AUTOMOTIVE ENGINEERING

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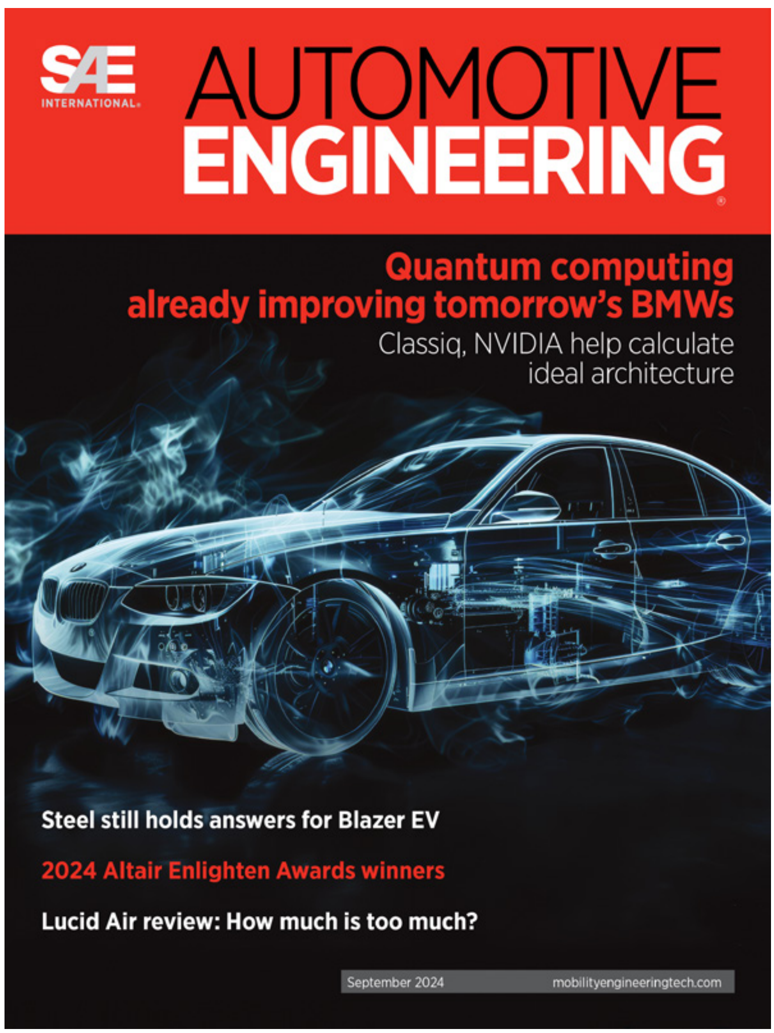

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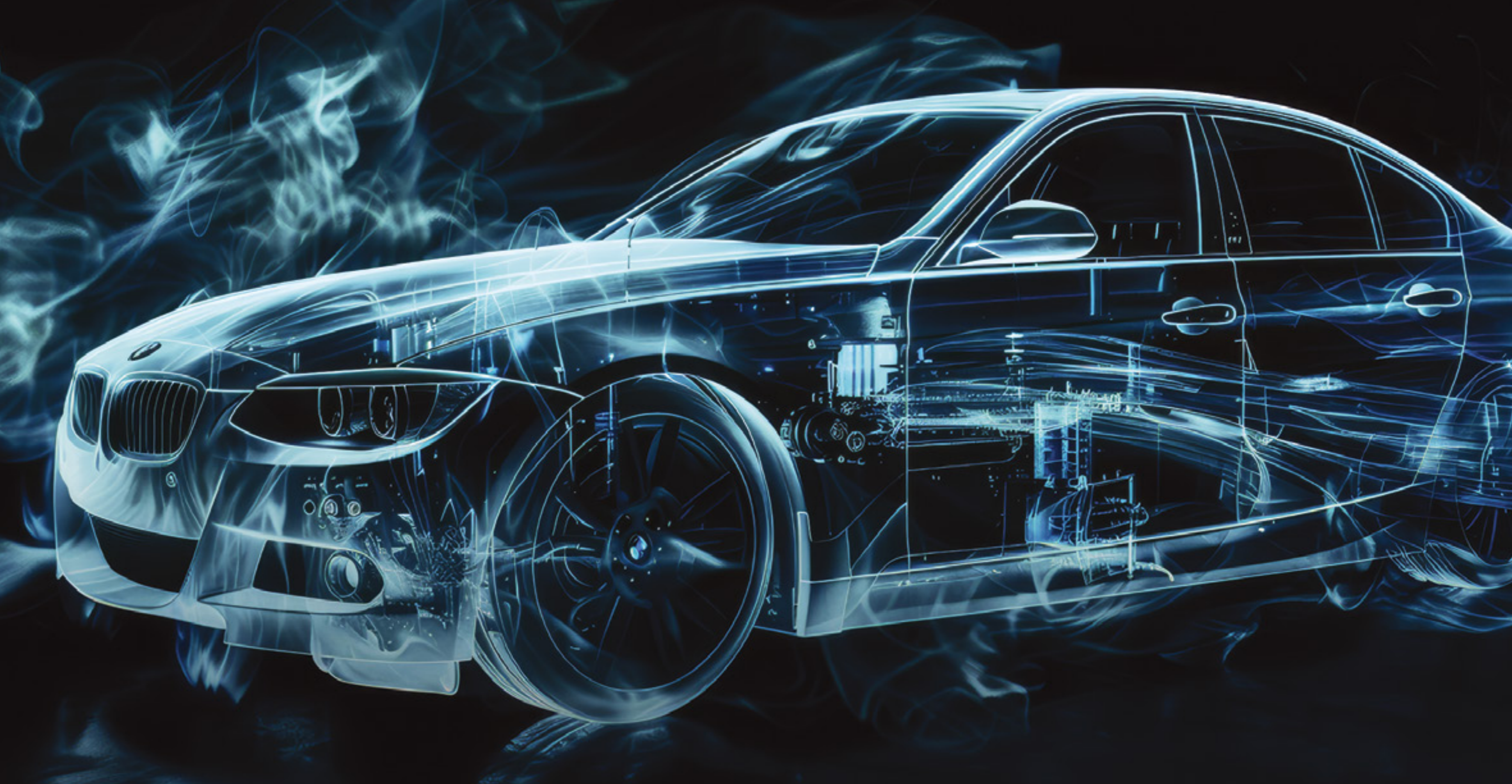
Quantum computing already improving tomorrow's BMWs

Classiq, NVIDIA help calculate ideal architecture



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ON THE COVER

BMW and Classiq are using quantum computing to improve vehicle architecture and the actions of factory robots. (Image: BMW)

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EDITORIAL

No, really, what's an SDV?

