The role of Pb batteries in future automotive power trains

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WE ARE CLARIOS

The World Leader in Energy Storage for Low-Voltage Mobility

1 in 3 CARS
IN THE WORLD IS POWERED BY OUR BATTERIES

155MM
BATTERIES SOLD ANNUALLY

140+
COUNTRIES SUPPLIED BY OUR VOLUME GLOBALLY

55
MANUFACTURING, RECYCLING & DISTRIBUTION CENTERS WORLDWIDE

16,000+
GLOBAL EMPLOYEES

130+
YEAR TRADITION
OF INNOVATION AND GROWTH

THE BROADEST AND MOST EFFICIENT PORTFOLIO OF BATTERIES

STANDARD LEAD-ACID	ADVANCED LEAD-ACID	LITHIUM-ION

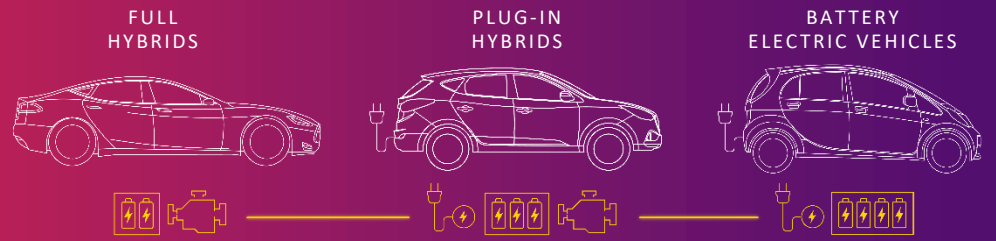
A FAMILY OF GLOBAL BRANDS:

LTH · OPTIMA BATTERIES · Heliar · MAC · VARTA · Delkor

CLARIOS

Clarios xEV. The Power of X for any EV.

A 12V battery lives inside every hybrid, plug-in hybrid and electric vehicle.



Working in perfect tandem with the vehicle's high-voltage battery, Clarios xEV delivers optimal vehicle performance, constant power and crucial safety.

PARKED
Vehicle security and software updates

DRIVING
Starting and peak load support

SYSTEM FAILURE
Powering safety-critical loads

Performance for every state.

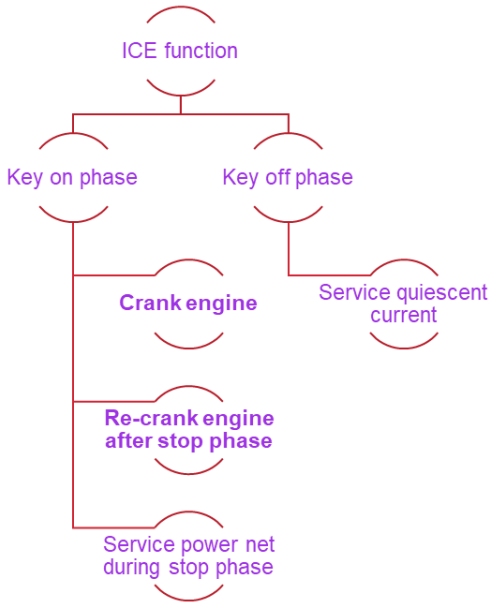
The Clarios xEV battery enables critical safety and performance functionality whether the vehicle is parked, driving or experiencing a high-voltage system failure.

CLARIOS

THE ROLE OF Pb BATTERIES IN AUTOMOTIVE POWER TRAINS

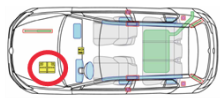
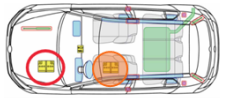
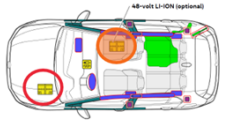
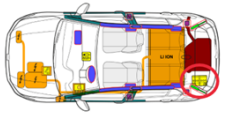
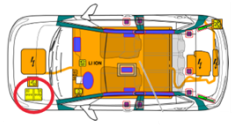
Vehicle Examples OEM compact car

12V Battery
Functions in ICE cars:



