Unlocking the full potential of **Battery Management Systems**

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Executive summary

As EV adoption faces battery costs, charging, and lifespan challenges, next-generation battery management systems offer an opportunity for OEMs to regain competitive advantage while enhancing performance, safety, and sustainability.

This document outlines how modern battery management system architecture, powered by AI, cloud integration, and advanced diagnostics, enables new business models like battery-as-a-service and predictive maintenance. Regulatory shifts, such as digital battery passport, provide a catalyst to leverage battery data and intelligence.

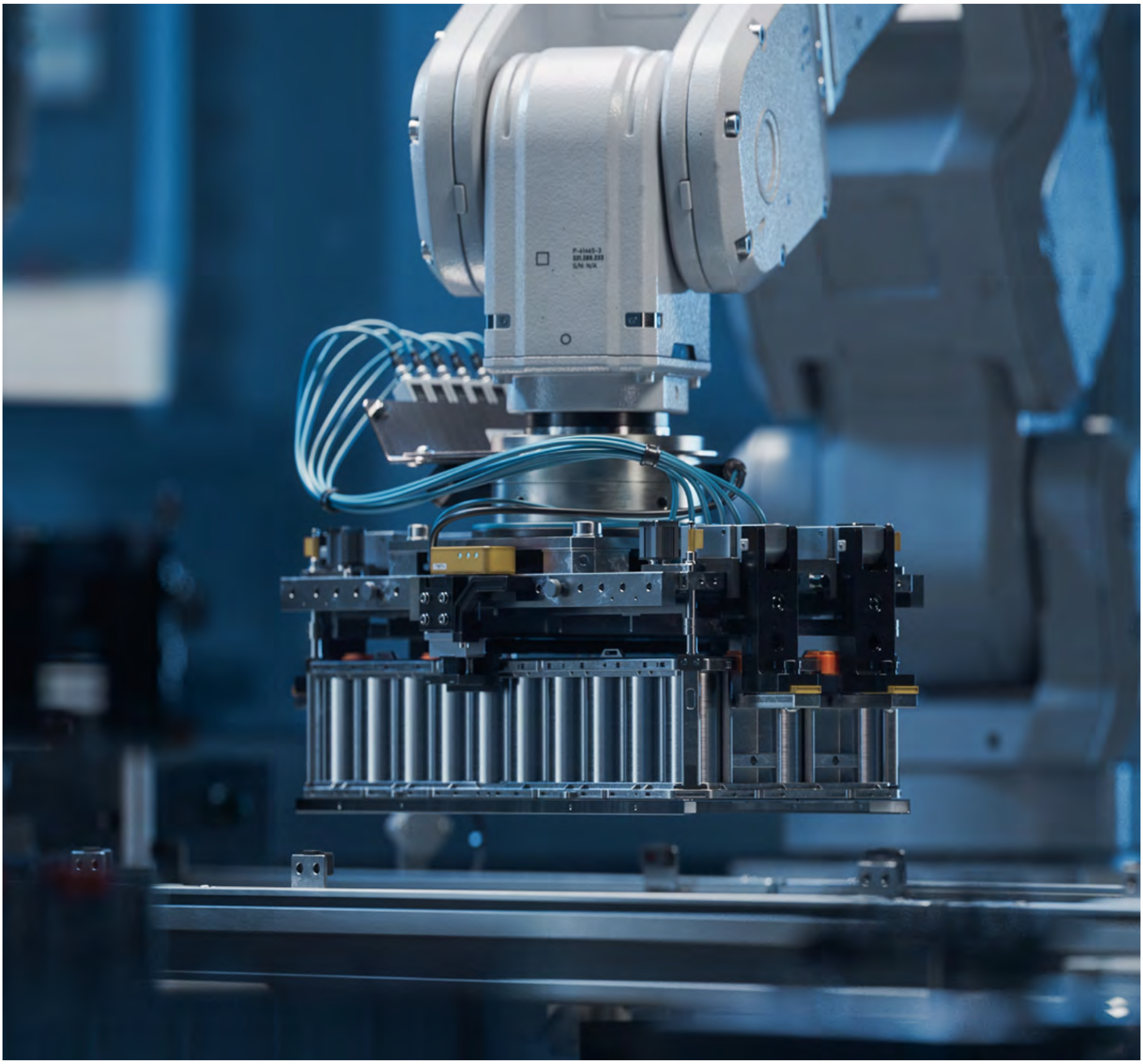
To stay competitive, automotive and industrial OEMs may consider investing in data-centric, software-defined battery management system platforms that are modular, secure, and scalable. At Capgemini, we help clients make this shift by combining engineering depth with cloud-enabled services to renew competitive advantage across the battery lifecycle.

Introduction

Who should read this point of view and why?

This document is primarily intended for professionals in the automotive sector, particularly Electric Vehicle (EV) engineers and decision-makers involved in battery management systems and the broader EV powertrain. While the insights presented are especially relevant to automotive applications, many elements are equally applicable to adjacent domains, such as Battery Energy Storage Systems (BESS).

Although we emphasize the central role of the battery and the intelligence embedded within it in the transformation of the automotive industry, a comprehensive understanding also requires attention to other key drivers. These are explored in our previous Capgemini Research Institute reports, available online, such as The Battery Revolution[1] and Software Defined Vehicle[2].