What is an SDV? No, you can't just say "software defined vehicle," because that's not precise enough. Software has been part of modern vehicles for decades, but the code didn't define the car. So, what is an SDV? It's a question worth exploring. What are the components required? What are the dependencies? What is the tipping point when you can finally call a vehicle "software-defined"?

One person with an answer is Elektrobit's Moritz Neukirchner, who I spoke with last year on this topic and have since followed on social media. He recently posted a proposal to describe SDVs using a scale similar to the SAE's five levels of automated driving. The list starts with Level 0, which simply means "software enabled" or a vehicle that uses some sort of software, and ends with the Level 5 "innovation platform," which would be a full SDV that has the same sort of upgrade functionality as a smartphone, where new apps can allow the same hardware to do things it couldn't before.

What is the tipping point when you can finally call a vehicle "software-defined"?

It's the intervening stages that are the most revealing. They require us to think through what it takes to actually build an SDV. Level 2 on Neukirchner's list is "updateable vehicle," which means an OEM can update the software, but the feature set is the same. If the code breaks, engineers can put a bit of fixing on it. Level 3, or "upgradeable vehicle," is where we start getting into SDV-like behavior with "dynamic functionality on a static target hardware." Level 4, then, is a car that's really a "software platform," which "breaks up the lifecycles of hardware and software" and allows software updates to target a fleet of vehicles that can all accept the software even if the "target hardware onto which it is deployed [changes] over the years with new vehicles being released."

Neukirchner's post was an excellent counterpart to a panel at the Center for Automotive Research's Management Briefing Seminar in Traverse City, Michigan in August. The host asked the panelists to collectively explain how they defined SDVs, including the broader effects SDVs are likey to have on the industry.

The panelists started with the fact that an SDV separates hardware from software, and is updatable and upgradable. So far, so good. SDVs should enhance the user experience, they said. Also, SDVs do not necessarily have to be EVs, since improved software can just as easily be used to improve ICE vehicles.

The panelists explained more sides to SDVs. Creating themn means OEMs have to put software in the center stage of vehicle development. Everyone understands that software is a key part of new vehicles today, but SDVs ramp that up to extreme levels. The panelist said there's an upside here for OEM and supplier software engineers, since SDVs might allow automakers to reduce the amount of software they need to develop. Like a smartphone OS, the code in an SDV could last for many years with regular updates. This code – when used in Neukirchner's Level 4 or 5 SDVs – could be applied across model generations instead of each model year requiring its own software. Finally, the growth of SDVs may happen within a larger ecosystem that includes software-defined homes and infrastructure. Perhaps this brings us to the real definition of SDVs, which is just one more example of that oft-mentioned situation where something is both a difficult challenge and an opportunity.

Sebastian Blanco, Editor-in-Chief

A New Reckoning

As the industry worked through accelerated production volumes last decade, there were few concerns surrounding low capacity utilization in our fixed-cost-heavy North American ecosystem. With the benefit of stronger demand and a rich product mix, the industry was allowed to shift attention toward other priorities. Having too much capacity or not properly utilizing it was not a major concern in a market that averaged 17 million units from 2016 through 2019. The first few years of this decade – with the onset of COVID, low chip availability, growing inflation and a host of other supply disruptions – provided plenty of reasons not to focus on emerging utilization issues.

Despite last year's increasing production volumes, the new UAW and Unifor labor agreements (and their no-facility-closure clauses) place the issue of capacity utilization back at the head of the line, this time with the added complication of an industry grappling with the complexity of integrating battery EV and hybrid variant builds into the same plants that have assembled ICE vehicles for decades. The build processes, supplier requirements and plant requirements are too different to meld into one factory. Many OEMs have opted to convert ICE facilities to BEV – never to return. While efficiencies can be gained with a singular build focus (ICE/Hybrid or BEV), any delay by customers to adopt BEVs upends these efforts.

Other factors will impact overall capacity utilization through the end of the decade. Key among them will be the addition of incremental plants by current and new OEMs. This includes

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SAE Foundation Trustee
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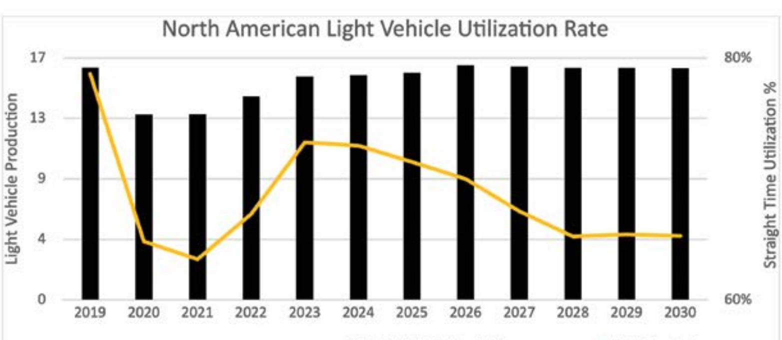
Smaller suppliers may not have the financial flexibility that OEMs have. Closing or selling plants may be their only option.



Data compiled July 2024.