Battery Application - Vehicle Architectures / Power Net

Vehicle Examples OEM compact car

Version 7 ICE	Version 7 12V Micro Hybrid	Version 8 48V Mild Hybrid	Version 8 PHEV	Version full EV BEV
				
Energy storage @				
1. fuel tank	1. fuel tank	1. fuel tank	1. fuel tank	1. 400V battery Li-Ion 58kWh
2. 12V battery PbA	**2. 12V battery PbA 69Ah**	**2. 12V battery PbA 59Ah**	**2. 12V battery PbA 59Ah**	**2. 12V battery PbA 59Ah/0.7 kWh**
	3. 12V battery Li-Ion 6Ah	3. 48V battery Li-Ion 14Ah	3. 350V battery Li-Ion 10kWh	
92kW – CO_2 120g/km	**96kW – CO_2 113g/km**	**110kW – CO_2 108g/km**	**180kW – CO_2 34g/km (1.5l/100km)**	**107kW – CO_2 0 g/km**

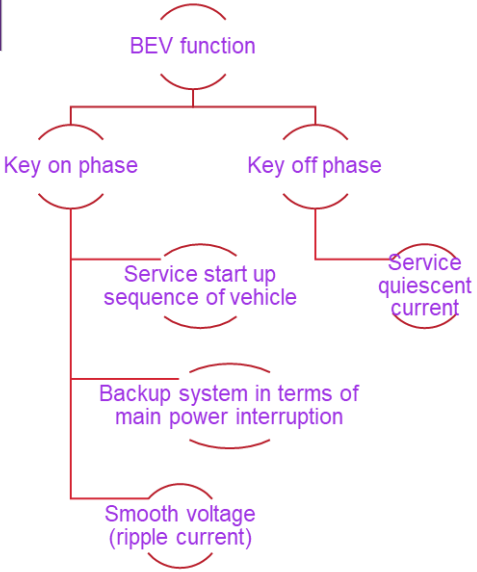
fuel / CO2 saving (driven by regulation) & fun to drive (customers are willing to pay for it)

Change of 12V Battery Application (how the battery is used) ➔
↳ e.g. engine cranking demand change

mainly in PHEV & BEVs
HV battery with high energy

ICE = internal combustion engine, BEV = battery electric vehicle, PHEV = plug in hybrid

12V Battery
Functions in EV cars:



WHAT IS AT STAKE IN THE AUTOMOTIVE TRANSFORMATION

Differentiated technology portfolio to lead in low-voltage transition to electric and autonomous vehicles

BY 2040

75% of new vehicle sales expected to be EVs[1]

Autonomous Functionality Increasing

Low Voltage Battery Remains Critical

Technology Choices Driven by Application Need

PRODUCT DEVELOPMENT PIPELINE

CLARIOS xEV
MULTI-BATTERY AGM SOLUTIONS

Today: Full portfolio addresses specific needs of today's xEV applications

SMART AGM
FOR AUTONOMOUS FUNCTIONALITY

- ACCURATE BATTERY MONITORING
- DIAGNOSTICS AND COMMUNICATION
- AGM CONSTRUCTION

Tomorrow: Functionality required for autonomous applications + AGM advantages and aftermarket business model

LV LI-ION
EXPANDING PORTFOLIO

- PACKAGING
- WEIGHT
- EXTENDED LIFE

Future: Li-Ion offerings across multiple chemistries for improved packaging and life supported by 15+ years of experience

[1] Based on IHS data for Clarios core geographies of Americas, Europe, China

CLARIOS

The main 12V Product Choices in Comparison

Standard Flooded Battery	
	
CHARGE ACCEPTANCE	
RE-CHARGABILITY	
CYCLING	
PARTIAL STATE OF CHARGE	
WEIGHT TO PERFORMANCE RATIO	
HIGH HEAT PERFORMANCE	
SUSTAINED PERFORMANCE	
DIAGNOSTIC CAPABILITY	

EFB Gen 1	
	
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HIGH HEAT PERFORMANCE	
SUSTAINED PERFORMANCE	
DIAGNOSTIC CAPABILITY	

AGM	
	
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12V Li-Ion	
	
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WEIGHT TO PERFORMANCE RATIO	
HIGH HEAT PERFORMANCE	
SUSTAINED PERFORMANCE	
DIAGNOSTIC CAPABILITY	

