LG Chem

Global Market Dynamics & LG Chem's Strategy for Low Voltage Battery

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AGENDA

1. LG Chem Overview
2. Global Market Trend for Low Voltage System
3. LG Chem's Strategy for Low Voltage System

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LG Chem's History for Automobile Battery

LG Chem is a leading supplier of automotive Li battery.

'95 Beginning of LIB R&D

'99 LiPB Mass Production

'00 LIPB Development for Automobile

'09 LiPB M.P. for HEV*

Hyundai Avante

'10 LiPB M.P. for PHEV

GM Volt

'11 LiPB M.P. for EV

Renault Twizy

'13 LiPB M.P. for HEV Bus

Hyundai CNG Bus

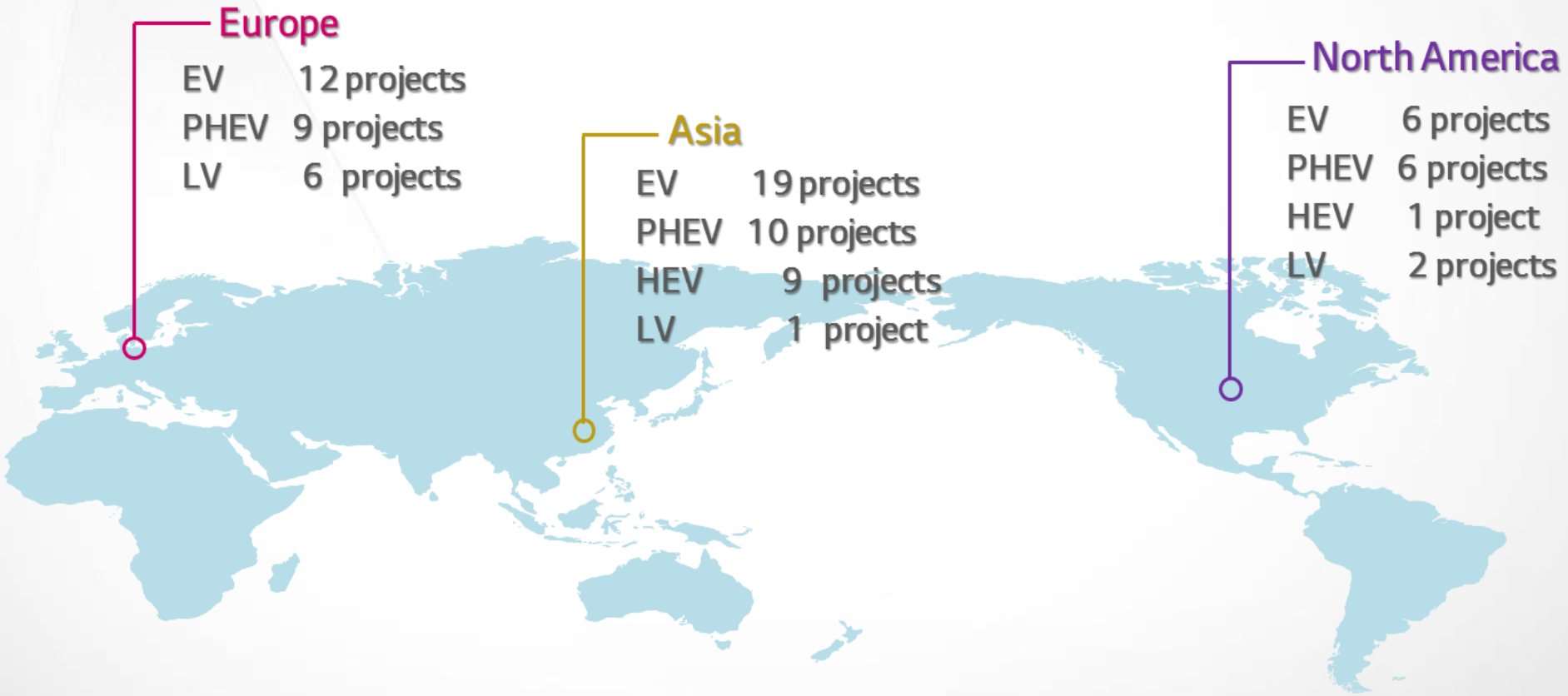
'14 Development for Long range EV*

'16 LiPB M.P. for 48 V System*
37 Ah PHEV M.P.*

* The first time in the world

LG Chem's Business Status for Automobile Battery

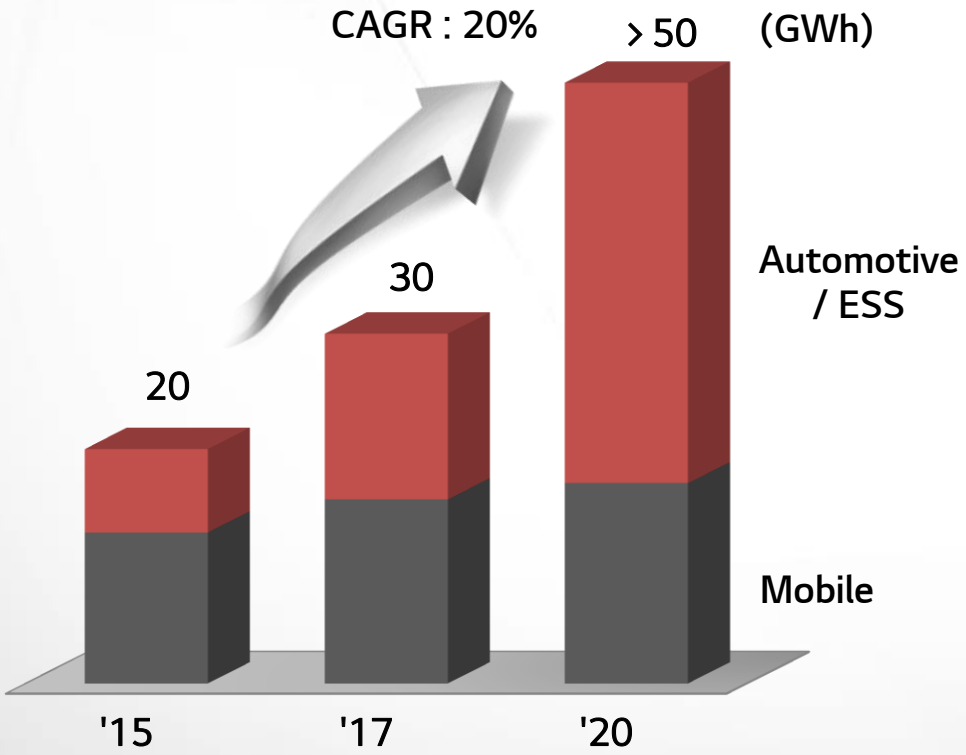
LG Chem awarded 81 projects from total 28 "Global OEMs Customers" across North America, Europe and Asia.



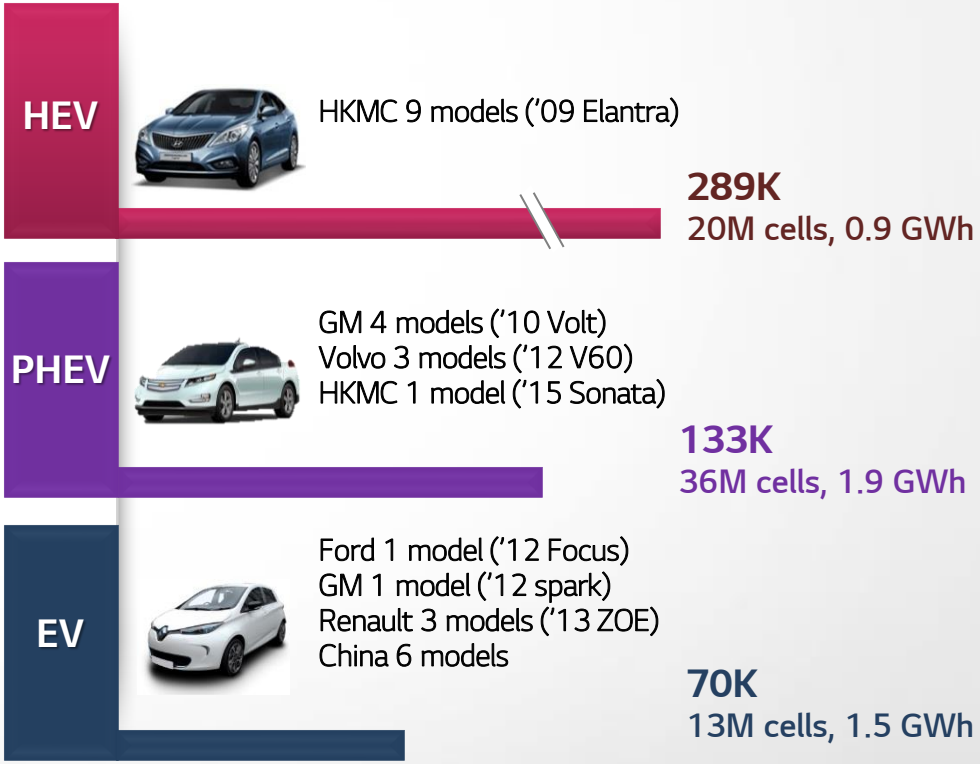
LG Chem's Business Experience for Automobile Battery

15+ years of experience has led to matured manufacturing capability and reliable quality. ~ 500K vehicles powered by LG are running on the road.