[1] www.capgemini.com/wp-content/uploads/2025/02/CRI_Future-of-batteries_V12.pdf
[2] www.capgemini.com/gb-en/insights/research-library/software-defined-vehicles-for-the-commercial-vehicle-market/

Recalibrating expectations in the EV landscape

Electric vehicle (EV) sales have fallen short of expectations. Forecasts were overly optimistic, as illustrated in a recent Bloomberg publication. The current product offerings may not be sufficiently compelling to attract a broad customer base. Additionally, fiscal incentive programs remain inconsistent and sometimes inadequate.

There are two key barriers to EV adoption from a consumer perspective:

Financial barrier:
EVs remain expensive, and their resale value remains lower than their combustion engine equivalent.

Practical barrier:
Charging is still perceived as inconvenient and represents the main obstacle to the adoption of electric vehicles in fleets.

Newer model generations and the development of smaller, urban-optimized vehicles, partly solve the issues of affordability. For example, new market entrants like BYD, propose affordable models now rolling into Europe, surpassing Tesla in mid-2025 sales. Lower upfront costs also mitigate concerns about resale value.

The race is on for battery differentiation

The battery holds the key to winning in the EV market and there are three clear levers to victory:

Cost

Representing between 1/3 and 1/2 of the vehicle cost, the battery is by far the most expensive EV component. The leading EV players today have vertically integrated battery production, sometimes down to the cell level: controlling the core components enables control of the margin.

Charging ubiquity and speed

Technically and systemically complex, the charging operation has seen innovations like wireless charging stations and battery swapping. Yet fast charging remains the holy grail, caught between two forces: Standardization of infrastructure and hyper-optimization of battery design. Again, vertical integration wins: Tesla's Hyper charger and BYD's Megawatt charging are prime examples.

Battery capacity and lifespan

Manufacturers are racing to bring higher battery capacity and extended warranties to the market. Indeed, large battery capacity directly contributes to alleviating range anxiety and to improving cabin comfort.

Regulation: Pushing for greener and safer batteries

Battery lifespan is increasingly shaped by regulations that demand increased durability, safety & traceability along a complete lifecycle. A founding principle is the need for nations to improve their sovereignty on the key materials that compose the battery system. The battery management system is directly involved in this regulation enforcement.

For example, starting in 2027, the full Digital Battery Passport (DBP) will be mandatory across Europe (see our Battery Passport Point of View). However, **key requirements are already in effect**: since 2024, manufacturers must disclose electrochemical performance and durability metrics to end-users through documentation linked to the battery and its battery management system.

Greener batteries

A global push for battery traceability, sustainability and circularity is gaining momentum, reflected in regional battery directives and clean-battery regulations. These efforts are summarized in the **Global Regulatory Timeline** (Figure below).

Greener batteries: A global evolution of regulations

EU battery passport

For EV (Electric) & ESS (Energy Storage Systems)

Year 2023: Regulation (EU) 2023 / 1542 adopted
Year 2024: Regulation effective
Year 2025: Supply-chain due diligence begins
Year 2026: Carbon footprint reporting starts
Year 2027: **Battery passport mandatory (Feb 18)**
Year 2028: Lifecycle impact assessments required

China full traceability

For lithium batteries

Ongoing since year ~2018: Lifecycle traceability already enforced via national NEV battery platform
Year 2020: Continuous enhancement and enforcement
Year 2024: Draft rules to strengthen reuse and traceability
Year 2027: Formal implementation of full lifecycle traceability for lithium batteries

US alignment (expected)

For circular battery reporting

Year 2022: Inflation Reduction Act (IRA) passed
Year 2023 - 2025: Industry and government alignment efforts
Post - year 2025: Expected adoption of traceability standards
Year 2027: IRA/FEOC (Foreign Entity of Concern) rules push deeper tracing for critical materials
Year 2028 + : A plausible target for anticipated alignment on circular battery reporting alignment via pilots, standards, and state-level policies

India alignment (expected)

Battery Aadhaar initiative (proposed for traceability, recycling efficiency, and sustainability) for lithium batteries

Year 2025 (Dec): Draft guidelines issued

- Initial framework released through draft memorandum

Year 2026 (Jan): Mandatory ID proposed

- Proposal: 21-character **Battery Pack Aadhaar Number (BPAN)**
- To apply to all EV battery packs

Post-2026: Systematic implementation

- Phase wise implementation expected through AIS (Automotive Industry Standard) process
- Full adoption may take multiple phases

Safer batteries – regulations driving innovation

Batteries are the most mission critical component in an EV and regulatory bodies like ISO, UNECE, UL (Underwriters Laboratories), and AIS are tightening safety standards. As a result, modern battery management systems must incorporate:

- Redundant safety layers to prevent cascading failures
- Real-time diagnostics for proactive fault detection
- Fail-safe mechanisms to ensure operational integrity under stress

International Organization for Standardization (ISO)

ISO 26262 – functional safety:

- Applies to electrical and electronic systems in vehicles, including BMS.
- Requires fail-safe design, redundancy, and risk classification for BMS components.

