

# The Beginning of Commercial Vehicle Innovation

LG Energy Solution's Automotive Batteries  
for Commercial Vehicles

## LG Energy Solution Commercial Vehicle Marketing Department

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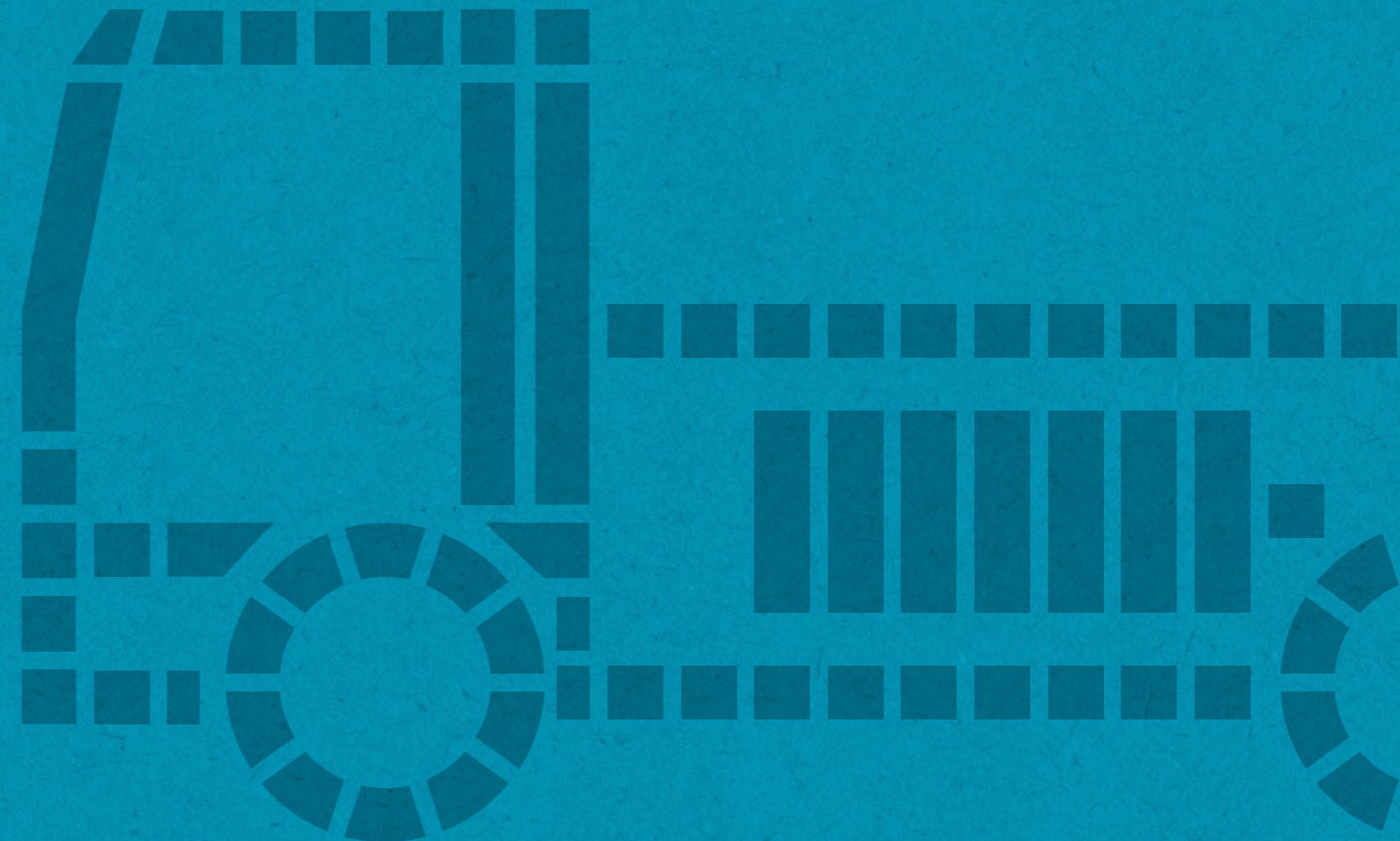
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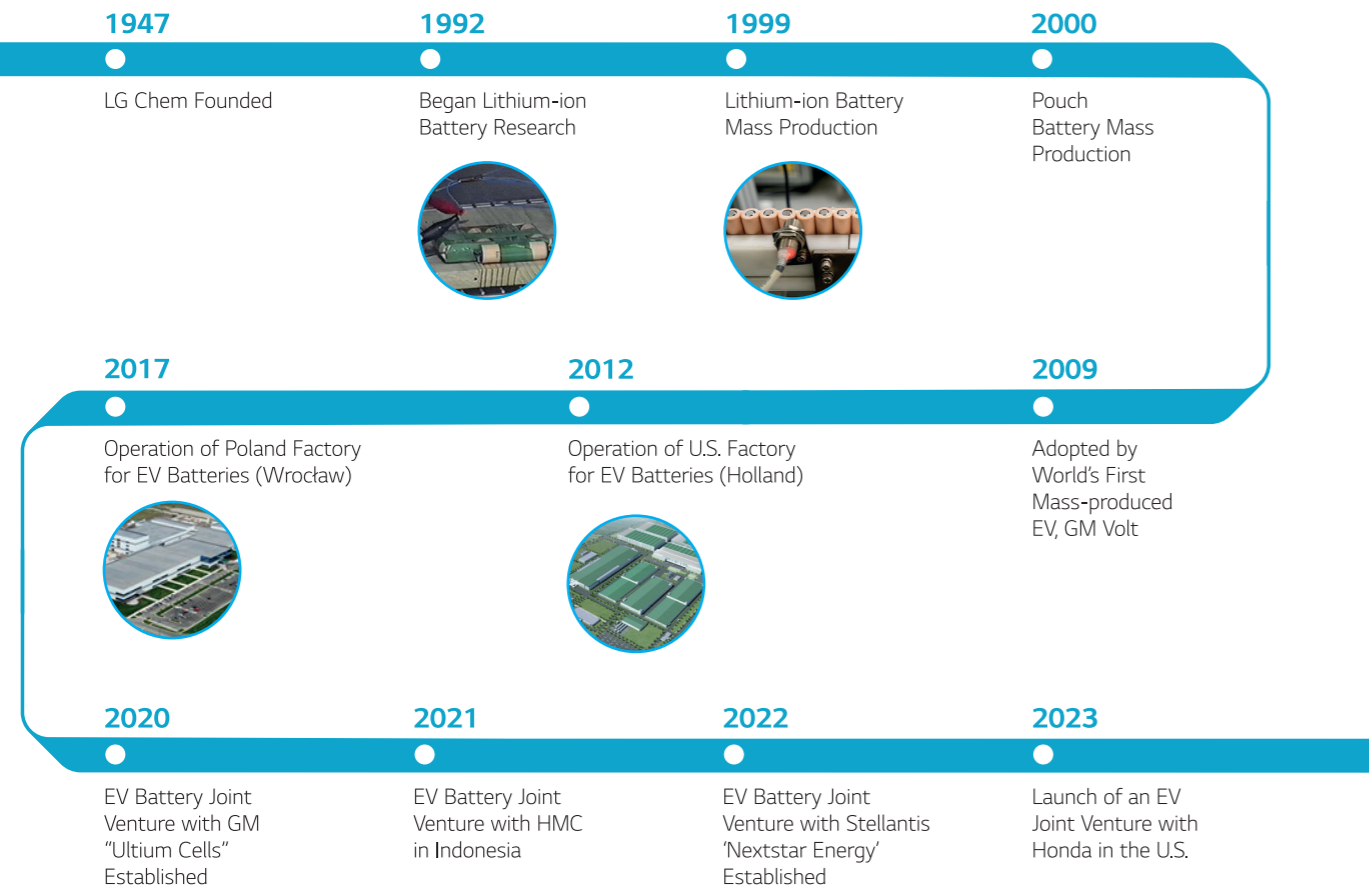


# A Firm Global Leader in EV Batteries

## Pioneer of EV Battery Industry

Since initiating lithium-ion battery research in 1992, LG Energy Solution has pioneered the global battery industry by achieving significant milestones such as mass-producing and supplying the world's first EV battery, and successfully developing the high-capacity NCMA battery.

