



Thermal Management Pitfalls in EV and Hydrogen Platforms: A Technical Perspective

As vehicle OEMs rapidly transition to electric (EV) and hydrogen (H₂) propulsion systems, the demands on thermal management systems have evolved significantly. The shift away from combustion powertrains introduces new energy flow pathways, system integration requirements, and environmental constraints that legacy approaches can no longer address efficiently. This paper explores four recurring challenges observed across OEM thermal strategies: siloed system design, increasing battery cooling demand, poor component sizing, and late-stage supplier engagement. By highlighting these challenges and their implications, we aim to inform future-ready design thinking and systems integration.

1. Fragmented or Isolated System Design

OEMs commonly approach thermal system development by treating the battery, power electronics, cabin HVAC, and electric drivetrain as discrete units, each with its own cooling loop. This legacy design approach, while understandable given historical modularity, is sub-optimal for the energy flows and space constraints of EV and H₂ platforms.

Impact:

Such fragmentation leads to increased weight, reduced thermal efficiency, and redundant components such as pumps, heat exchangers, and control units. Vehicle range and charging efficiency are often compromised.

What's Needed:

Integrated Thermal Management Systems (ITMS) are essential. These allow the vehicle to share energy between subsystems, coordinate energy flows dynamically, and reduce system mass and cost. A study published in the **Journal of Cleaner Production** highlighted a 15–25% energy efficiency improvement using ITMS for fuel cell–battery hybrid systems.

2. Increased Demand for Battery Cooling and Rapid-Charge Applications

As EV battery packs provide increased performance and energy density, the thermal load they generate during both operation and charging has increased significantly. This is further exacerbated by the global trend toward faster charging times — with many vehicles now targeting 10–20 minute fast charge capabilities. Such demands create acute spikes in heat generation, which must be rapidly and reliably managed.

Impact:

If battery cells exceed safe thermal limits, they risk not only system derating but also catastrophic thermal runaway. Heat accumulation during repeated acceleration or rapid charging events leads to reduced battery lifespan, performance degradation, and potential safety concerns.

What's Needed:

Effective battery thermal management now requires active liquid cooling, thermally conductive structures, and potentially phase-change materials. Systems must be capable of rapidly absorbing and distributing transient energy spikes. Thermal paths from cell to coolant loop must be short, highly conductive, and reliably maintained across vehicle lifetime. Next-generation EV platforms are increasingly incorporating zonal cooling loops, dedicated chiller circuits, and thermal buffer reservoirs.

3. Incorrect System Sizing and Component Selection

Thermal components are often either oversized (leading to inefficiencies and cost) or undersized (leading to thermal stress and inefficiencies). This arises from incorrect load profile modelling during concept phases.

Impact:

Improper sizing compromises both performance and reliability. Oversizing adds unnecessary weight and cost, while undersizing risks overheating, especially during transient high loads such as fast charging or steep climbs.

What's Needed:

Duty-cycle-based design supported by early system-level simulation is critical. Thermal loads should be mapped across realistic usage profiles. Thermal modeling tools can simulate operational duty cycles and environmental inputs for simulation to predict dynamic thermal interactions more accurately.

4. Delayed Supplier Collaboration in Thermal Design

Thermal systems are often treated as a late-stage integration item, which compromises both innovation and packaging flexibility. This is especially problematic for low- to mid-volume OEMs who rely more heavily on bespoke engineering and supplier insight.

Impact:

Late engagement increases rework, extends validation cycles, and leads to sub-optimal use of available technologies.

What's Needed:

OEMs should engage specialist suppliers during early concept phases. Co-development allows better packaging integration, material compatibility validation, and energy efficiency trade-off studies. Collaboration leads to better whole-vehicle thermal management and durability.

Conclusion

As OEMs push the boundaries of vehicle electrification, the thermal challenges they face are becoming more complex and interdependent. From increased battery cooling demands to the risks of fragmented system design and late-stage integration, each decision has vehicle-wide consequences. A tailored, engineering-led approach — one that incorporates early collaboration, duty-cycle-informed simulation, and system integration experience — is vital to achieving efficiency, safety, and commercial viability.

Calatherm supports OEMs in meeting these evolving demands through collaborative development, specialist thermal design, and bespoke system engineering. Our work is grounded in practical experience with low- to mid-volume vehicle platforms, helping customers deliver robust thermal solutions that align with both technical and operational requirements.

If the above resonates with you or you would like to discuss specifics of a project, it would be great to hear from you. Do reach out via the details below, or alternatively, you can book a introductory Teams call via the link:

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