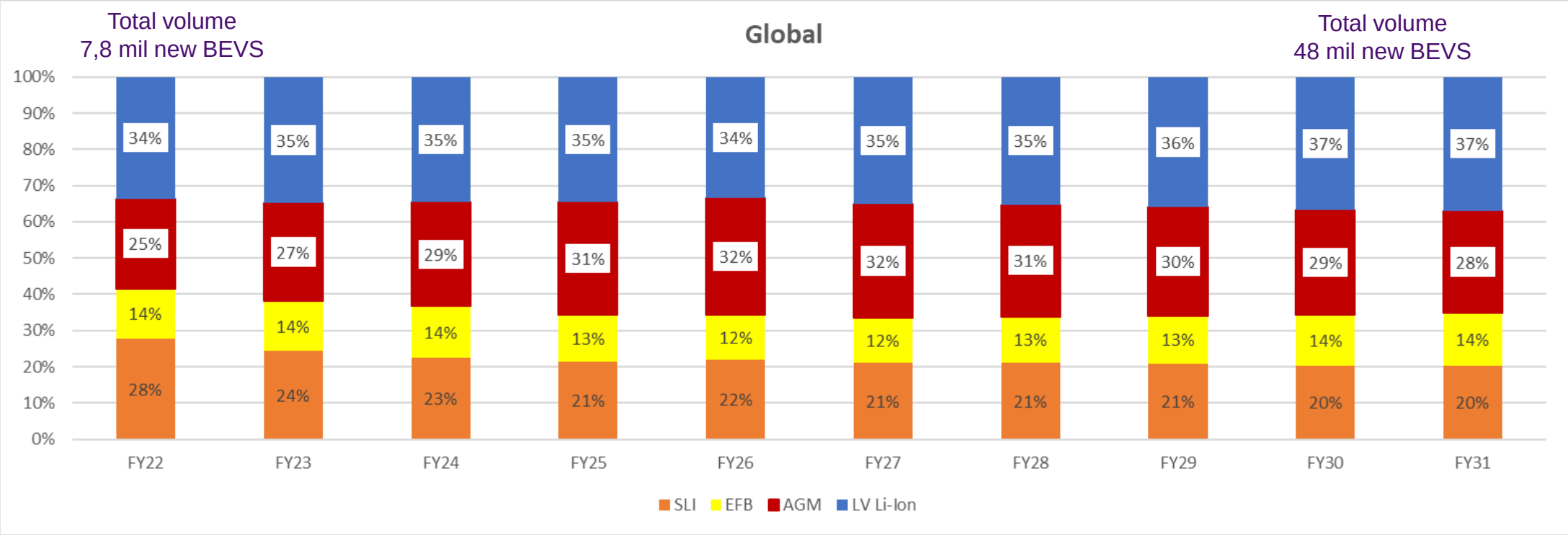
Low Voltage Technology Share in new Electric Vehicles FY 22 – FY 31

The 12V Power net will be needed in future power train

Pb-Batteries will remain to be the predominant technology with a declining trend in new BEVs

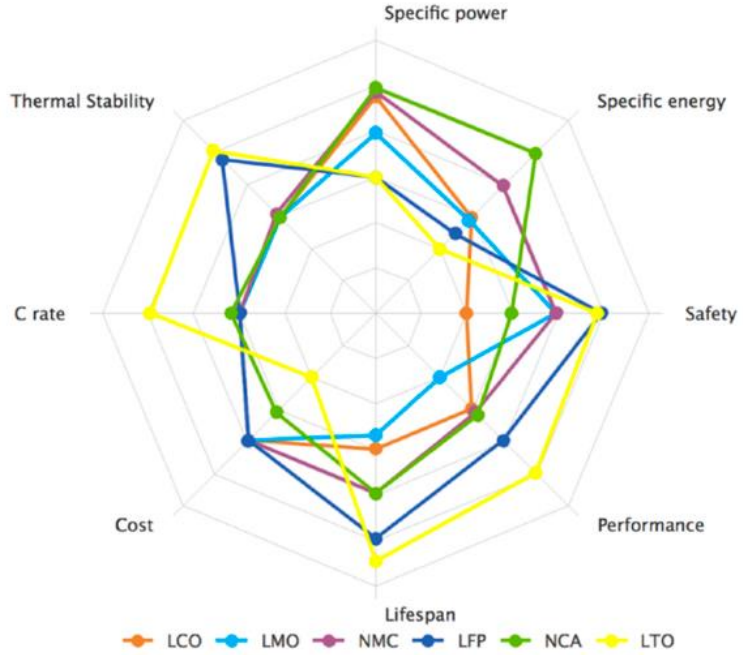
The total market is predicted to grow from 7,8m EV to 48m EV in 2031.