### LG Energy Solution Milestone



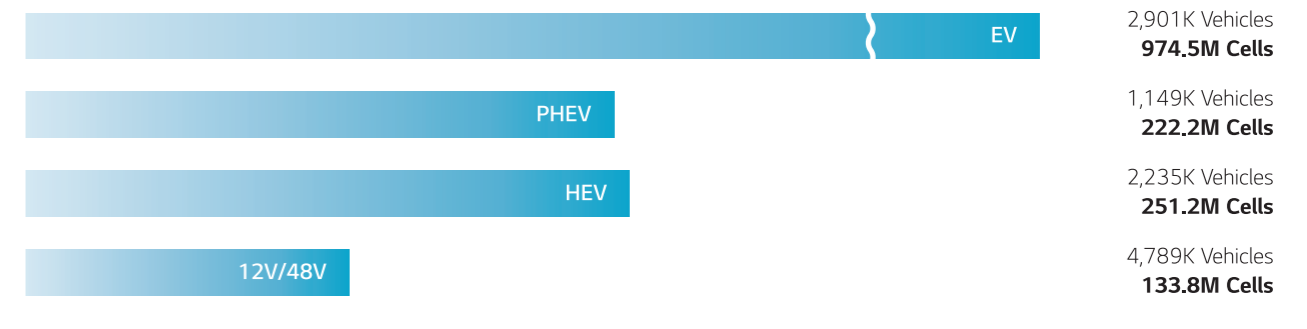
Batteries play a central role in shaping the performance of EVs. As a firm global leader in the battery sector, LG Energy Solution propels the mass adoption of EVs while driving future mobility innovation.

## Unparalleled EV Track Records

LG Energy Solution has undertaken numerous projects with more than 30 global automakers, expanding its portfolio from cell to pack, and other various solutions.

### LG Energy Solution's xEV Battery Supply (2009-2023)

Since 2009, a total of 1.58 billion LG Energy Solution cells have been adopted to more than 11 million xEVs.



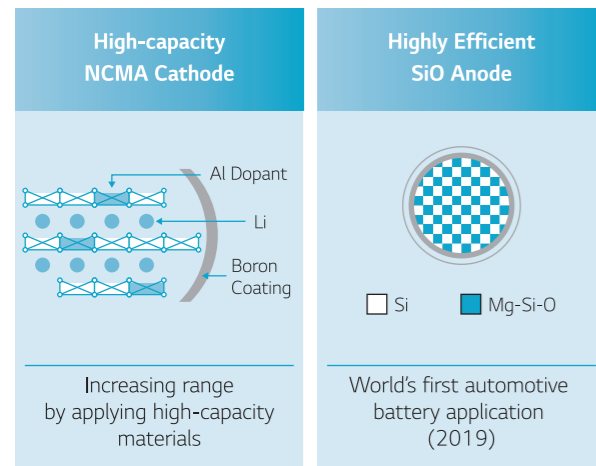
### Partnerships with Top Automobile Manufacturers



# State-of-the-Art Lithium-ion Batteries

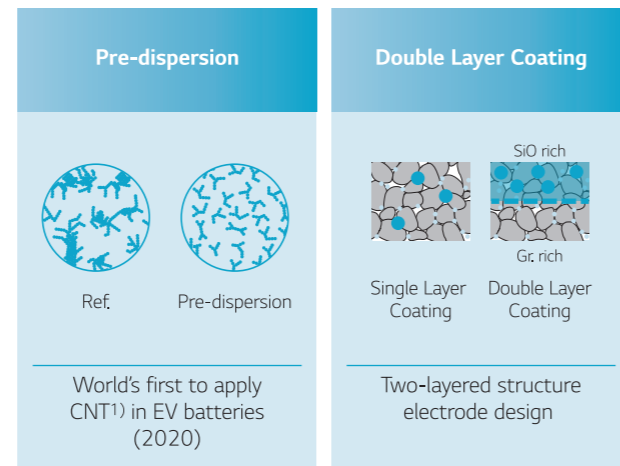
## Ultra Power NCMA Cell

High-tech materials like 'NCMA cathode' and 'silicon anode' enable longer driving distances, faster charging, and longer product life.



## Innovative Processing Technology

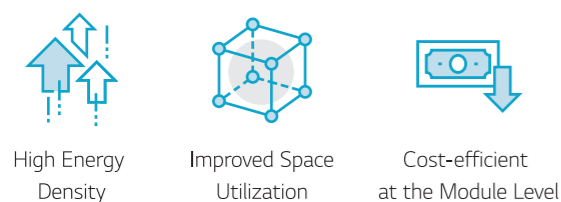
LG Energy Solution's technologies guarantee performance and quality by maximizing battery density, efficiency, and safety.



※ 1) CNT : Carbon Nanotube

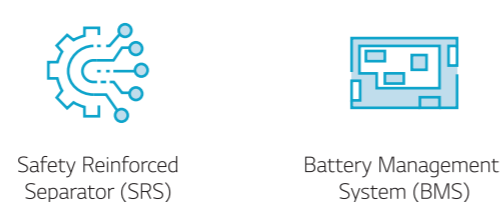
## Flexible Cell Design

Flexible cell design secures high energy density with longer battery life and customizable designs.



## Higher Safety

Rigorous safety technologies, such as SRS and BMS, prevent thermal risks or fire hazards and maintain high battery quality.



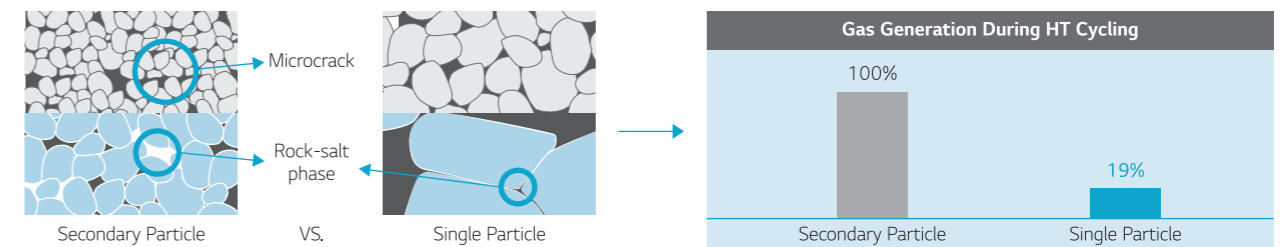
From materials to design, processing, and quality management, LG Energy Solution's accumulated expertise innovates all battery production stages to deliver the most robust batteries.

## HV Mid-Ni Chemistry Technology

Our material technology improves durability and reduces gas generation in high-voltage Mid-Ni systems.