United States – National Highway Traffic Safety Administration (NHTSA)

Federal Motor Vehicle Safety Standards (FMVSS):

- NHTSA is adopting GTR (Global Technical Regulation) No. 20 into FMVSS to align EV and battery management system (BMS) safety standards globally, streamlining compliance and improving vehicle safety.

China – GB/T standards

Safety requirements

GB/T 31485 – for traction battery packs:

- Specifies thermal management, short-circuit protection, & overcharge/over-discharge safeguards.

GB/T 38031-2020 – for EV batteries:

- Mandates thermal runaway detection, fire resistance, and mechanical integrity.
- Increasingly referenced in global BMS design due to China's EV market leadership.

European Union / United Nations Economic Commission for Europe (UNECE)

GTR No. 20 – Global technical regulation on electric vehicle safety:

- Covers in-use operational safety, post-crash electrical safety, & battery fire risks.
- Includes provisions for thermal runaway, water immersion, and vibration resistance and is expanding to cover advanced BMS protocols.

UNECE R100 (Rev. 3):

- EU-wide rule covering EV battery safety, electrical, shock, & thermal protection.
  EU Battery Regulation (2023/1542): Mandates battery passports tracking health, carbon footprint, and recyclability.

India's BMS and battery safety standards

AIS-156 – Battery safety for electric vehicles:

- EVs must have microprocessor-based BMS with key protections, thermal sensors, alerts, EMC compliance (AIS-004), earth leakage detection, & traceable, cell-level monitoring for safety and diagnostics.

AIS-038 Rev 2 – Functional safety of electric powertrains:

- This regulation ensures protection from electric shock, water ingress, & thermal events, with labeling and system-level battery validation requirements.

IS 16893 – Indian Standard for lithium-ion cells:

- Must ensure cell-level compliance with thermal, electrical, & mechanical safety factors.
- Supports battery pack validation and certification under Indian regulatory frameworks.

As batteries become smarter and more connected, cybersecurity is no longer an option. It is a critical mission. A compromised battery management system can jeopardize safety, performance, and data privacy. With remote monitoring on the rise, battery management systems have emerged as a prime target for cyber threats.

To meet evolving standards, modern battery management systems must support secure Over-the-Air (OTA) updates and comply with ISO/SAE 21434 and UNECE WP.29. The recent Cyber Resilience Act (CRA) also impacted the design of the battery management system, falling under Critical Class I or Class II devices due to its network connectivity and safety-related functionalities.

A continuously evolving battery landscape: Staying ahead of technological and product shifts

One of the most pressing challenges in battery technology is its **relentless pace of innovation** combined with the **dynamic physical behavior** of batteries once deployed.