The high share of 12V Li-Ion in new vehicles in FY22 is driven by US and China.



OEM DECISION MAKING – Low Voltage LITHIUM ION

MEET AUTONOMOUS REQS	PACKAGING / WEIGHT advantages	ELV Directive PROTECTION	LITHIUM For LITHIUM SAKE



OEM DECISION MAKING – LEAD ACID

COST	RELIABLE	SUSTAINABLE	SAFE

XEV battery design and application

Key services for non cranking applications

New requirements driving the change:

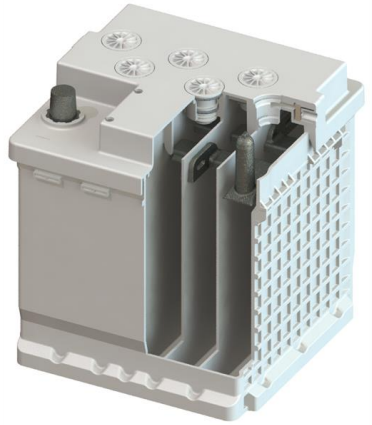
- Cranking function disappear.
- Service function becomes key.
- Less energy required = smaller batteries and mainly AGM.
- Key off load service function.
- Peak power demand needed

  (interrupted high voltage power source).
- Mobile office services.
- Cycle and backup scenarios possible.
- Battery range from H3 (LN0) to H6 (LN3).

AGM H3 (LN0) Design

Characteristics

- CCA-EN: 380
- Ah: 40
- Weight: ca. 13 kg
- Dimensions (HxLxW): 190 x 175 x 175mm
- 5 pos. Plates (PF E-Grid)
- 6 neg. Plates (ConCast)
- 1,45 mm AGM Separator (1,5mm Rijie)
- EN hold down & robotic rips

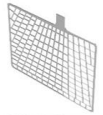


Usage of existing components

AGM Flame Arrestor

AGM Plug with valve

Standard EN Bushing



AGM E-Grid

Development of new components

New AGM H3 Cover

New AGM H3 Case

New AGM H3 COS

xEV future design and application options

12V Pb battery choices

Design option for future AUX applications:

- **Housing** :

  Flame retarding material if needed (up to UL94 V0 class)

- **Connector**:

  Screw type connection → save connection over very long life (over come problem of ductile lead post).

- **Rechargeability**:

  Additives to NAM and electrolyte to maintain rechargeability over life (not DCA but CA).

- **Power output:**

  Usage of thin plate technology to improve significant cold storage peak performance (for e.g. @ -30°C) or 7 cell design for meet requirement of high cut off voltages.

- **Cycle life :**
  - Usage of thick plate technology to improve significant cycle life with high DOD's (for e.g. 80% DOD).

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CLARIOS

MARKET ANALYSIS

COMPETITIVE VIEW – STATE OF HEALTH (SOH) / STATE OF FUNCTION (SOF)