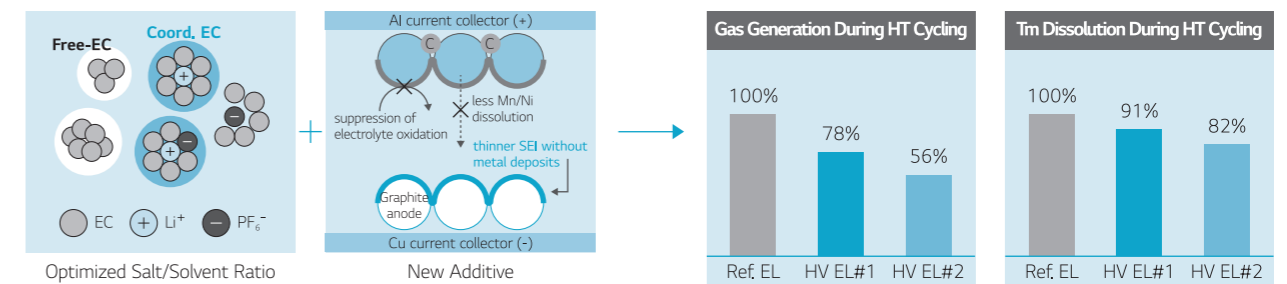
### Single Particle Cathode Materials

Low effective surface area and high structural stability reduce gas generation and extend cycle life at high voltage.



### New Electrolyte for High Voltage System

Lowering electrolyte oxidation and metal dissolution extends high voltage cycle life while reducing gas.

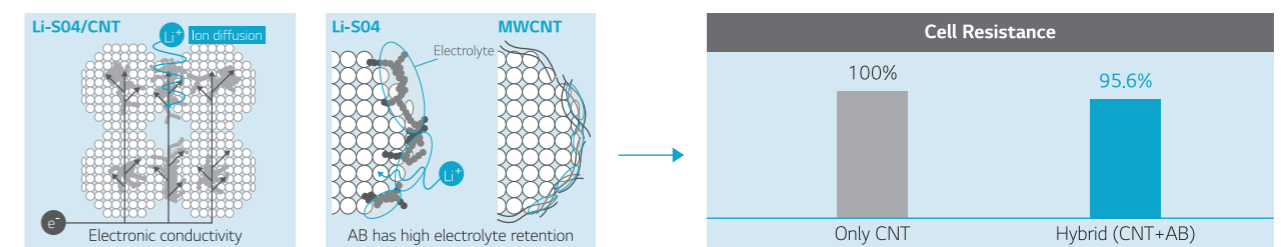


### Hybrid Conducting Agent System

0-Dimensional Conducting Agent: Higher electrolyte absorption for ionic path.

1-Dimensional Conducting Agent: High-conductivity electrical path.

→ Optimal ratio of 0D / 1D conducting agent reduces cell resistance and improves producibility.

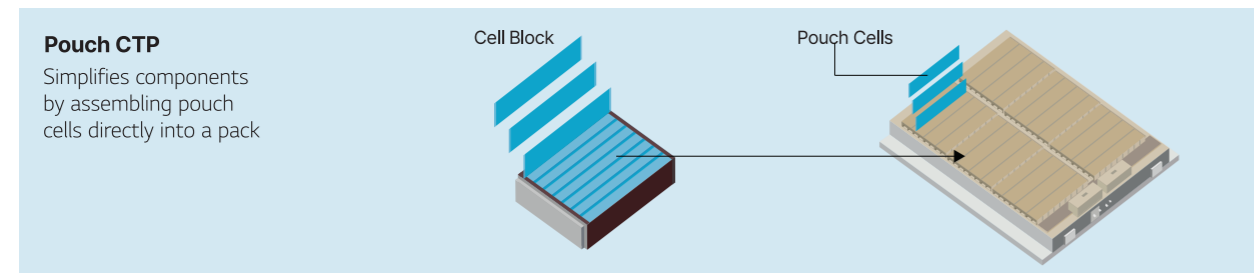




# Highly Optimized Solutions for Commercial Vehicles

## HV Mid-Ni Pouch CTP Technology

LG Energy Solution introduces a lighter, safer, and more energy-efficient pack with our 'Cell to Pack (CTP)' technology, tailored for pouch batteries.



### Lighter

LG Energy Solution developed a lighter and more energy-efficient pack with fewer pack components and lightweight of pouch batteries.

### Safer

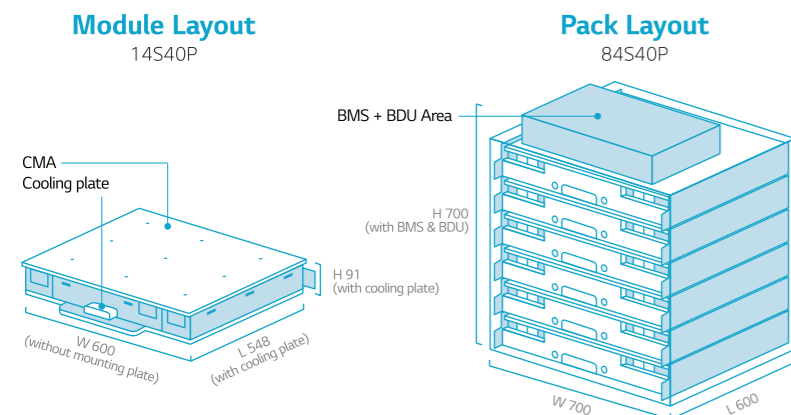
LG Energy Solution secured structural hardness in our 'Cell to Pack' technology and achieved thermal propagation safety by using materials and structures to delay thermal propagation.

### Higher Energy

LG Energy Solution boosts EV driving range by allowing more cells to battery packs, thereby increasing energy density.

## Standard Module Solutions for Cylindrical Batteries

The standard module is a highly versatile solution for various vehicle types, with a rigid structure that withstands loads up to six stages in a pack.



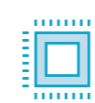
Chemistry	High-Ni
Form Factor	Module (Cylindrical)
Energy [kWh]	10.3
VED <sup>1)</sup>	349.4
GED <sup>2)</sup>	190.0
Size[mm] L x W x H	548 x 600 x 91
Cycle	1,000 (1.0C/1.0C) 2,000† (0.3C/0.5C)
Cooling Type	Active
Production Site	Vietnam
Target SOP	2026.1Q

1) Volumetric Energy Density | 2) Gravimetric Energy Density

The most ideal battery solutions for commercial vehicles are provided by LG Energy Solution based on its world-renowned technology and varieties of knowhow.

## BMTS (Battery Management Total Solution)

LG Energy Solution's BMTS is the most intelligent way to enhance battery performance, leveraging both expertise and advanced technology.



### BMS Solution

- Customized BMS
- Standard BMS (OTS BMS) \*



### App. S/W Solution

- Safety Diagnostics SW
- State Estimation SW



### Cloud Solution

- Cloud BMS (OEM)
- B-Lifecare (B2B, B2C)



### SDV Solution

- SDV BMS
- Edge Computing BMS

### \*Standard BMS (OTS BMS) Compatible with Various Applications

LG Energy Solution's Standard BMS (OTS BMS) is engineered to seamlessly integrate into diverse applications.



EV/PHEV  
E-Truck/E-Bus



E-Bike  
E-Scooters



Lawn Mower  
Golf Carts



Robot AGV\*  
\*AGV: Automatic Guided Vehicle

## Saving Time and Reducing Costs

Pre-development for OTS (Off-the-Shelf) products dramatically reduces both time and costs.

Pre-development

2-3 months

Validation

Reduce Time and Costs

VS.

New Development

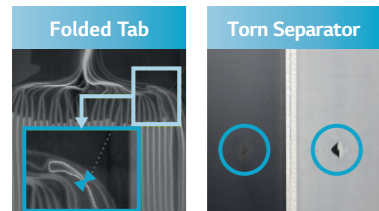
Total Time Required : 2-3 years

# Rigorous Safety Management with Competitive Safety Diagnostics SW

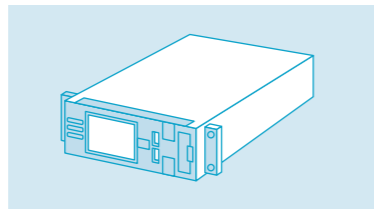
## Ensuring Safety and Reliability

Our diagnostics software has been verified through extensive cell, pack, and vehicle testing, and is continuously improved through field data analysis after mass production.