Ford's massive Blue Oval Project (now called TEVC-Tennessee Electric Vehicle Center), capacity added by **Tesla** in Texas, **VW/Scout** in South Carolina, the now-delayed **Vinfast** project in North Carolina and other capacity expansions by current players. Add to this a market that is grappling with the impact of pent-up demand from the last four years essentially being satisfied with little inventory build and the affordability of those offerings starting to come into question as consumers face interest rates three times higher than just a few years ago. Mix in the impact of various new China-sourced vehicle tariffs by NA countries and reciprocal ones installed by China, and volume will face another constraint. Without the Detroit 3's safety valve to take capacity offline, we have a growing utilization issue which will impact profits and the ability to compete in the future.

The graphic (below left) from the **S&P Global Mobility** Light Vehicle Capacity Utilization Forecast outlines that straight-time capacity utilization may dip towards 65% later this decade. Without the ability to restructure vehicle sourcing to drive overall corporate efficiency, one can already anticipate a growing list of plants to be addressed when labor contracts expire in 2027-28. OEMs with reduced profitability and few strategic options to improve efficiency while facing strong competition from China-based OEMs outside of North America may face a real reckoning.

Suppliers will not be immune. When OEMs experience low utilization at one or more plants, odds are that suppliers increased capacity to handle the same lofty volumes. Thus, issues at the OEM level immediately find their way to the supply base. Several of these smaller suppliers may not have the financial flexibility of their larger OEM customers. Closing or selling plants may be their only option.

In the end, several moons aligning to drive utilization downward later this decade will have severe consequences for an ecosystem still climbing out of the recent COVID-driven supply impacts. This new reckoning will not be solved easily or delicately. It is clear that critical manufacturing decisions will be forced upon many OEMs, their labor unions and associated suppliers later this decade. ■

S&P GLOBAL MOBILITY

EV Accelerators

EV Accelerator Interview with CSA Group's Dana Parmenter

CSA Group is a testing, inspection, and certification provider working to assure safe and accessible operation and charging of electric vehicles for consumers. In this edition of EV Accelerator sponsored by Keysight, CSA's vice president of Industrial, Dana Parmenter, talks about how his company tests EVs and electric vehicle charging equipment.

***EV Accelerator:* What is CSA Group's relationship to electric vehicle technology?**
Dana Parmenter: We are a testing, inspection and certification (TIC) provider and a standards development organization (SDO). The TIC portion of our group operates labs around the world that test and certify EV technology, including batteries, charging infrastructure and components. Much of our testing focuses on batteries and includes electrical and mechanical stress tests for events such as overcharge, over discharge and thermal or fire events, and how these relate to the battery, its functionality and safety. We also test charging infrastructure, and EV components such as electric motors, wiring and other electrical and mechanical parts for potential environmental and safety impacts. As an SDO, CSA facilitates the creation of important consensus-based safety and performance standards to address the needs of emerging technology while also working with other SDO's such as the International Standard Organization (ISO) and International Electrotechnical Commission (IEC) to create and develop new standards.

Dana Parmenter, CSA's vice president for industrial operations.

CSA

***EV Accelerator:* As a TIC provider, how can CSA contribute to better consumer acceptance of EVs?**
Parmenter: We test and certify EVs to meet predefined safety protocol. This alone introduces an inherent level of safety supporting consumer confidence. Additionally, we utilize performance-related standards to consider reliability and output performance for EV chargers. We constantly create and update test methods and adopt the latest standards to assure they are state-of-the-art. We consider best practices to make sure EV products keep consumers safe as they operate at maximum output and uptime.

***EV Accelerator:* How does CSA address charging anxiety and charger reliability?**
Parmenter: We address hardware failures with tests that place stress on electrical, mechanical and environmental components. We simulate such conditions as cable abuse and extreme temperatures to help manufacturers mitigate real world issues and allow them to build more robust and reliable products. We test for communication and interoperability to ensure various chargers are compatible with a vehicle or a broader network. When EVs and EV chargers use the same communication protocol, there's less risk of incompatibility. Our Electric Vehicle Supply Equipment (EVSE) tests use the latest, most adopted communication standards to make sure a charger can operate with the greatest number of EVs.

***EV Accelerator:* Most major EV manufacturers are switching to Tesla's NACS (SAE J3400) configuration. What part does CSA play to assure reliability and safety in this standard?**
Parmenter: As an SDO, we help create consensus-based standards. Additonally, participating with the likes of SAE, IEC or ISO, we adapt and address new capabilities, including J3400. Our standards set minimum performance requirements and consider compatibility requirements. Are they communicating properly? Are they operating properly? The heart of our business is to stay current with the latest technologies and assure our labs are equipped to evaluate, test and certify them regardless of the protocol. The greater adoption and standardization of any protocol, the greater the impact on reducing charge anxiety with consumers worrying less about the inability to successfully recharge.

***EV Accelerator:* How does CSA contribute to the reduction or elimination of fire risks?**
Parmenter: We test for flammability and thermal runaway, in which we force a battery into an internal fire condition. We also test for how the battery reacts to an external fire. We work with manufacturers on how to mitigate those dangers and reduce catastrophic events and how to safely handle a battery if one of these rare events occurs.