	TELEMATICS	IBS SIMPLE	IBS ADVANCED	CLARIOS SMART AGM
Test Frequency	5 mins intervals	Seconds	Milliseconds	Milliseconds
Battery Voltage	System voltage, not battery voltage	✓	✓	✓
Battery Current	✗	✗	✓	✓
Battery Temperature	Ambient only	✓	✓	✓
Cell Level Voltage	✗	✗	✗	✓
Reliability	✗	(+)	+	++ (+) *
Performance Optimization SOC	✗	✗	+ accuracy?	++ (+) through ext. charging
Proactive Replacement Predictive SOH (aging)	✗	✗	✗***	✓
Safety Integrity Predictive SOF (start ability)	✗	✗	✗***	✓
Diagnostic Result	NA	NA For calibrating charging only	+	++ (+)*
Uninterrupted Diagnostic	✗	✗	✗	✓
ASIL characterization	✗	✗	✗***	✓
Recyclability	NA	NA	NA	+
Space/Weight	NA	+	+	++
Cost/Installation	$	$ (excl. battery)	$ (excl. battery)	$$
Standardized product	Standard	Standard	Standard	Unique

IBS: Intelligent Battery Sensor

*** Based on averaged measurement values

CLARIOS

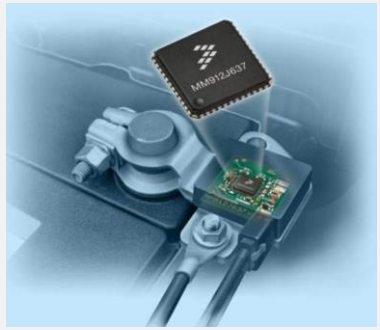
EVOLUTION OF THE 12V BATTERY – CURRENT AND FUTURE STATE

CURRENT STATE

Most applications use off battery/terminal monitoring

Effectiveness of the system relies on pairing the battery technology with the appropriate sensor

Battery and sensor technology are not developed jointly.



CLARIOS SOLUTION

Integrated BMS solution for 12V battery

Optimized for each OE to offer maximum functionality, reliability, safety for xEV and autonomous applications

Accurately predict the state of the battery to ensure that it is available to support emergency functions

LEVERAGING ELECTRONICS EXPERIENCE FOR NEW PRODUCTS

STANDARD AGM

20+ Years of AGM experience

NO BATTERY MANAGEMENT SYSTEM (BMS)

12V LI-ION

15+ Years of Li-Ion/Electronics Experience

INTEGRATED BMS

- Manages battery state of charge, health and function.
- Electronics, sensors, diagnostics, communications.

SMART AGM

Cell level sensing + AGM Performance

INTEGRATED BMS

- Manages battery state of charge, health and function.
- Electronics, sensors, diagnostics, communications.

Our Lead acid mfg expertise and Li-Ion electronics/software experience made SMART AGM possible.

CLARIOS

SMART AGM - PRODUCT TIMELINE

OE & Fleet SAMPLES
Q1 2023

SOP – LOW SCALE
Q1 2024

SOP – Customer Launches
Q2 2024

SOP: Start of Production

WHAT DO CONSUMERS WANT?

DEPENDABLE

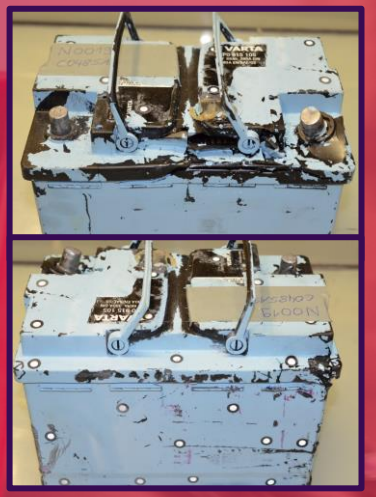
RELIABLE

AFFORDABLE

OUT OF MIND

AGM battery after crash test:

- Container damaged (container cracked at several positions)
- Terminal deformed but
- Battery is still fully functional!



CLARIOS

THE ROLE OF Pb BATTERIES IN AUTOMOTIVE POWER TRAINS

Summary

- 12V Power Net will be needed through 2031 - No matter the vehicle type, nearly every single vehicle will depend on a 12V battery.
- We're seeing significant changes in the way low voltage batteries are used — from increasing electrification to autonomous features that make cars safer and more convenient.
- The intrinsically high safety of PbAcid batteries is recognized by OE customers, but the predictability with BMS is key to success.
- OEM’s interest in 12V lithium-ion growing, however Pb batteries will be around for a while with new innovations.