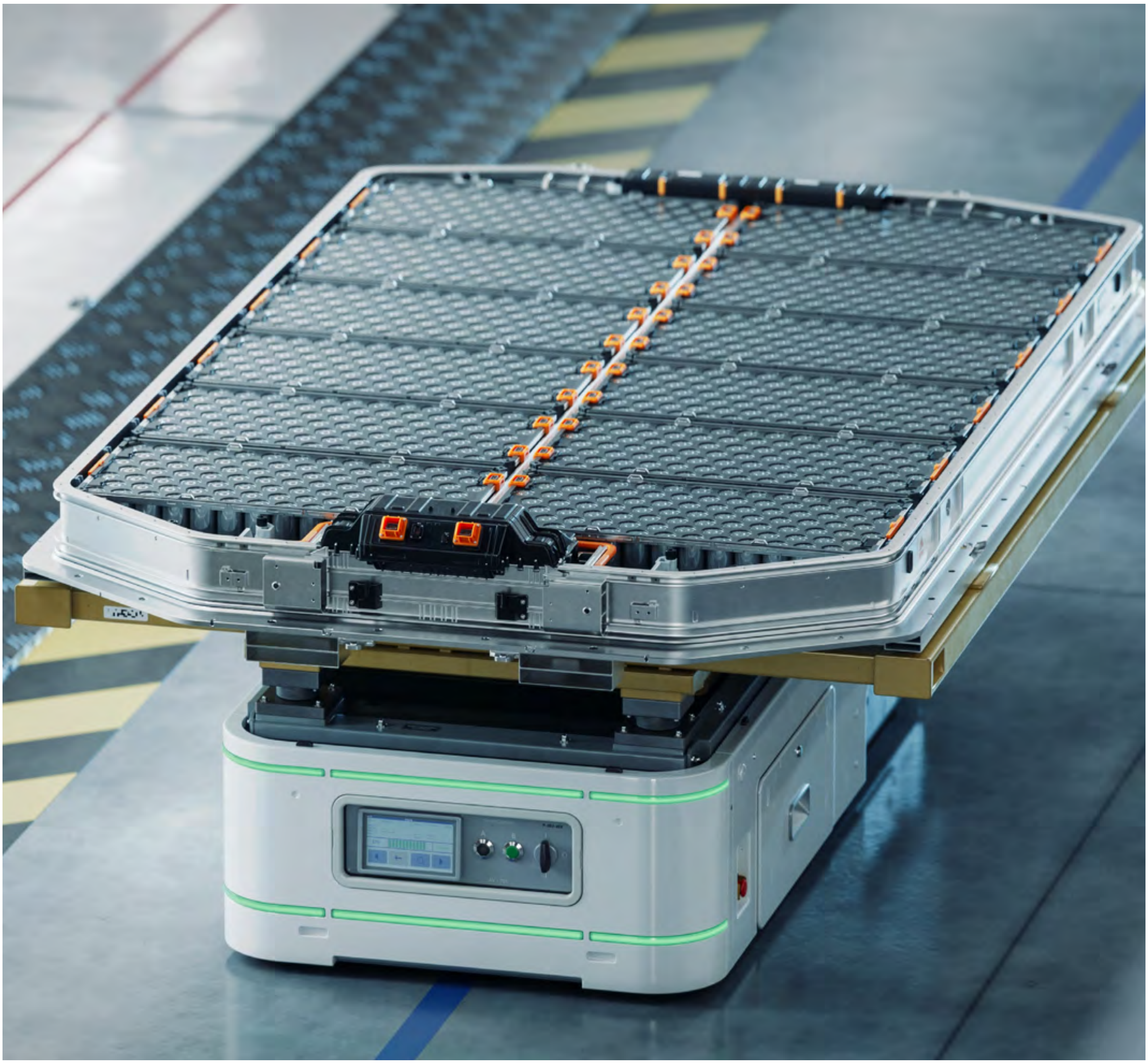
Continuous evolution

Battery cells rapidly change in composition and design. Advances in materials and manufacturing, coupled with increasingly specialized OEM demands, mean today's best cell could be technologically obsolete in 3–5 years.

Changing characteristics

Once deployed, batteries degrade incrementally with every charge cycle. Monitoring this aging process and adapting vehicle usage over an 8+ year lifespan is essential to maintain performance, ensure reliability and uphold warranty commitments.

Manufacturers face dual pressure: Keeping pace with fast-moving innovation while managing real-world battery degradation without compromising performance or safety. This demands **continuous adaptation** across product portfolios and production ecosystems.



A strategic shift to "MAKE"

The outlooks of this situation can be synthesized in two strategic questions:

- How can OEMs and battery integrators that do not manufacture battery cells develop advantages comparable to fully integrated players?
- How can they shift value creation from the battery as a static object to equipment usage? How can they unlock data, performance, and lifecycle insights and reclaim control over the value chain?

The answers lie in rethinking the battery not just as a component, but as a service, a data source, and a strategic asset.

The solution is clear: The battery management system must evolve. It must become smarter, more adaptive, and deeply integrated to handle both rapid innovation and long-term reliability.

Why is the battery management system central in the answer?

The battery management system is at the core of battery performance

The Battery Management System (BMS) is central to battery performance and increasingly a key differentiator for OEMs. It governs the battery's three macro-states:

Rest:
Whether idle for hours or months, the battery management system must operate in ultra-low power mode while maintaining critical safety functions. Smart power state management ensures a safe and responsive rest mode.

Charging:
The battery management system monitors each cell to prevent overcharging and overheating while supplying real-time data to the charger. Fast charging depends on seamless coordination between the battery management system, the charger and sometimes the grid itself.

Discharging:
The battery management system protects against overdischarge and provides accurate residual energy estimates, factoring in temperature and battery aging, all while minimizing its own energy consumption.

Throughout all states, the battery management system performs **cell balancing** to prevent voltage drift, preserve capacity, and extend battery lifespan. Transitions between rest, charge, and discharge demands advanced algorithms and precision control.

Given its role in fast charging, battery health, and user trust, **OEMs are investing in proprietary battery management system designs**, moving beyond off-the-shelf solutions to gain full control over battery performance and quality.

The battery management system generates battery data

When up to half the value of an EV lies in its battery, the data it generates is far too important to ignore. With its array of sensors, the battery management system holds deep insights into battery health, usage patterns, and even the vehicle's operational history.

The rollout of the Digital Battery Passport (DBP) brings legal and regulatory backing to this data, enhancing transparency and reliability. Battery data serves multiple stakeholders as shown in the figure.

As battery data grows in quality and precision, so does battery intelligence and its role in shaping trust, performance, and the future of mobility.

Technology providers & tier-1 suppliers

Unlock scalable growth via technology innovation, and co-developed smart features.

End users and/or vehicle owners

Know the origin of battery materials, its nominal and current performance and assess resale value with confidence.

OEM or vehicle manufacturer

Diagnose failures, enforce warranties, and improve design and quality.
Enable battery buy-back business models.

Regulators & insurers

Enable compliance, risk mitigation, and safety oversight through traceable battery data, support for battery passports and circular economy standards.