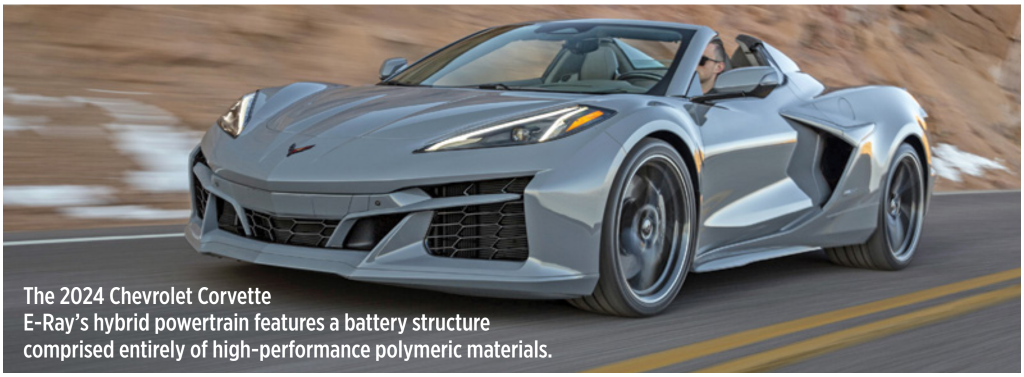
***EV Accelerator:* What about vehicle-to-grid (V2G) technology? What requirements must an EV meet to supply power back into the grid?**
Parmenter: We test an EV and its charging equipment for how it supports vehicle-to-grid functions. The EV must be capable of bi-directional power flow and needs to be approved to interface with the grid. This means designing onboard inverters that meet appropriate standards for bi-directional function for the applications they're using, including SAE standards. We also evaluate the power exported and the correct communication protocol. On the charging side, manufacturers need to design their products to support V2G from the beginning. These products need to be tested and certified for grid connection and support of the intercommunication requirements for the grid to ensure the right voltage is passed at the right frequency and power factor. Failure to address those can cause damage to grid infrastructure or other attached equipment. As V2G becomes more prominent, testing requirements and complexity likely will increase. ■

For more on CSA's EV testing, go to www.csagroup.org.

Watch the full interview with Dana.

AWARDS

Altair honors innovations in automotive lightweighting and sustainability



The 2024 Chevrolet Corvette E-Ray's hybrid powertrain features a battery structure comprised entirely of high-performance polymeric materials.

General Motors engineers opted for a battery structure comprised entirely of high-performance polymeric materials for the 2024 Chevrolet Corvette E-Ray's hybrid powertrain. The thermoplastic battery module, which delivers a 37% weight reduction and a 25% cost savings compared to traditional aluminum, took the top spot for the Module Lightweighting category in this year's Altair Enlighten Awards.

Five other category winners, along with runners-up and one honorable mention, were also honored during an awards ceremony at the 2024 CAR Management Briefing Seminars (MBS) in August. They demonstrate how automotive and off-highway companies are applying advanced technologies and computational intelligence to create a more sustainable future for the industry.

Collaboration throughout the supply chain was paramount in driving innovation, according to Nick Compton, global battery plastics and composites technical specialist at GM. "We're working hand in hand with our suppliers. There's a bigger input especially in the materials space and injection molding or whatever the process is," he said at the MBS conference. "In the past, it was 'okay, we have this resin that we've used in engines for 20 years,' you just specify it and that's the end of it. We don't have that luxury" with hybrid and EV batteries.

Module Lightweighting

Winner: Engineers at General Motors worked closely with counterparts at RTP and Syensqo to develop the thermoplastic battery module for the hybrid E-Ray. Designed to fit the ICE Corvette's tunnel, the hybrid battery structure uses RTP's PARA material for the two side plates and Syensqo's 45% glass-reinforced Amodel PPA for 45 repeated spacers that eliminated the need for compression limiters and isolation countermeasures. The design includes a unique cell-lock feature that stabilizes battery cells.

"We started this project off with a metal-plastic combined module," GM's Compton said. "But the Corvette vehicle team really challenged us to remove as much weight as possible from this module. We had a great supporting cast with **RTP** and **Syensqo** – we asked a lot from the resins that we selected." The team even targeted the fasteners used in the module, selecting aluminum instead of steel, "trying to get grams wherever we could out of this module," he said.

Runner-up: Toyota worked with supplier partners US Farathane and BASF to develop the second-row composite seat structure in the 2024 Toyota Tacoma. The seat structure features 30% less mass than the previous generation of steel seats and 20% less mass than the current resin seats in the 2022 Toyota Tundra. The new structure also consolidated more than 55 parts into just four components.

Enabling Technology

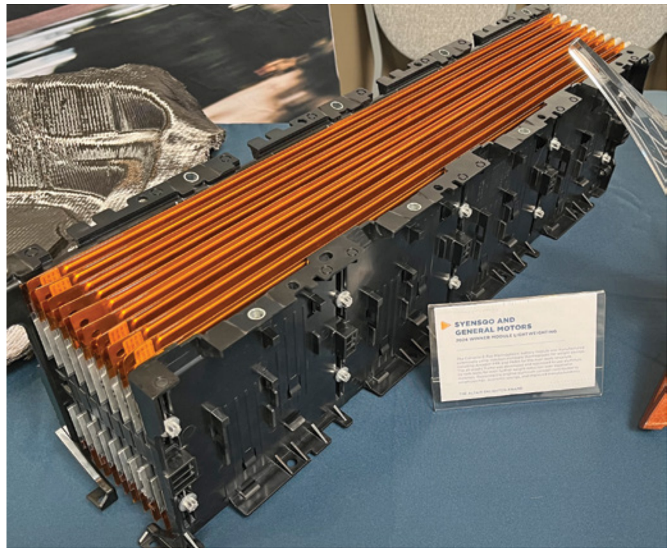
Winner: **CompositeEdge GmbH** won for its EcoFiber AFP (automated fiber placement) high-performance structures that utilize natural fiber composites – such as flax and hemp fiber – blended with plastic to support the automated manufacture of body panels, interior trims, chassis and suspension parts without additional adhesives. The thermoplastic matrices reportedly maintain the integrity and recyclability of the composite structures better than bio-resins, which can degrade. The use of

CHEVROLET

natural fiber composites significantly reduces carbon emissions and energy consumption compared to synthetic materials, according to CompositeEdge.

Runner-up: **Teijin Automotive Technologies**' fully automated preforming process enables the mass production of carbon fiber preforms to be used in automotive components – in this case, a vehicle door. The precision of the automated process optimizes the amount of material used and recycles a small amount of offal (waste). The new process reduces required labor by 20%.

Honorable mention: **Bemis Manufacturing** and **BASF** developed large hydraulic tanks for compact excavators using BASF's polyamide, which delivered reductions in lifecycle costs and CO2 emissions. By combining injection molding and vibration welding, the approach resulted in 5% mass savings and 20% lower costs compared to traditional roto-molding.