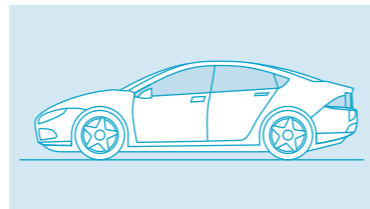
### Retrofit Cells Test > 10,000



### Pack Test > 1,000



### Vehicle Data > 100,000



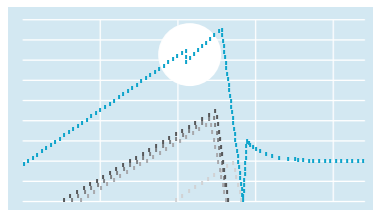
## Advanced Safety Diagnostics

Through a comprehensive analysis and thorough detection of cell defects, we ensure the safety and stability of battery performance.

### MAVD

Moving Average Voltage Deviation

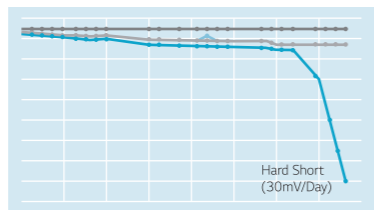
Detects a fine voltage that drops momentarily due to the cell tab failure.



### RdV

Relaxation delta Voltage

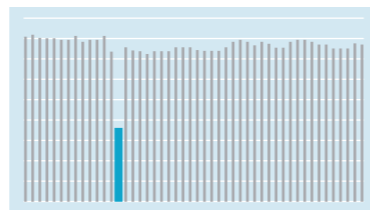
Detects continuous voltage drop due to the micro internal short circuit in cell.



### dSOH

delta State Of Health

Detects capacity anomalies due to Lithium deposition or pouch damage.



Since 2018, LG Energy Solution has been a leader in developing battery safety diagnostics software that detects cell defects, proven effective in mass production. With the expertise of our domain specialists, our research in battery data analysis and diagnostics has made significant advancements.

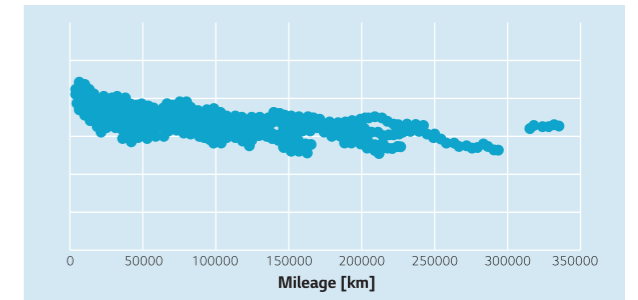
## Unrivaled Lifetime Estimation

Our unique battery algorithm solutions provide a precise, stable, and predictive battery management system.

### FRISM

Cell Data Free SOH Model

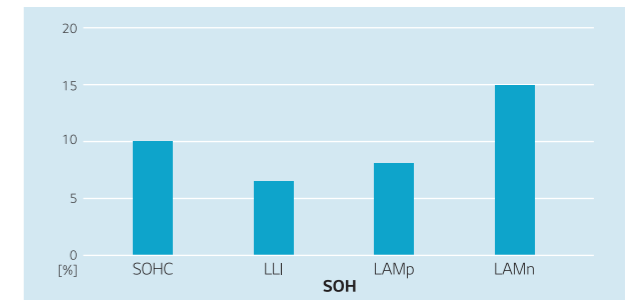
Define error factors affecting SOH calculation and improve accuracy in calculating remaining capacity using the ML-based correction method. Error rate :  $\pm 2\%$  point



### LLAZER

LAM LLI Analyzer

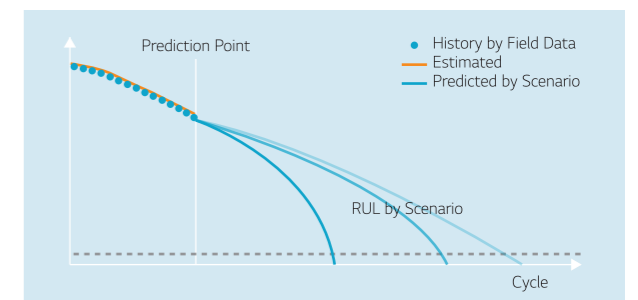
Estimate SOH and degradation parameters such as LLI and LAM from field data.



### BLiS

Battery Life Simulator

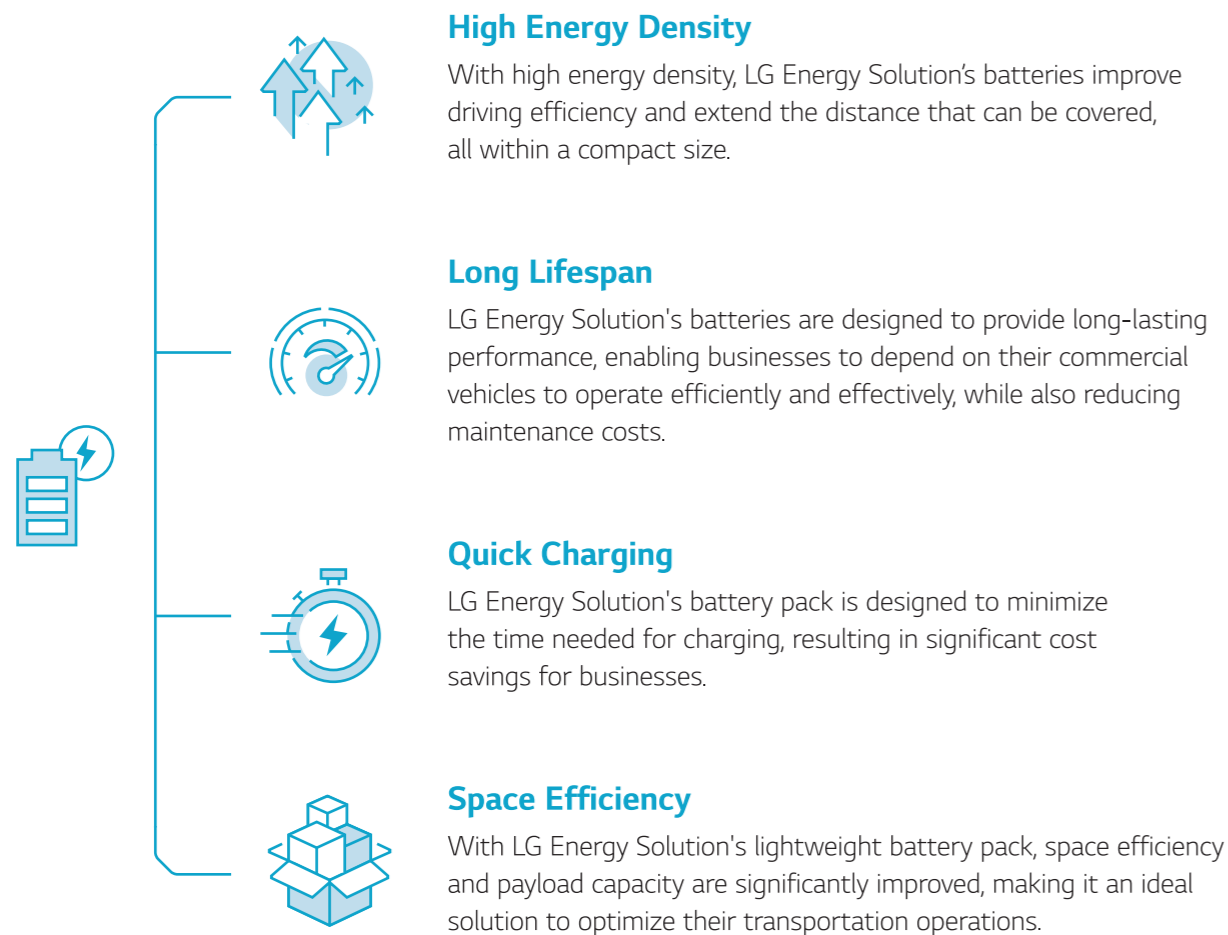
Calculate LLI, LAM, and lithium plating through chemical mechanisms, and predict future RUL using driving pattern data.