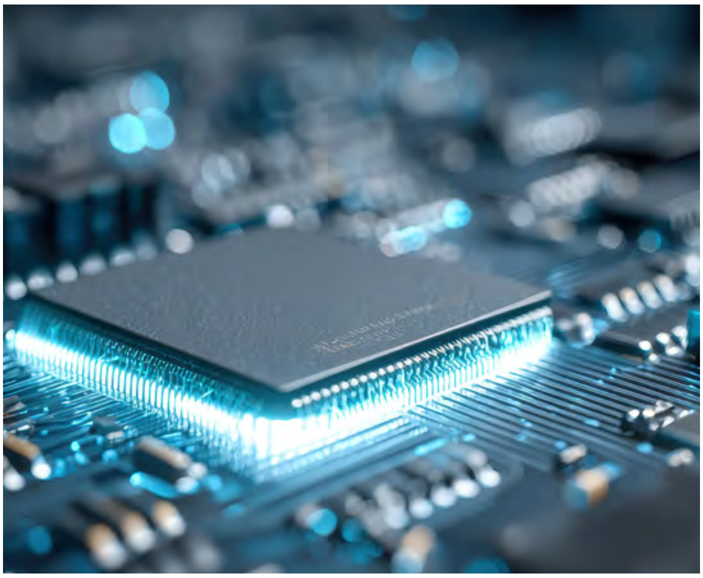
Battery ecosystem players

Brokers, repairers, leasers, recyclers, and assessors rely on the data to evaluate condition, value, and reuse potential, often relying on cloud-based solutions.

Fleet operators

Optimize usage, enable predictive maintenance, and refine future battery specifications.

Identifying gaps in current battery management system architectures



Current battery management system are hardware-centric in design

Current battery management systems feature hardware-centric design. They evolved incrementally from basic Protection Circuit Modules (PCM) to complex assemblies built around vendor-specific Analog Front Ends (AFEs). This means even minor design changes, or a component shortage, can trigger costly redesigns and long lead times. To future-proof battery management system architectures, flexibility, modularity, and updatability must become core design principles.

Blurred separation between safety-critical and non-safety-critical functionalities

Another challenge is the blending of safety-critical and non-critical functions, which makes designs very difficult to improve or adapt for different batteries. Preventing battery fires is a core functionality, and safety components should be clearly isolated to avoid interference from auxiliary, less critical operations. This design discipline often overlooked in consumer electronics is essential in automotive-grade systems.

Software and cybersecurity

Finally, software and cybersecurity are now central to any smart component. With multiple sensors and communication interfaces, the battery management system is one of the most exposed components in a vehicle. Implementing robust, secure software is vital, yet difficult to implement in today's hardware-defined architectures. The shift toward software-defined, secure, and modular battery management system is no longer optional, it's urgent and inevitable.

Setting grounds for the next-generation battery management system

A data-centric architecture

Battery Management Systems (BMS) are evolving rapidly, driven by Software-Defined Vehicle (SDV) architectures. They now feature enhanced communication protocols, deeper parameterization, and tighter integration with **manufacturing and cloud ecosystems**.

AI and machine learning are increasingly used for diagnostics, safety monitoring, and predictive maintenance, making battery management systems smarter and more proactive. This is at the core of the Energetic European project (2024-2026) for example, where Capgemini explores and proposes, with 10 industrial and academic partners, an innovative artificial intelligence-based approach to improve battery energy storage.

However, this software-centric shift introduces new cybersecurity risks, requiring strong protection against hacking **and data breaches.**

Despite the software advances, traditional engineering remains essential: Battery management system calibration, cell modelling, and extensive testing are more critical than ever to ensure safety and reliability. The trend toward standardized, highly integrated solutions for Analog Front Ends (AFE) and communication interfaces supports scalability and efficiency across platforms.

Yet, growing reliance on vendor-specific solutions raises concerns about lock-in, interoperability, and technological sovereignty. In this evolving battery management system landscape, **balancing innovation with architectural flexibility** is essential to ensure **scalability, resilience, and long-term control over product evolution.**

Configurable and reusable battery management system architecture

The automotive electronics landscape is rapidly evolving toward modular, reusable architectures that support accelerated **system integration and scalable deployment**, and cross-platform compatibility. High-speed interconnects enable seamless communication between heterogeneous components, facilitating the development of complex Vehicle Control Units (VCUs). This trend is particularly impactful in software-defined vehicles (SDVs), where hardware abstraction and dynamic reconfiguration are becoming foundational principles.

Battery management systems are increasingly benefiting from these architectural innovations. The integration of LG's battery management system onto Qualcomm's Snapdragon platform exemplifies how high-performance, automotive-grade SoCs can be repurposed to support battery management functions. This approach enables scalable, software-centric battery management system designs that can be adapted across multiple vehicle platforms and battery configurations.

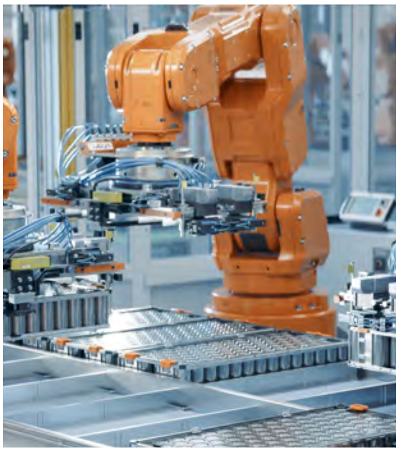
To fully leverage these capabilities, battery management system development must embed algorithmic intelligence at the core of the design process. Key focus areas include:

- AI/ML-based fault diagnostics for early anomaly detection
- Adaptive cell balancing to optimize performance and longevity
- Thermal management algorithms for dynamic cooling control
- Predictive maintenance leveraging real-time data analytics

Once foundational constraints such as ISO 26262 functional safety compliance, UNECE WP.29 cybersecurity requirements, power optimization, and multi-protocol communication support (CAN, LIN, Ethernet) are addressed, the same hardware and software stack can be reused across multiple product lines.
This reuse not only reduces development time and cost but also ensures consistency and scalability.