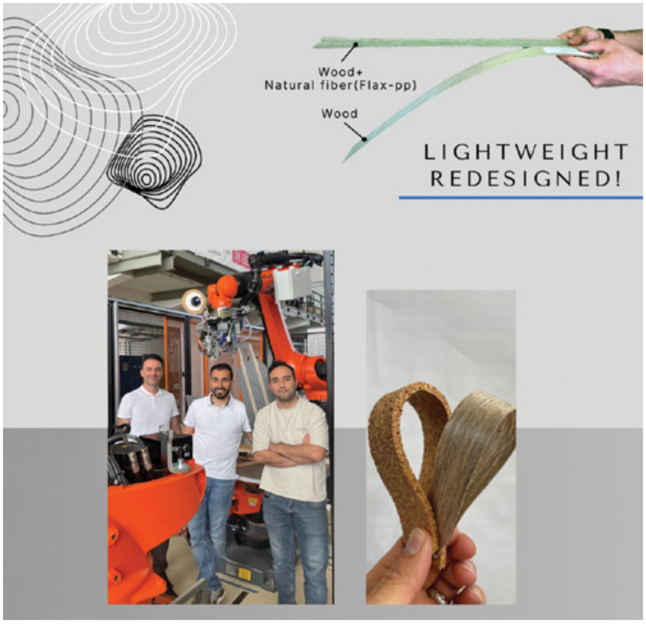


Module Lightweighting: General Motors and Syensqo designed a thermoplastic battery module structure that's 37% lighter and 25% less expensive than traditional aluminum.

SAE/RYAN GEHM

Future of Lightweighting

Winner: **WEAV3D**, **Braskem** and the **Clemson Composites Center** collaboratively developed a composite lattice-reinforced polypropylene sheet suitable for vehicle body structures. Manufactured with a highly automated forming cycle that produces more parts



Enabling Technology: CompositeEdge's EcoFiber AFP structures utilize natural fiber composites blended with plastic for body panels, interior trims, chassis and suspension parts.

using less energy, the new sheet reduces cost by 50% and weight by 23% compared to CFPA6 organosheet (nylon 6) and weighs between 60-70% less than steel. The process also results in a 62% reduction in trim scrap by weight. Compared to steel, the polypropylene sheet reportedly displays better energy absorption and shape recovery.

"Our line of sight to first production is likely model year 2026, production [commencing] at the end of next year," Lewis Motion, founder and CEO of WEAV3D, said at the MBS conference. "The more we can get people to design with the approach that we have, the more beneficial it can be used throughout the vehicle – not just as closures but even things like the battery box."

Future of Lightweighting: WEAV3D, Braskem and Clemson Composites Center developed a composite lattice-reinforced polypropylene sheet that reduces cost by 50% and weight by 23% compared to CFPA6 organosheet.

Runner-up: **Carsolia Composites i**ntroduced a patent-pending composite coil spring that's 50% lighter than steel. The carbon fiber composite material also has 50% less CO2 equivalent per kilogram vs. steel, resulting in a 75% overall reduction of CO2 emissions. Carsolia claims it can incorporate variable thicknesses for tuned spring rates during compression range and that its production process can support high-volume vehicle production.

Sustainable Product

Winner: **DuPont** BETAMATE broad bake adhesive technology helps reduce energy use and greenhouse gas emissions during vehicle body manufacturing by allowing adhesives to cure at about 25°C lower temperatures, thus saving energy via reduced e-coat oven temperatures and shorter oven cycle times. The technology also eliminates the need for cold storage thanks to a special formulation that extends shelf life.

Runner-up: **Bridgestone Americas** manufactures the Turanza EV grand touring tire with 50% renewable and recycled materials – one of the highest percentages among commercially available replacement tires – and features Bridgestone ENLITEN technology to optimize performance and improve life span. Bridgestone is aiming for all its tires to be composed of 100% renewable and recycled materials by 2050.

Sustainable Process

Winner: **BMW M GmbH** along with partners **AMC GmbH**, **Bcomp Ltd.**, **Gradel Lightweight Sàrl**, and **Lasso**

The Altair Enlighten Awards were presented at the 2024 CAR Management Briefing Seminars in Traverse City, Michigan.

CLOCKWISE FROM TOP LEFT: COMPOSITEEDGE: SAE/RYAN GEHM; SAE/RYAN GEHM

Ingenieurgesellschaft designed the BMW M Visionary Materials Seat that focuses on circular design principles. The seat features a monomaterial lightweight design that uses sustainable, renewable materials such as recycled polyester textile, flaxfiber BioComposite, and biogene leather alternatives. The composite can be made from carbon, basalt, glass fiber or natural fibers as needed.

Runner-up: **Toyota Motor Manufacturing Canada** and **PPG Industries** were ecognized for EPIC200X electrocoat, which enhances corrosion protection for automotive bodies while significantly reducing environmental impact. At the Toyota facility, the new product and application process enables a total reduction of 3,500 metric tons of CO2 emissions per year. It also reduces the amount of applied product per vehicle by 0.6 kg, and the new application process saves 5,626,000 kWh of energy and 1,843,000 gallons of water per year.

Responsible AI

Winner: **Dow Inc.**'s SPECFLEX polyurethane solutions focus on developing and using cleaner raw materials and unique design principles to optimize performance. Achieving equivalent mechanical and aging properties compared to traditional formulations, these solutions reduce total volatile organic compounds (VOCs) by more than 50%, formaldehyde by 60% and acetaldehyde by 80%. An AI aldehyde predictive model accelerates market response by capturing the factors contributing to odor and translating complicated non-linear features into real-world related performance features – enabling outcome prediction. Dow says machine learning enabled a reduction in the number of experiments from about 800 down to 50 and cut a two-year design cycle down to about six months.