# Core Competencies of LG Energy Solution's Battery for Commercial Vehicles

## Most Competent Battery for Commercial Vehicles

Electrification of commercial vehicles has become a reality. LG Energy Solution's advanced battery technology opens the door to the next generation of electric commercial vehicles, making sustainable driving possible.



With high performance and enhanced efficiency, LG Energy Solution's batteries are an ideal solution to a wide range of electric commercial vehicles, boosting productivity and increasing profit.

## Various Commercial Vehicle Applications

LG Energy Solution provides best solutions for various commercial vehicles with our safe, reliable and innovative battery product lineups.



### Bus

Our fast-charging batteries minimize charging time and reduce passenger transportation costs.



### Vessel

We promote a sustainable marine ecosystem with longer driving duration from one-time charging.



### Utility Vehicle

Light and slim battery pack design improves design freedom for multi-purpose vehicles.



### Light & Heavy-duty Truck

High-capacity battery for electric trucks is space-efficient, maximizing cargo space.



### Urban Air Mobility

Robust yet lightweight battery enhances reliability and energy efficiency in the UAM industry.






### Off Highway Vehicle







We offer stable and long-lasting power for electric tractors or mining vehicles.

## Partnerships with Global Commercial Vehicle Manufacturers







# Cell Solutions for Powerful EV Performance

Category		Pouch-type Cell		
Model		E101A	E72B	E79
				
Chemistry		NCMA/Graphite	NCMA/Graphite+SiO	NCMA/Graphite
Performance	Capacity (Min, 25°C, 0.3C) Ah	101.8	72.2	78.0
	Nominal Voltage Vdc	3.67	3.67	3.69
	Energy Wh	374	264	287
	Energy Wh/L	637	625	591
	Density (Min) Wh/kg	287	287	267
	Pulse Charge Max Current (A)* (10sec, SoC 50%, 25°C, BOL)	395	316	202
	Pulse Discharge Max Current (A)* (10sec, SoC 50%, 25°C, BOL)	590	550	546
	Continuous Discharge Performance* (SoC 100%→0%)	-	3C, 10.1min, 10°C	3C, 17.3min, 45°C 3C, 12.4min, 25°C
	Max Discharge Power (W) 10sec, SoC 50%, 25°C	1174	1540	1365
	Internal Resistance (mΩ) 10sec, SoC 50%, 25°C	1.05 ~ 1.45 (10sec, SoC 28%(Shipping), 23°C)	1.09	1.27
Power to Energy Ratio W(Power: 10sec, SoC 50%, 25°C) /Energy	3.1	5.8	4.7	
Quick Charge	8 ~ 80% @30 ~ 40min			
Warranty		80% Capacity retention @8years, passenger car condition		
Dimension	L*W*T (mm)	580*112.4*9	354*101.65*11.44	548*100.1*8.55
Weight	g	1303	906	1075
Operating Temperature (°C)		-30 ~ 55		
Storage Temperature (°C)		-30 ~ 60		
Mass Production		USA	Poland	Poland

Pouch-type Cell				Cylindrical Cell (2170)	
JP3	JF1	JF2	JH4	M50L	M52V
					
NCM/Graphite	LFP/Graphite	LFP/Graphite	NCM/Graphite	NCMA/Graphite	NCMA/Graphite
62.4 (0.5C)	56.6	159.2	70.6	4.93 (nom, 0.2C) (reference value)	5.07 (nom, 0.2C) (reference value)
3.68	3.22	3	4	3.69	3.69
229.6 (Min.)	182.25	509.4	266 (nom)	18.2 (nom)	18.73 (nom)
389	320.4	388.4	467.8 (nom)	746 (nom)	763 (nom)
184	165.68	182.4	213.7 (nom)	270 (nom)	278 (nom)
192	90.6 (25°C, BOL)	69.79 (0.5CP, 3.65V)	-	13.2*	17*
192	90.6 (25°C, BOL)	101.89 (0.5CP, 2.5V)	120	28.5*	48*
-	0.33CP, 180mins, 25°C	1C, 50mins, 25°C	-	-	-
706.5	182.25	254.72 (0.5CP)	199 (0.75CP)	108	120
0.88 ± 0.25	1.261 ~ 2.261 (SOC19%, 28.3A, 10sec)	0.708 ≤ x ≤ 1.208 (SOC19%, 79.6A, 10sec)	1.061 ≤ x ≤ 1.561 (SOC30%, 120A, 10sec)	23	24
-	1	-	-	5.9	6.4
-	-	-	-	-	-
To be calculated and guaranteed based on customer's driving profile					
353.5*101.7*16.4 (Max.)	352.5*100.2*16.1	Max 601.0*125.0*18.0 (At shipping state, without lead tab)	Max 101.7*353.5*16.4 (At shipping state, without lead tab)	Diameter : 21.15mm (max) Height : 70.20mm (max)	Diameter : 21.15mm (max) Height : 70.60mm (max)
Max. 1245	Max. 1100	Max. 2800	Max. 1245	67.2	67.4
-10 ~ 50	Charge : -10-50 Discharge : -20-50	Charge : 0-45 Discharge : 0-45 Ordinary temperature 23 ± 4 °C with Uniformity 4 °C	Charge : 5-50 Discharge : 0-50 Ordinary temperature 23 ± 4 °C with Uniformity 4 °C	Cell surface Temp. 0 ~ 55 (Charge) -30 ~ 70 (Discharge)	Cell surface Temp. 0 ~ 50 (Charge) -20 ~ 70 (Discharge)
-30 ~ 60 (7 days) -20 ~ 45 (6 months)	Max. 7days : -30-60 Max. 6months : -20-45	Max. 7 days -30-60 Max. 6months -20-45	Max. 7 days -30-60 Max. 6months -20-45	-20 ~ 55	-20 ~ 55
China	China	China ('25.3Q-) Poland ('25.4Q-) USA ('26.1Q-)	China	China / Korea	China / Korea

\*As just reference data of cell level test, the detailed values can be modified upon system specification such as derating logic, cooling performance, etc. Concrete values can be specified based on customer's definition of its value.