Beyond battery management system: Unlocking new battery services

The **next-generation battery management system** is no longer just a monitoring tool, it's the **core of a dynamic platform** where new business actors tap into the value of batteries in service. It **transforms batteries into service-driven opportunities.**



Battery as a Service (BaaS)

Concept: Instead of owning batteries, customers (especially fleet operators) subscribe to battery usage. This model decouples the battery from the vehicle.

Benefits:

- Reduces upfront vehicle cost.
- Enables flexible upgrades or replacements.
- Shifts maintenance and performance responsibility to the service provider.

Predictive & curative maintenance

Predictive maintenance:

- Uses data analytics and AI to forecast battery health issues before they occur.
- Minimizes downtime and improves reliability.

Curative maintenance:

- Involves **restoring autonomy and charging time** by replacing degraded **battery sub-modules**.
- Requires modular battery design and a flexible battery management system that allows **dismounting/insertion** of submodules.

Impact on TCO (Total Cost of Ownership):

- Reduces long-term costs for fleet operators.
- Extends vehicle life and improves operational efficiency.
- Enables targeted repairs rather than full battery replacements.

Selling used batteries or used EVs

Traceability of battery sub-modules:

- Each sub-module should have a unique id and lifecycle data (usage, health, charge cycles).
- Enables informed resale decisions and supports second-life applications (e.g., energy storage).

Centralization of information:

- A digital platform or cloud-based system that aggregates battery data across vehicles and modules.
- Facilitates transparency, compliance, and resale value estimation.

Innovation pathways: Two development tracks for battery management system

Invest in battery management system architecture

Battery management system design never starts from a blank page. The semiconductor industry is proposing battery management components that are increasingly programmable, reducing the re-design effort but demanding an initial greater software effort. Mastering these components and finding the right balance between hardware circuits and software-defined functions is the central activity of battery management system architecture.

For OEMs and Tier-1 battery suppliers, mastering battery management system architecture is essential to delivering differentiated battery solutions with reduced time-to-market. It enables the creation of battery management systems that support product diversification, simplifies product lifecycle management and avoid systematic re-certification costs and delays.

On the software side, this architecture can help OEMs and Tier-1 ensure cybersecurity compliance and enable Over-the-Air (OTA) feature deployment - key capabilities in the transition to electrified mobility.

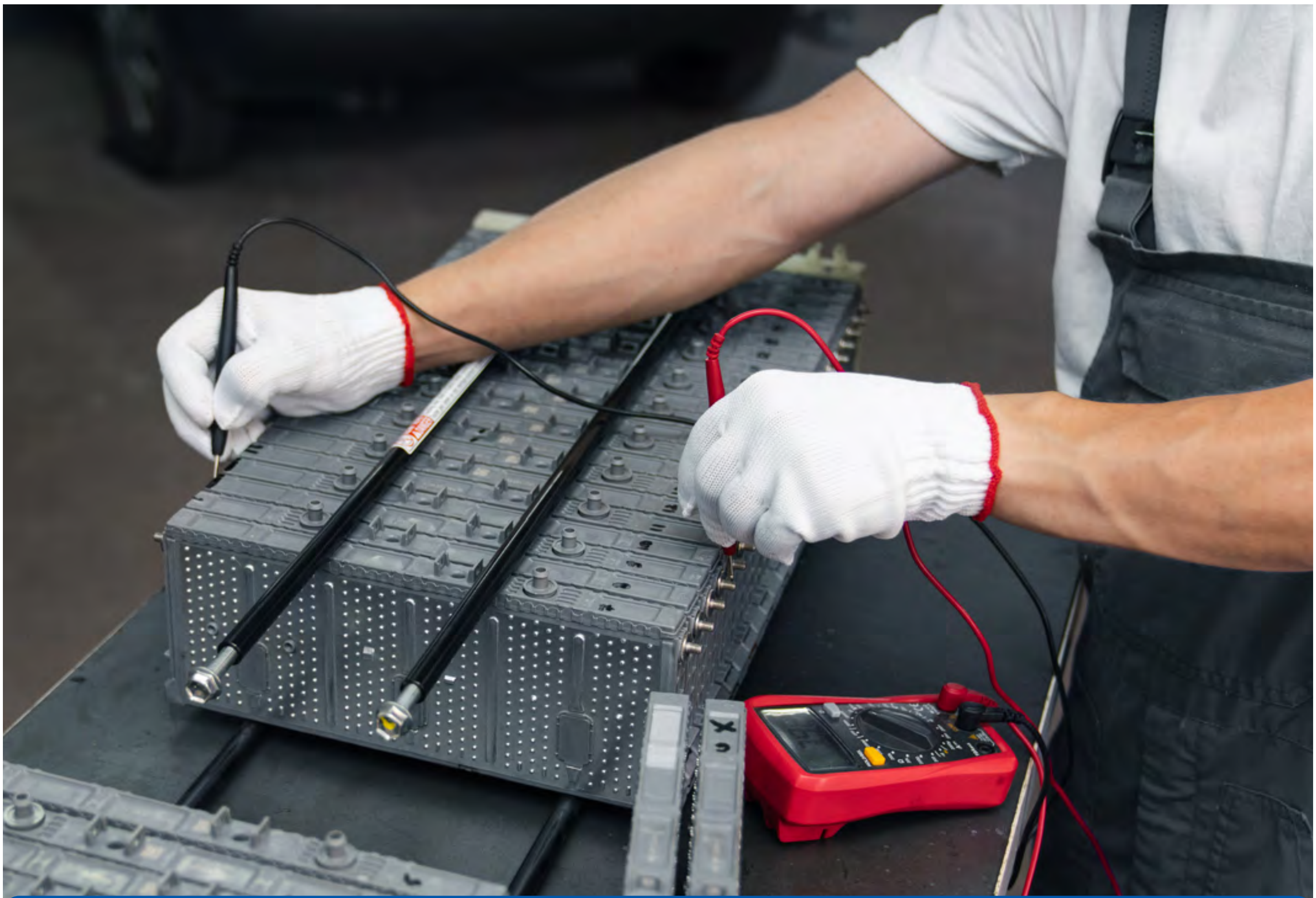
Adopt these advanced battery management system technologies to create key differentiators