Cell Production Capacity



Automotive Experience ('09 ~ '15. 12)



Global Operation Capability

LG Chem is establishing its production facilities and R&D centers in 4 global sites close to Major OEMs for better understanding of customer needs and to provide real time stable support.

Location	Korea	China	USA	Europe
PLANT	 Ochang Plant	 Nanjing Plant	 Holland Plant in Michigan	 Under Planning
R&D Tech center	 Tech. center Battery R&D in Daejeon	 Under Developing	 Troy, Michigan	 Under Planning

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CO_2 Reduction Depending on Low Voltage System

Fuel economy gain & CO_2 reduction

Conventional Stop-Start 12V

Lead-acid 12V B.

12V BSG Stop-Start 12V

LIB 12V Single

Coasting Stop-Start 12V

LIB 12V Dual (5kW)

Mild HEV Costing 48V

LIB 48V (~12 kW)

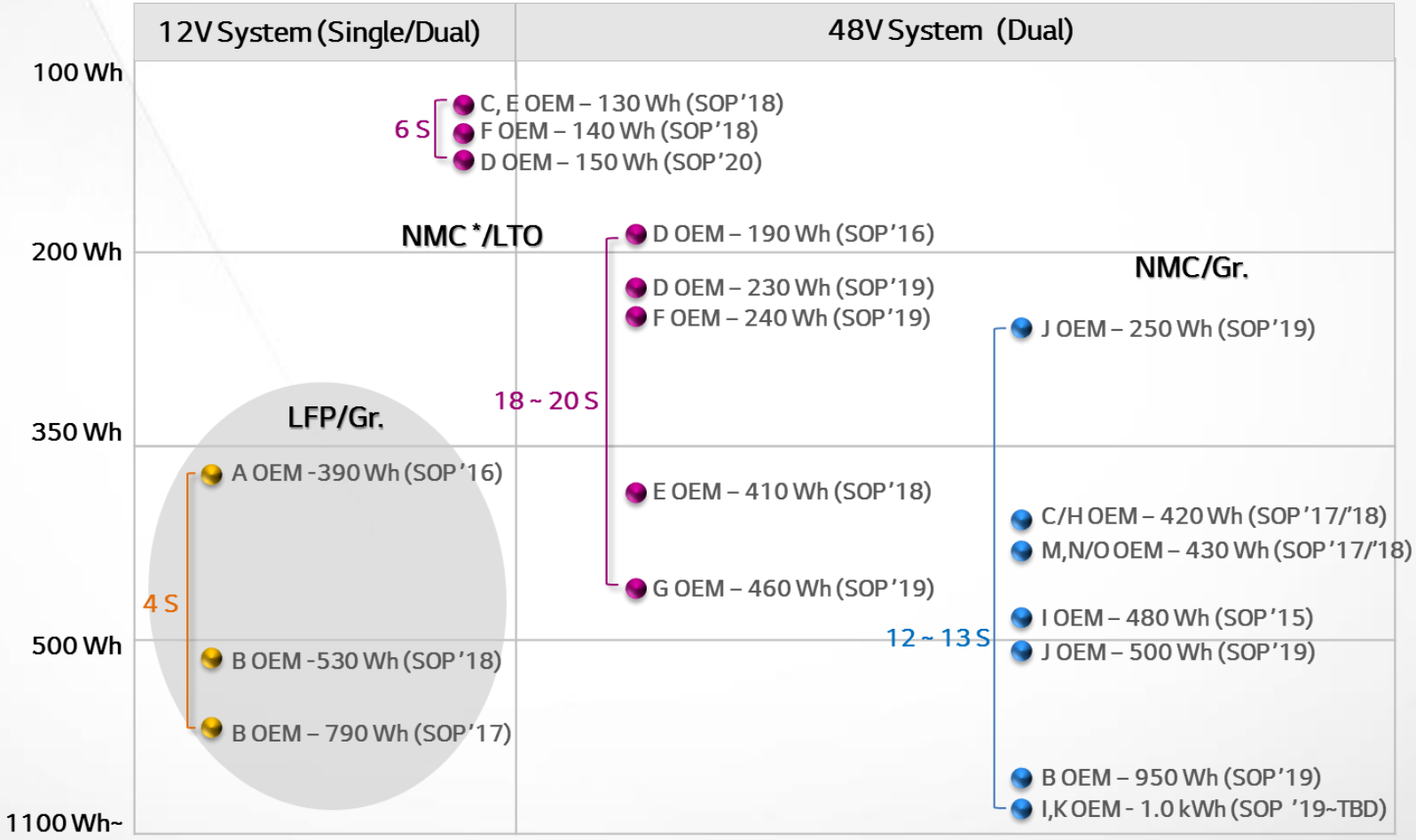
High power Mild HEV 48V

LIB 48V (>15kW)