# Module Solutions for Maximizing EV Space Efficiency

Category		Short Module	Long Module		Cylindrical Standard Module	
Model		VDA 390 2P6S	VDA 590 2P12S	VDA 590 3P8S	CM10	
						
Configuration		2P 6S	2P 12S	3P 8S	14S 40P / 28S 20P	
Chemistry		NCMA/Graphite+SiO	NCMA/Graphite		NCMA/Graphite	
Performance	Capacity	Ah	144.4	156.0	234.0	Min 203.0 / Min 101.5
	Nominal Voltage	Vdc	22.02	44.28	29.52	50.96 / 101.92
	Operating Voltage Range	Vdc	16.8 - 25.2	36 - 50.4	24 - 33.6	41.5 - 57.5 / 83 - 115.0
	Energy (Min)	kWh	3.17	6.91	6.91	10.36
	Energy	Wh/L	501	479	479	349.4
	Density (Min)	Wh/kg	240	223	223	190
	Max Charge Power (kW)	10sec, SoC 50%, 25°C, BOL	13.8	18.1	18.1	To Be Updated
	Max Discharge Power (kW)	10sec, SoC 50%, 25°C, BOL	20.8	40.1	40.1	To Be Updated
	Quick Charge		SOC6% - 79.6%, 21min @25degC	SOC 8% - 80%, 30min @25degC		To Be Updated
	Dimension	L*W*T(mm)	390.3*151*107.5	589*225.76*108.58 (W/O Foam Rope, Nominal)		548*91*600
Weight	kg	13.2	31.0		54.5±1	
Operating Temperature (°C)			-30 ~ 60		-20 ~ 60	
Storage Temperature (°C)			-30 ~ 60		-20 ~ 60	
Warranty		80% Capacity retention @8years, passenger car condition			To Be Updated	
Production Site		Poland	Poland		Vietnam ('26.1Q-)	

\* DISCLAIMERS OF WARRANTIES (For cells & modules)  
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# Key Features of LG Energy Solution's Batteries for Commercial Vehicles

## Cell Solutions

We offer pouch-type battery cells in various lengths and widths, as well as cylindrical battery cell line-ups, achieving high energy capacity and performance to meet our customers' diverse needs.



**Robust Energy for Longer Driving**



**High Power for Improved Energy Efficiency**



**Diverse Cell Line-ups**



## Module Solutions

Compact battery volume enables flexible height and width variations, leading to diverse module combinations that support more innovative EV designs.



**Compact & Slim Size**



**Customizable Structure**



**Higher Cooling Efficiency**



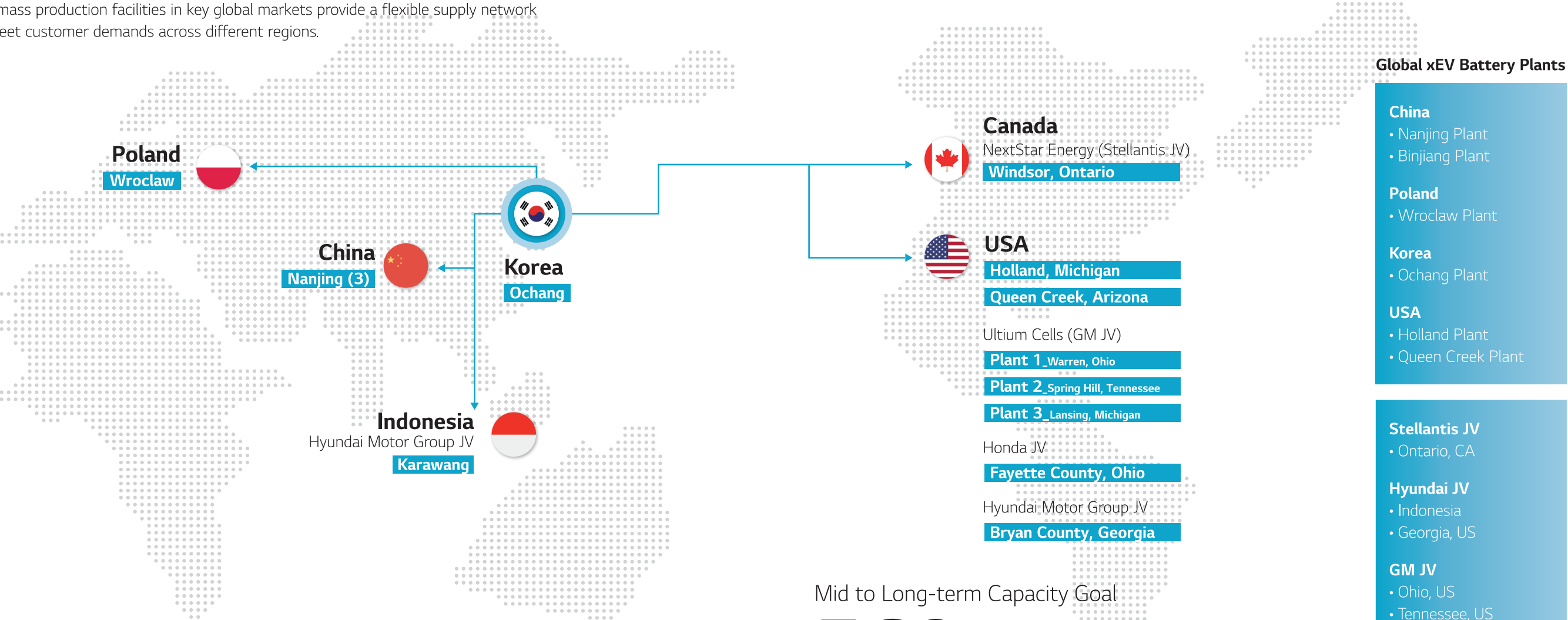


# Unmatched Global Production Capacity

LG Energy Solution boasts the highest global production capacity with multiple facilities on major continents. This global system streamlines local production and quality control to secure a reliable battery supply.

## Global Network

Our mass production facilities in key global markets provide a flexible supply network to meet customer demands across different regions.



### Global xEV Battery Plants

- China**
  - Nanjing Plant
  - Binjiang Plant
- Poland**
  - Wroclaw Plant
- Korea**
  - Ochang Plant
- USA**
  - Holland Plant
  - Queen Creek Plant
- Stellantis JV**
  - Ontario, CA
- Hyundai JV**
  - Indonesia
  - Georgia, US
- GM JV**
  - Ohio, US
  - Tennessee, US
  - Michigan, US
- Honda JV**
  - Ohio, US

Mid to Long-term Capacity Goal

# 560 GWh/Year

# Extensive Global Supply Chain Network

With worldwide raw material and component partners, LG Energy Solution maintains a stable supply chain for high-performance battery production.

## Long-term Partnerships for Stable Raw Material Procurement

We ensure stable raw material procurement and cost innovation through long-term partnerships with global partners.