1

Artificial intelligence

- Embedded AI/ML: The integration of advanced AI/ML algorithms, such as deep learning and reinforcement learning, enables more accurate state of charge, state of health and failure predictions and improved overall system safety and performance.
- Edge AI: Integrating AI directly into the battery management system will enable real-time, low-power decision-making, reduce latency and increase system responsiveness.
- Digital twins: Creating digital twins of batteries will allow for virtual testing and optimization of battery management system strategies, accelerating development cycles and improving system reliability.
- Personalized battery management: AI-powered battery management system can tailor charging and discharging profiles to individual user needs and preferences, is a gamechanger for commercial vehicle fleets. By tailoring charging and discharging profiles to individual vehicle needs, personalized battery management can significantly optimize fleet uptime charging efficiency, and overall operational performance.

Finally, AI can also accelerate cell testing and battery management system development: AI can be used to minimize test cycles, surpassing traditional design methods. For instance, Monolith has shown that AI can reduce aging tests by 40% and cell repetitions by 75%.



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Embedded Electrochemical Impedance Spectroscopy

Electrochemical Impedance Spectroscopy (EIS) is a powerful diagnostic technique used to analyse the internal electrochemical processes of a battery by applying a small AC current over a range of frequencies and measuring the resulting voltage. The latest generation of battery management circuits allow this technique to be embedded directly in the battery.

Key diagnostic functions benefit from performing EIS inside the battery:

- State of Health (SoH) estimation: EIS can detect early signs of degradation (e.g., increased internal resistance, SEI (Solid Electrolyte Interphase) layer growth) before significant capacity loss occurs.
- State of Charge (SoC) Estimation: Impedance varies with SoC, allowing for more accurate and robust SoC estimation, especially under dynamic conditions.
- Fault diagnosis and safety monitoring: By identifying anomalies in impedance patterns, EIS can help detect internal short circuits, gas formation, or thermal runaway risks before they escalate.

Implementing EIS in a battery management system requires high-speed sampling and synchronization between stimulus current and voltage measurements. Major circuit manufacturers provide “EIS Ready” products (STMicroelectronics, Infineon), while Magneti Marelli has implemented an EIS functionality in their automotive grade battery management system.

3

Active cell balancing

Keeping cells in balance is one of the key functions of battery management systems. Indeed, the autonomy of a battery is limited by the first cell to reach full charge or full discharge.
The principle of active cell balancing is to redistribute energy among series-connected cells to allow uniform charge and discharge, improving range (+5% to +9% in this study)[3] and lifespan (up to +19.8% here)[4] of the battery.

Active cell balancing has side benefits for battery assembly: It increases the tolerance to cell mismatch, it allows the battery management system to self-adapt to new cells, it facilitates battery repair by managing aged cells and fresh cells in the same battery and in some configurations, it can perform cell Electrochemical Impedance Spectroscopy (EIS).

Cost and efficiency of active balancing circuits have been an active topic of research. Industrial solutions are becoming available to put active balancing at the reach of EV applications. Monolithic Power Systems and Texas instrument for instance commercializes circuits that perform active balancing with currents from 1A to over 3A using a simplified buck-boost design.

[3] Chen, J. et al. 2024 https://doi.org/10.1109/TASE.2023.3291679
[4] Kremer, P. et al. 2021 https://doi.org/10.1109/ISLPED52811.2021.9502500

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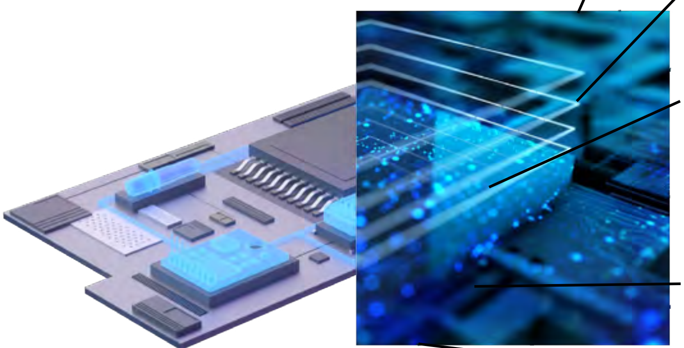
Wireless communication

- Reduced complexity: Wireless battery management system eliminates bulky wiring, resulting in lighter, more compact systems that are easier to manufacture and integrate.
- Enhanced efficiency: Wireless communication improves energy density, reduces production errors, and streamlines assembly processes.