Ryan Gehm

SAE International and its Automotive Engineering and Tech Briefs publications served as a media partner for the 2024 Altair Enlighten Awards, and the author participated as a judge for the three lightweighting categories.

HOME POWER

GM EVs will soon provide V2H backup power during blackouts

Rendering of a 2024 Chevrolet Silverado EV RST in a residential garage with anticipated GM Energy offerings. Simulated products shown. Actual production model may vary. Simulated vehicle shown. Actual production model may vary.

GM

General Motors is following **Ford** into the home power business, using EVs to provide backup power during electric outages.

By 2026, GM intends for all of its new electric vehicles on the Ultium EV platform to be capable of providing vehicle-to-home (V2H) power. Ford offers a similar bidirectional home backup system that draws power from the battery in its F-150 Lightning electric pickup, as does Tesla with the Cybertruck and Volkswagen with some of its EVs. BMW has said it will make bidirectional charging a feature of its new generation EVs starting in 2025.

GM's power play starts with the 2024 Silverado EV RST, which carries a massive 200-kWh battery pack. That's enough to power the average American home for about 5 days with 20%, or 40 kWh, left to get the truck back on the road.

EVs with vehicle-to-load (V2L) capability, such as the Hyundai Ioniq 5, typically provide a maximum energy flow of 1.8 kW, sufficient to power one or two 120-volt appliances simultaneously. The GM system provides 9.6 kW to keep power sucks such as electric ovens and air conditioning and heating systems running.

While the system is available with the Silverado EV RST model, other GM EVs – the 2024 Cadillac Lyriq, GMC Sierra EV Denali and Blazer EVs, and the 2025 Chevy Equinox EV – will need over-the-air or manual software updates in order to be able to share power with a customer's home. The capability will be built-in by the 2026 model year.

For now, the GM Energy Home System only works with GM products – just as Ford's only works with Ford and Tesla's with Tesla. Cross-compatibility depends on the finalization of the long-awaited ISO 15118 standard, which will govern bi-directional and vehicle-to-grid (V2G) communication.

What's it cost?

GM V2H system may not make economic sense without an EV. But for anyone who already owns or intends to purchase a GM EV, the home power system can be a relatively inexpensive add-on that provides clean residential backup power without the CO2 emissions of a whole-house generator or the cost of stationary storage batteries.

GM Home Power was developed by the recently formed GM Energy unit. The automaker started it in 2022 to bring to market a "suite of charging energy products and services," GM Energy vice president Wade Sheffer told SAE Media.

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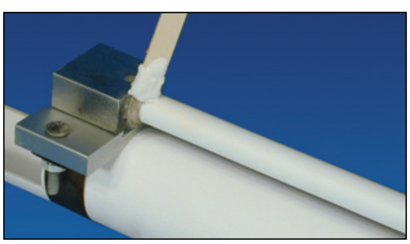

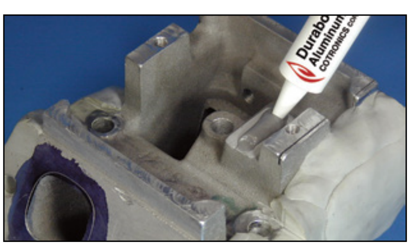

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Rendering of anticipated GM Energy V2H Bundle offering. Simulated products shown. Subject to change. Actual production model may vary. Expected timeline for delivery will vary.

2024 Chevrolet Silverado EV RST in a residential driveway with GM Energy products.

BOTH IMAGES: GM

Ultimately, GM intends to enable its system owners to earn some money back by charging when power is cheap and selling unused energy to the grid at peak periods when utilities will pay them a premium, said Aseem Kapur, GM Energy's chief revenue officer.

In addition to the Silverado EV, which lists for $96,495 (less expensive trims will follow), the GM Energy Home System requires $7,299 worth of equipment. Ford's is around $5,200. This isn't a DIY system, so installation could add more than 50% to the total, depending on how many circuits you want on backup power, how long the electrical runs are and whether you need to upgrade your home's electrical service in order to handle the mandatory EV charger's maximum draw of 80 amps.

An equivalent whole-house solar backup power system could cost more than $20,000 but doesn't require EV ownership. Whole house generators that run on natural gas or propane cost considerably less, but are noisier and emit environment-damaging gases

By the end of 2024, GM Energy plans to make modular storage batteries available and implement solar panel system connectivity that would make the system – like Tesla's Powerwall – usable without being connected to an EV.

How it Works

GM recently showed off its system at a 10,000 sq-ft (929 sq-m) residence in Beverly Hills, California, that powered critical home elements – lights, ventilation and kitchen appliances – for an entire evening using just a few kW.

The system components were installed on an interior wall of the garage behind a neatly finished pop-out that hid all of the electrical plumbing. If there isn't sufficient room on a garage or carport wall, everything is rated for outdoor installation as well, William Hotchkiss, GM Energy's head of safety and quality, told SAE Media.

The proprietary system consists of a $1,699 GM Powershift Charger, a $5,600 V2H Enablement Kit and, available later this year, an optional $5,000, 10.6 kWh modular backup storage battery stack. A 17.7 kWh battery will also be available, and each segment can be purchased separately, so a system can be staged over several years to accommodate budgetary constraints. Additional modules can be added to the backup battery for a total of 35.4 kWh of storage.

There are three parts to the Enablement Kit – the Home Hub, a power inverter and a small "dark start" battery that provides initial power when a blackout hits.

GM Energy's home system contains a Wi-Fi modem and Ethernet connection that enables remote monitoring and control via the homeowner's smartphone or computer, along with an electrical panel that connects to up to 200 amps of home circuits. There's also a controller with the programming and circuitry to identify a power outage, shut down the home's connection to the grid and order the charger to stop delivering current to the vehicle and start drawing from it.

The bidirectional charger allows the appropriate GM vehicle's battery to be charged at up to 19.2 kilowatts when connected to a dedicated 80-amp, 240-volt circuit.