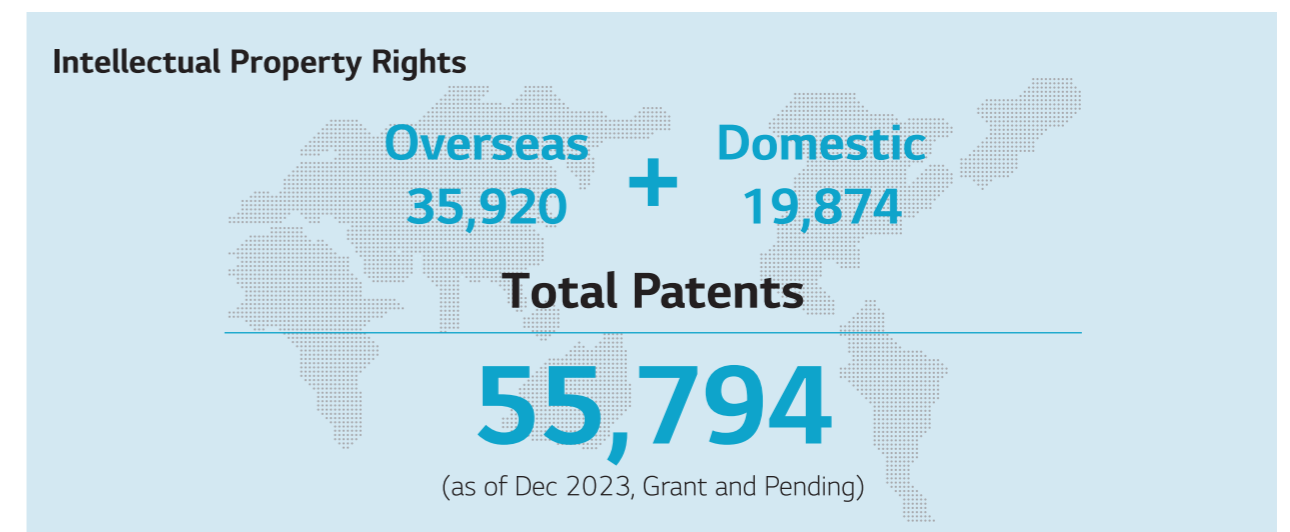
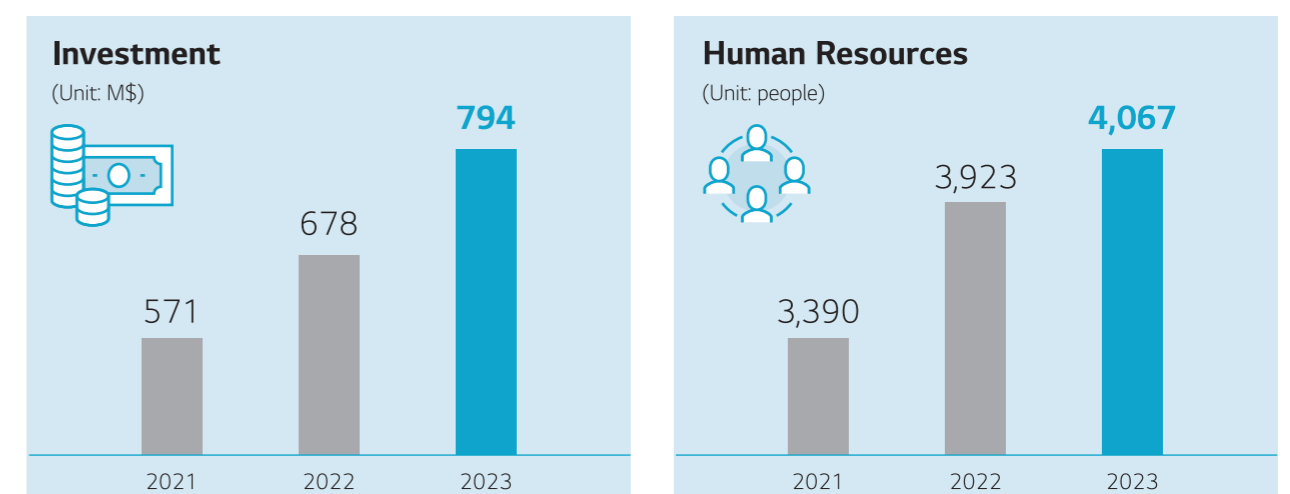
Year	Month	Entity	Details
2020	OCT	QPM	10-year supply agreement for 7,000 tons of nickel and 0.7 tons of cobalt
	DEC	Indonesia Government	MOU to secure local nickel deposits for the Indonesia's local JV
2021	JAN	SQM	8-year supply agreement for 55,000 tons of lithium
		Solus Advanced Materials	\$380 million contract for copper foil produced in Hungary
	Shenzhen Capchem Technology	Acquisition of 15% equity stake in a joint venture electrolyte factory in Poland	
	APR	QPM	20,000 tons of nickel secured for 6 years from 2023
	JUN	EcoPro	Partnership agreement for scrap metal recycling in battery manufacturing plants
2022	JAN	Liontown	700,000 tons of lithium ore (Spodumene) secured for 5 years from 2024
		Vulcan Energy	45,000 tons of lithium hydroxide secured for 5 years from 2026
	OCT	Syrah	To start supply of 2,000 tons of natural graphite from 2025, with continuous cooperation for expanding mass production
2023	MAY	Green Technology Metals	25% supply of lithium ore produced for 5 years from 2026
	JUL	SQM	100,000 tons of carbonate and lithium hydroxide secured for 7 years from 2023
2024	FEB	WesCEF	1-year supply agreement for 85,000 tons of lithium ore from 2024 50,000 tons of lithium hydroxide secured for 5 years from 2026
		Changzhou Liyuan	160,000 tons of LFP cathode material secured for 5 years from 2024

# Expertise in World-class Technology

LG Energy Solution leads the battery sector with the world's largest number of patents, and our commitment to widening this lead continues through continuous investment in R&D and specialized manpower training.

## Empowering the Future through Research & Development

We provide our customers with both safety and assurance for future business while simultaneously ensuring the freedom for technological expansion through our commitment to R&D investments.



# Next Generation Technological Roadmap

## Future Technology Development Path

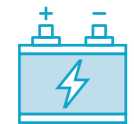
LG Energy Solution take the lead in developing future technology in all areas of the battery industry.



### Material & Cell

#### Basic Materials and Cell Technologies Innovation for Improved Performance

- High-capacity NCMA
- High-efficiency Silicon
- Dry Electrode Process



### Module & Pack

#### Integrated Design Cell + Module + Pack + System

- Cooling and Cell Fixing Structure
- Fire Extinguishing/Heat Barrier Design
- Integrated Structure Development Based on Vehicle Platform



### Simulation

#### Optimal Thermal, Electrical, and Mechanical Feedback

- Battery System Performance Forecast
- Safety Prediction
- Process Mechanism Analysis and Build an Analytical Model



### Digital Transformation

#### New Business Models in Battery Certification and Reused Battery Analysis

- Battery Performance / Life Prediction Based on AI and Big Data
- Battery Life Prediction
- Safety Diagnostic Technology
- New Business Model(BaaS) Development

LG Energy Solution is paving the way for the future of batteries with continuous process innovations and technological advancements in battery materials and cell technology. We are moving the industry closer to the next generation of high-performance, low-cost batteries that are safer and more efficient.

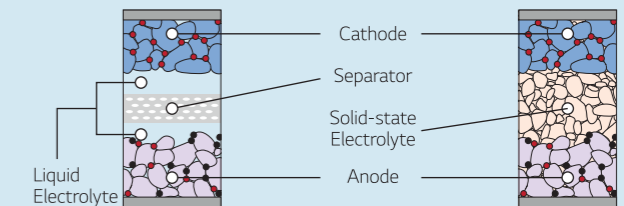
## Next-generation Batteries

LG Energy Solution is developing a revolutionary next-generation battery portfolio employing state-of-the-art technology.

### Solid-state Battery

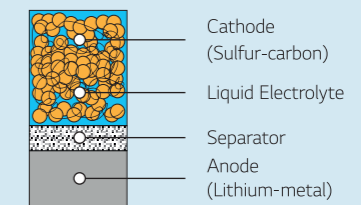
Solid-state batteries are rechargeable batteries with a solid-state electrolyte between a cathode and an anode, enabling high energy density and high capacity with a low risk of combustion.

