Power Supply)

## Benefits of Lithium-ion Battery for UPS

Less Space/Weight	Longer Life	Fast Charge/Discharge Rate
<p>Lead-acid vs Lithium-ion [Equal capacity]</p>	<p>Lead-acid 3~7 years vs Lithium-ion 15 years</p>	<p>Lead-acid 0.1C/2C vs Lithium-ion 0.5C/6C [Back-up 10min]</p>
<ul style="list-style-type: none"> <li>• Less space for battery room</li> <li>• No structure reinforcement required</li> </ul>	<ul style="list-style-type: none"> <li>• Battery replacement deferral</li> <li>• Enhanced reliability</li> </ul>	<ul style="list-style-type: none"> <li>• No oversizing required</li> <li>• Shorter charging time</li> </ul>

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

## Product Line-up

DC UPS	AC UPS : 4C	AC UPS : 6C
<p>0.5C Power output, Back-up time (2hrs~)</p>	<p>4C Power output, Back-up time (15min~)</p>	<p>6C Power output, Back-up time (~10min)</p>
Substation, Electric power station	Data center, Factory	Data center, Factory

## Specification (Single Rack)

Item		DC UPS (120V)	UPS 4C (600V)	UPS 6C (600V)
Module		M2968	M2968	M2963
Configuration of rack		32S3P	144S1P	144S1P
Cell capacity	Ah	68	68	68
Energy	kWh	23.8	35.7	35.7
Continuous power	kW	11.9	143	214
Nominal voltage	V	117	526	526
Operating voltage	V	96~131	432~590	432~590
Dimension (WxDxH)	mm	650 x 600 x 1,500	650 x 600 x 2,000	650 x 600 x 2,000

# Battery System for Hybrid UPS

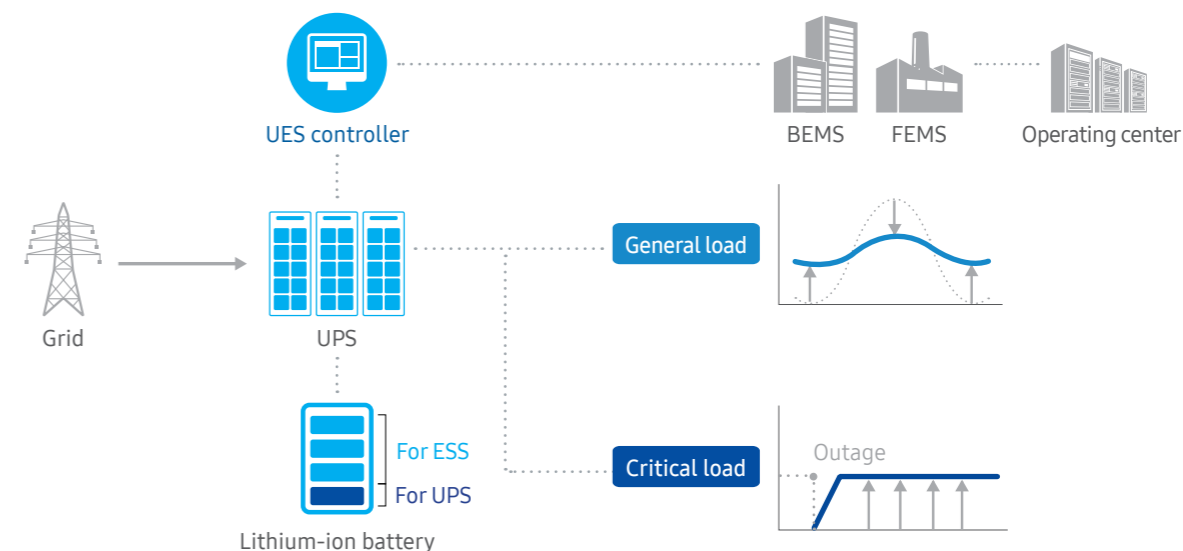
## New Business Model: Samsung SDI's UES(UPS+ESS)

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





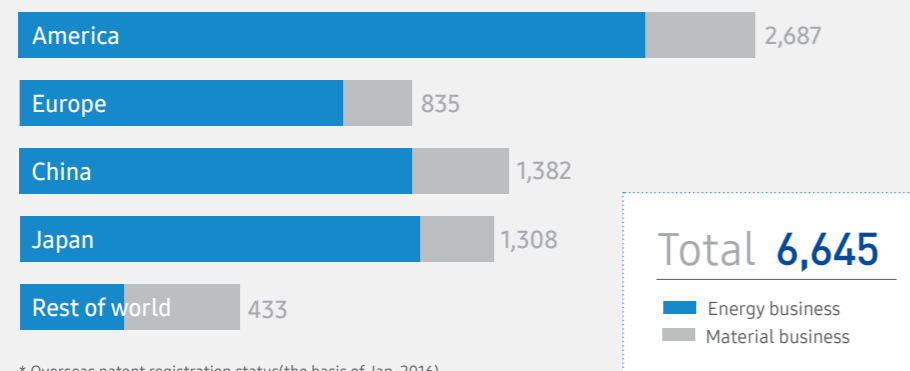
# Battery Solutions, Opening the Future Energy World



## 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\*

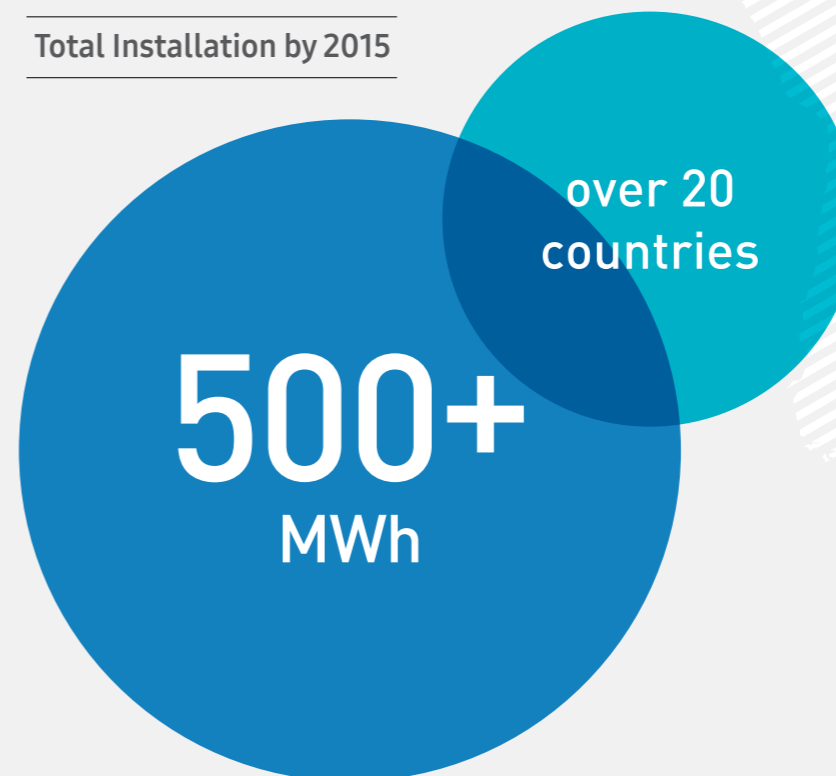


\* Overseas patent registration status(the basis of Jan, 2016)

## Global Track Record

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

### Total Installation by 2015



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

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