The charger will operate with power from the grid or from a home solar panel array. It sends alternating current to the vehicle, where an onboard inverter changes it to direct current for storage in the battery pack. When the system draws power from the battery, at a maximum of 9.6 kW, the inverter in the Enablement Kit changes it back to AC to feed the home's circuitry.

GM Energy is using Qmerit, a national EV charger installation company, for installation.

John O'Dell

VEHICLE CONTROLS

Supplier technologies could deep-freeze the steering wheel

A driver's finger movements engage with a mouse-like device to steer a demonstration vehicle. Eleven stereo cameras on another demonstrator enable detection and prediction of the distance from vehicles navigating a roundabout.

"When we develop technology, our vision is to have everyone in society benefit from the innovation," said Harsha Badarinarayan, **Hitachi Astemo**'s vice president of advanced engineering. Badarinarayan spoke with SAE Media during a June press briefing at the company's headquarters for the Americas in Farmington Hills, Michigan.

Hitachi Astemo's in-development steer-by-wire system's palm-size device, located on a demo vehicle's center floor console, responds to finger glide movements with virtually no lag time from input to the front wheels' response. "The idea is to make this input device, which especially caters to people who need an alternative steering interface, as intuitive to use as a steering wheel," said Badarinarayan.

SAE Media test drove Hitachi Astemo's steer-by-wire system on a **Honda** Civic with a steering wheel and another Civic sedan equipped with the finger-operated device. Both technology demonstration cars were easy-to-steer through a parking lot dotted with orange cones to replicate slalom curves, a tight U-turn, and a three-point Y-turn.

In another demonstration vehicle, 360-degree object recognition and three-dimensional point cloud generation was facilitated by 11 fifth-generation Hitachi Astemo stereo cameras fitted on a Cadillac XT6 SUV. In a replicated parking lot roundabout, the technology demonstrator SUV detected other vehicles

"This is a vision-only system, so it doesn't use lidar or other sensors," Hitachi Astemo's Harsha Badarinarayan said about the company's 360-degree stereo vision camera system.

HITACHI ASTEMO

A driver uses a mouse-like operating device to steer a Hitachi Astemo technology demonstration vehicle.

Close-up view of Hitachi Astemo's console-located steering device.

and their distance from the demonstration vehicle.

"Stereoscopic vision provides accurate information versus a mono-camera system that gives you distance estimation," Badarinarayan said. Precise vision information is crucial for SAE Level 3 automated driving technology development. "For example, in a roundabout driving scenario, the vision system needs to determine when it's safe to enter the roundabout, how to maneuver around the roundabout, and how to exit the roundabout," said Badarinarayan. The vision system also needs to detect lanes, curb height, and other obstacles.

Hitachi Astemo's stereo camera system provides automatic calibration during driving to maintain measurement accuracy as well as high-density 3D point cloud generation from disparity information (via artificial intelligence) of each camera pair. "We offer the stereo cameras and the IP (intellectual property) for the perception stack," said Badarinarayan.

Kami Buchholz

PERFORMANCE AFTERMARKET

Mazda Motorsports keeps the MX-5 cool with a new differential plate

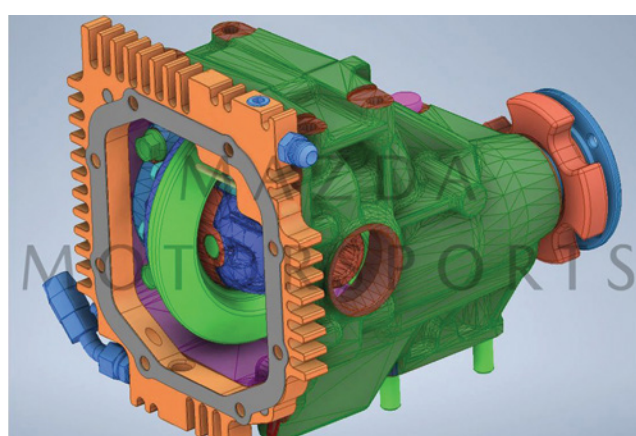
Mazda Motorsports, the company's North American-based racing program, serves as a support network for thousands of professional and amateur racers at road courses around the United States. In addition to contingency programs, discounted OEM parts and a ladder system into the professional ranks, the program also maintains a catalog of competition parts designed specifically for the rigors of racing.

One of the recent additions to Mazda's competition parts catalog is a differential cooling plate. The unit is intended for racers piloting the third-generation MX-5 roadster (known by its model code, NC). The unit reportedly provides a significant upgrade in the cooling performance and improves longevity of the vehicle's rear differential.

According to Mazda, the oil temperatures in a stock NC differential can become very hot during competition use. Mazda states that they have data showing operating temperatures of over 325 F (163 C) on multiple occasions, which is too high for the fluid to work effectively.

To mitigate this issue, Mazda Motorsports has developed a plate that sits between the factory differential housing and cover. It features strategically positioned ports for fluid circulation, including in/out oil lines and a dedicated temperature sensor port. The plate has fins on all sides that serve as heat sinks. Dowel pins are included to ensure correct alignment during installation and a reusable steel/rubber-coated gasket simplifies rear cover plate removal for routine maintenance.

"The plate by itself is all most sprint racers are going to need," Josh Smith, business development manager, Mazda Motorsports, said in an interview with SAE Media. "But if you're running an NC in an endurance environment, it's set up to attach additional coolers. We made sure (the plate) was spraying fluid on parts that need cooling by directing it where you want it to be on the gear stack."



According to Mazda, the oil temperatures in a stock NC differential can reach over 325 F during competition use.