#### Lithium-ion Battery (Liquid electrolyte)      Solid-state Battery (Solid-state electrolyte)



### Lithium-sulfur Battery

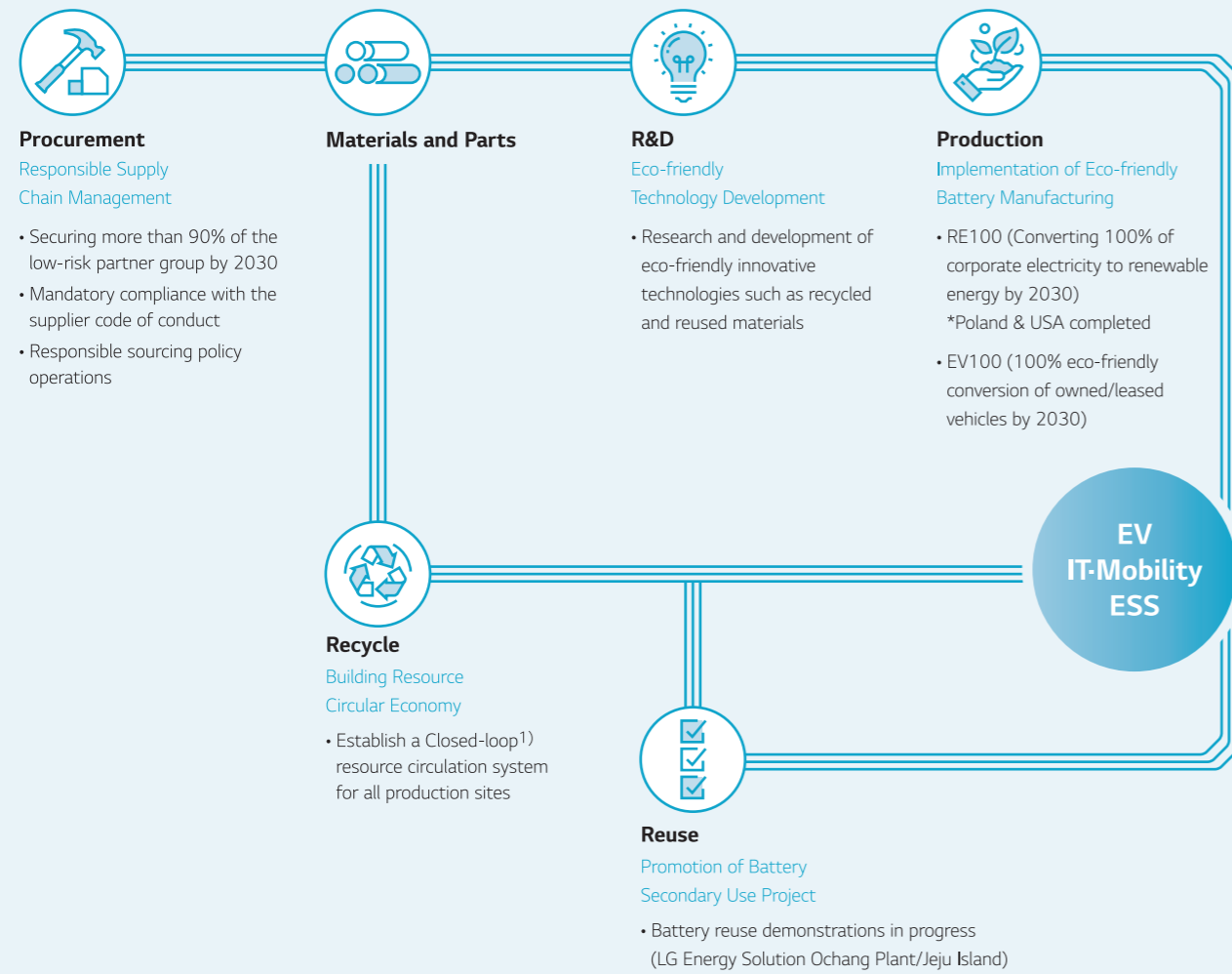
Lithium-sulfur batteries are made from lightweight materials, such as sulfur-carbon composite in the cathode and lithium-metal in the anode, providing them with twice the energy density of conventional lithium-ion batteries.



# Commitment to Sustainability

## Battery Circular Ecosystem of LG Energy Solution is Offering

From raw material procurement to recycling, we protect the environment and innovate businesses with a sustainable battery circular ecosystem.



Notes : 1) Closed-loop : Raw materials such as lithium, nickel, and cobalt are extracted from waste batteries or scraps generated during the production process and recycled in the cathode material production stage

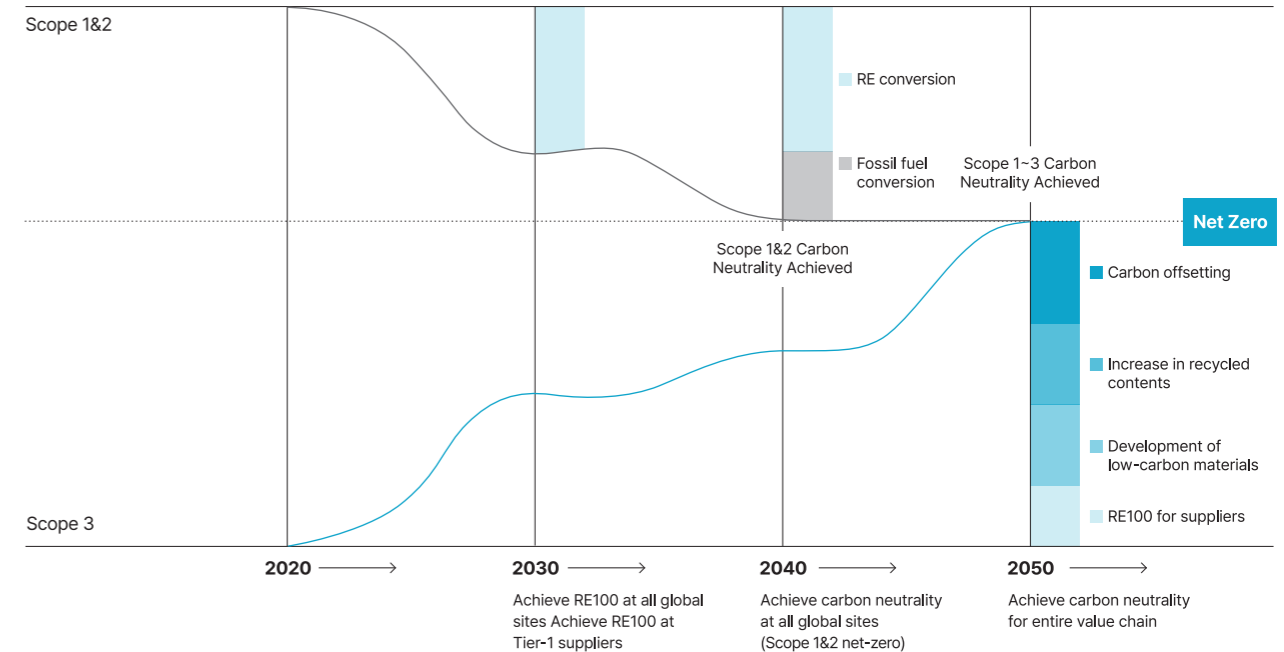
LG Energy Solution is fulfilling its corporate social responsibility by taking a lead in climate action by practicing sustainable business innovation in partnership with customers throughout the industry value chain.

## Carbon Neutrality Mission for LG Energy Solution and Partners

(Source: LG Energy Solution ESG Report, 2023)

	2030	2040	2050	Post- 2050
<b>LG Energy Solution</b>	<ul style="list-style-type: none"> <li>Achieve RE100/EV100* at all business sites</li> <li>Achieve 53% reduction of BAU emissions</li> </ul>	<ul style="list-style-type: none"> <li>Achieve carbon neutrality at all business sites(Scope 1&amp;2)</li> </ul>	<ul style="list-style-type: none"> <li>Achieve carbon neutrality throughout the value chain (Scope 1-3)</li> </ul>	<ul style="list-style-type: none"> <li>Achieve carbon negative</li> </ul>
<b>Suppliers</b>	<ul style="list-style-type: none"> <li>Achieve RE100 at Tier-1 suppliers * Core battery materials (ex. CAM, AAM, Cu-Foils)</li> </ul>	<ul style="list-style-type: none"> <li>Achieve RE100 of core value chain</li> </ul>		

\* RE100 (Renewable Electricity 100%), EV100 (Electric Vehicle 100%)



Scope 1,2,3:

Scope 1: Greenhouse gases emitted directly from a company's own business sites

Scope 2: Greenhouse gases emitted indirectly from a company's energy source such as electricity and steam

Scope 3: Greenhouse gases emitted indirectly from a company's value chain activities