Dutch semiconductor manufacturer NXP recently unveiled 'Industry's first' Ultra-Wideband (UWB) wireless battery management system – offering a quicker packet rate and up to 40% reduction in power consumption compared to traditional options and is currently available to OEMs for evaluation.

The figure below illustrates outstanding battery management features possible by following these innovation pathways.

Next generation battery management system



AI technology enabling predictive analytics – These technologies reduce the error rate in SOH prediction.

Repairability of battery packs – Predictive maintenance strategies and active balancing allow repairability – replacing modules or cells during lifetime.

Wireless BMS – Enabling simpler mechanical designs, reducing the weight of the battery pack.

Advanced fault detection – Pressure and gas sensor analysis powered by machine learning.

Battery passport ready – Supporting the regulation, but also additional features, e.g. for repair, reuse & repurposing.

Environment aware BMS – Enables more complex V2G and charging strategies.

Unlocking new opportunities with secure BMS and cloud integration

Collecting battery data on the cloud can help manufacturers better understand the behavior and ageing mechanisms of their batteries in the field. It can be used to provide predictive maintenance services. It also allows the retrieval of up-to-date performance data required for the digital battery passport.
As battery management systems connect to the cloud, security becomes essential. It protects data integrity, ensures system uptime, and maintains privacy compliance. Strategies like encryption, zero trust, secure updates, and AI-driven anomaly detection helps safeguard this ecosystem.

Battery data also contains sensitive information that, when associated with a driver, is considered personal data. As such, it is submitted to strict treatment under the General Data Protection Regulation (GDPR). This battery data, like charging history, battery deterioration patterns and geo-positioning information requires the explicit consent of the user before collection.

For instance, Capgemini is working with leading cloud providers to enable **predictive maintenance** as a transformative service layer within the battery ecosystem. It leverages real-time and historical battery data to forecast failures, optimize usage, and extend battery life.

Key use cases:

- **Fleet-level health prediction** using dedicated cloud services to monitor and forecast battery performance across fleets.
- **Battery digital twin** to create virtual models for lifecycle simulation and diagnostic insights.
- **Dynamic data ingestion** from batteries “in the wild” via IoT and cloud interfaces.
- **State of Health (SOH)** & **Remaining Useful Life (RUL)** forecasting for OEM dashboards and service centers.

These opportunities are accompanied by emerging revenue streams:
- **Battery upgrades:** Offered as paid services to extend performance and lifespan.
- **Battery value assessment and battery buyback:** Certified battery information can be produced on demand when a vehicle is changing owner.
- **Subscription-based diagnostics:** Continuous monitoring and insights delivered via tiered service models.
- **Second-life repurpose and recycling orchestration:** Coordinated orchestration of battery reuse and end-of-life processing.
- **Driver-specific tuning for** performance and longevity: Personalized battery management to optimize performance and longevity.

Call for action

In today's highly competitive and tightly regulated automotive landscape, battery system innovation demands a clear alignment between business objectives and technical capabilities. To remain competitive, OEMs and battery manufacturers must conduct a thorough assessment of their existing assets and define their strategic ambitions in the battery domain.

Key trade-offs must be evaluated early in the process:

- **Mass production vs. Low-volume customization:** Balancing scalability with tailored solutions.
- **Design stability vs. Design versatility:** Choosing between consistency and adaptability.
- **High cloud integration vs. Minimal connectivity:** Weighing digital depth against simplicity.
- **Technology leadership vs. Fast-follower positioning:** Deciding whether to lead innovation or optimize proven paths.

Evaluate and position your existing assets along the key pathways of battery management system evolution.

These decisions will shape the architecture and lifecycle of your battery management system. Positioning your assets along the battery management system evolution pathways requires a clear understanding of what is feasible in terms of:

Mechanical footprint and packaging constraints.

R&D investment vs. Commercial Off-The-Shelf (COTS) adoption.

Internal expertise vs. outsourced development.

Once existing assets are known and the strategic plan is defined, the battery management system development roadmap can be implemented in five key phases: **Architect, Design, Implement, Test, and Iterate**. This structured approach ensures agility, scalability, and compliance throughout the product lifecycle.

How Capgemini can assist

Whether you are considering a new battery management system or managing design derivatives, Capgemini can assist you today in:

Identifying your key business objectives:

Confirm your key challenges (charging speed, battery lifespan, battery cost…) and align your business goals with strategic initiatives in battery management systems.

Evaluating your existing strengths & assets:

Conduct assessments on existing capabilities, spanning concept design, simulation, SW / HW development to testing, validation and certification.

Refining and implementing your battery management systems strategy & roadmap:

Develop and execute a comprehensive plan for battery management system development.

Our battery management system capabilities span the entire development and production chain, accelerating time-to-market while reinforcing control over design quality and system performance.
Our objective: Empower electric vehicle OEMs and Tier-1s to master their own battery management systems, crucial for EV performance and safety.

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