NEDC	3 – 4 %	4 – 6 %	6 – 8 %	10 – 15 %	15 – 25 %
WLTC	2 – 3 %	3 – 4 %	12 – 15 %	15 – 20 %	20 – 25 %

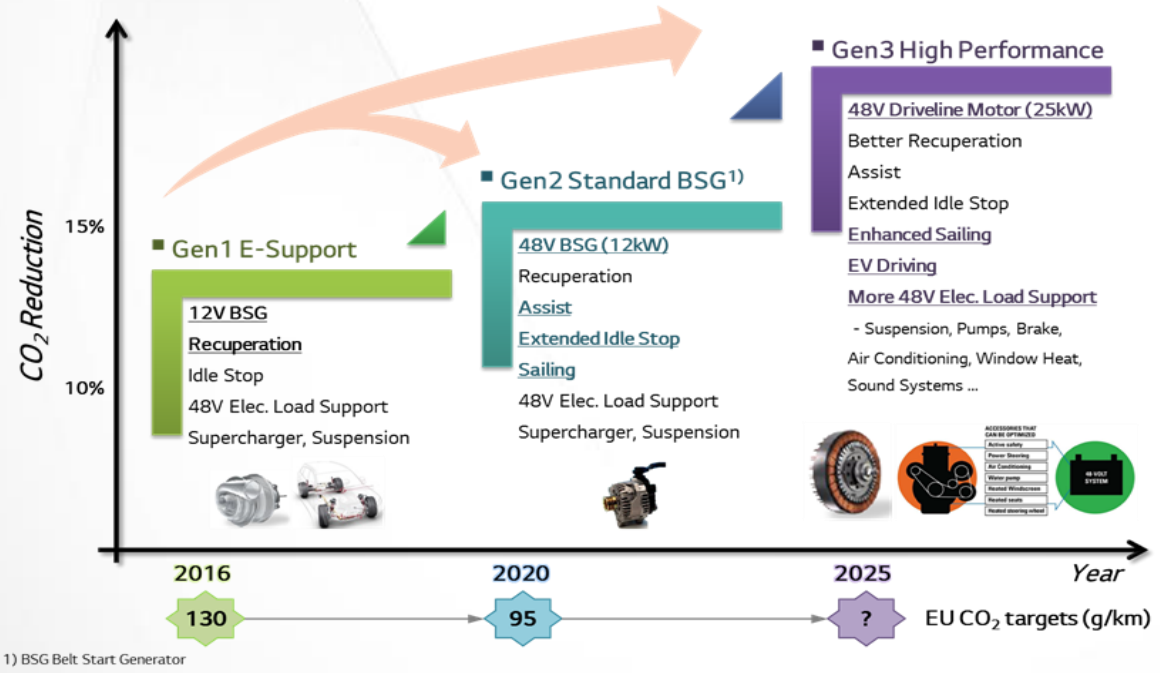
Global Market Status for Low Voltage System (12 V / 48 V)

LG Chem is actively participating in Low Voltage System projects for various OEMs.



LG Chem's Future Perspective for 48 V System

48V System is being developed from Mild Hybrid (CO_2 12~15%↓) to Full Hybrid (CO_2 15~25% ↓).



1) BSG Belt Start Generator

48 V Trends

1. Gen 1 : Stable 12 V power-net and apply more power functions (Supercharger, Suspension)
2. Gen 2 : 48 V BSG (12 kW) applied to get more regeneration energy and realize limited hybrid function
3. Gen 3 : 48 V Driveline motor (25 kW) and more electrical load applied for better CO_2 reduction.

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LG Chem's Chemistry for Low Voltage System

Various LiB chemistry could be chosen as a optimal chemistry for 12 V single, 12 V dual, and 48 V dual application.

○: Fair ◎: Good ●: Superior

Chemistry		NMC/LTO	LFP/Graphite	NMC/Graphite
Voltage Profile		1.7~2.5 V, 2.2 V	2.5~3.7 V, 3.3 V	3.0~4.2 V, 3.7 V
Performance	Energy density	○	◎	●
	Durability	●	◎	◎
	High/Low temp. performance	●	◎	◎
Key benefit		• Excellent durability over wide temperature range • High charge power at low temperature. • Excellent Safety behavior • Under the hood location possible	• Good cold cranking power at low temperature • A wide range of usable SOC for 12 V system	• Compactness through high power & Energy density • Lower cost due to high cell voltage and common usage with HEV battery
Key issues		• Cost increase due to low nominal voltage	• Difficult BMS sensing due to very flat voltage profile	• Cooling concept required due to high temp. performance • Incompatible voltage for 12 V system
Preferable application		12 V Dual, 48 V Dual System	12 V Single System	48 V Dual System

LG Chem's Development Strategy for 48 V System

48 V System can be divided by vehicle's motor performance such as "Low Power" and "High Power"'.