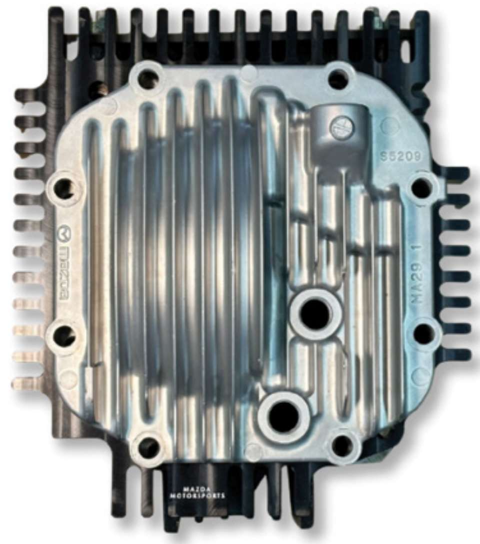
FROM TOP: HITACHI ASTEMO; HITACHI ASTEMO; MAZDA MOTORSPORTS

Smith explained the development process of the plate and how Mazda determined that this was a weak point for this chassis. "We had an Achilles heel in the NC differential from the OE standpoint and wanted to fix that," he explained. "Our sprint racers did not want to justify the cost of an entire differential cooling system with fans and other components. So, we were trying to find an elegant solution that added minimal cost to the car, but reduced the operating temperature of the fluid and allowed an upgrade path for the future."

Smith continued, "There's no expensive fluid you can use to fix the issue because there's no airflow and the exhaust is also located right next to the unit. So additional capacity and a heat sink was the logical solution." Smith said that during testing of the unit, vehicles using just the plate saw max operating temperatures of 300 degrees versus the factory configuration.

"With just the plate, it took two hours of constant use to reach that temperature. That's a 30–50-degree delta from the factory setup, which would reach those temperatures in just 20 minutes," he said. "If you're sprint racing for an hour or less, the spacer is all you need. If you're running for over an hour, you'll want the spacer with a pump and other components because it will eventually heat soak out."

Smith estimates that there are between 25-30 examples of the plates currently in circulation. Mazda Motorsports is currently developing a comprehensive kit featuring a cooler, pump and filter. The system will be designed for ease of installation and maintenance and will mount on a removable plate in the trunk.



Mazda's differential plate features strategically positioned ports for fluid circulation and fins on all sides serving as heat sinks.

MAZDA MOTORSPORTS

Matt Wolfe

2025 Lucid Air review: unnecessarily fast, astonishingly efficient


The 2025 Lucid Air sedan.

As amazing as the **Lucid** Air is to drive – and it is amazing – it doesn't hold a candle to hearing CEO Peter Rawlinson explain exactly why his company's all-electric sedans are, well, amazing. Rawlinson isn't just the CEO at Lucid. His history as vice president of vehicle engineering at **Tesla** and chief engineer of the Model S, as well as stints at **Lotus, Jaguar** and technology consulting firm **Corus Automotive**, help explain his other title at Lucid: chief technology officer.

During a visit to Lucid HQ earlier this year, Rawlinson eagerly held court to explain the Air's incredible efficiency numbers and why they matter.

"This car is 4.74 miles per kWH, so no one else is even close to that," he told SAE Media. "This is the most sustainable car in the world, in terms of energy utilization. Going from A to B, this car will use less energy than anything else on the market."

Rawlinson said the Air Pure AWD trim is more efficient than the impressive **Mercedes** Vision EQXX, which Rawlinson called "very artificial" because of all of the compromises Mercedes had to make in the concept vehicle, like narrow tires and a sparse interior. Earlier this year, Lucid announced it had achieved tests in the Air that returned over 5 miles per kWh, which Rawlinson told SAE Media would mean reaching the same range with smaller batteries. There's much more to be had on the efficiency front, Rawlinson believes.

"My vision is to get to six miles per kWh, and I think that's what's gonna save the planet because then you can have a car with 180-mile range with just a 30 kWh pack, now you change the design of the car," he said. "The paradox is that the long-range EVs of now, this decade, and the EVs of the future will have less range, [because] they'll cost less and the chemistry will accept the charge faster and the charging network will be much more mature and fully built out. Then, what's wrong with 180-mile EV? If you can get six miles per kWh, that's a 30 kWh pack to get the 180-mile range, and then it's a tiny pack. That's maybe a $4,000-$5,000 pack, and then you can make a truly affordable EV. I think we could do that in the next couple of years. We can get to five miles this year, for something like [the Air], and for a smaller, family car, we could do six miles maybe 18 months from now, two years from now."

Lucid is also improving its line-up of Air trim levels, even as the various trims keep their differences hidden behind matching sheet metal. The Pure and Sapphire updates, for example, were developed at the same time and Lucid engineers had to develop their own traction control system for these EVs, because the supplier version didn't perform well enough. The motors in the Grand Touring trim are like version 1.5 – maybe not quite different enough to be considered v2.0, Lucid representatives said – as the engineers continue to improve their understanding of how magnetic fields effect operation and the amount of resistance different coatings have on copper wires. Or take the 38-mm (1.3-in) aluminum busbars in the Air's battery.


Lucid Motors CEO Peter Rawlinson shows off a technical model of the Air's front end module assembly at the company's Silicon Valley headquarters.

"We've got the shortest busbars on the planet," he said. "Originally, these were about eight inches long, and I cannot tell you the pain that the engineers went through. 'We got them down to six inches, Peter,' and I said that's not going to fly. 'It's down to four inches and it's killing us.' 'This is not good enough, I want them like half an inch and it went this way for months and months and months trying to reduce the length of the busbars because the shorter they are, the more efficient they are, because the electrons don't have to flows so far. And it's like, '"What difference does this make?" I don't know. It's tiny, but you have to do it."

Tiny improvements, huge performance

Details of these small improvements that Lucid engineers made throughout the Air easily slip the mind when you get behind the wheel. A spacious interior welcomed me no matter which of the four Air trims I tested on a sunny day earlier this year, and the obvious headline is that it's impossible to miss the difference between the 1,234 hp (920 kW) Sapphire trim with its three permanent-magnet motors (one on the front axle and a twin rear-drive unit in back) and the 430 hp (320 kW) Pure base model with a single motor mounted on the rear axle. During an afternoon testing the Air lineup in the

BOTH IMAGES: SEBASTIAN BLANCO

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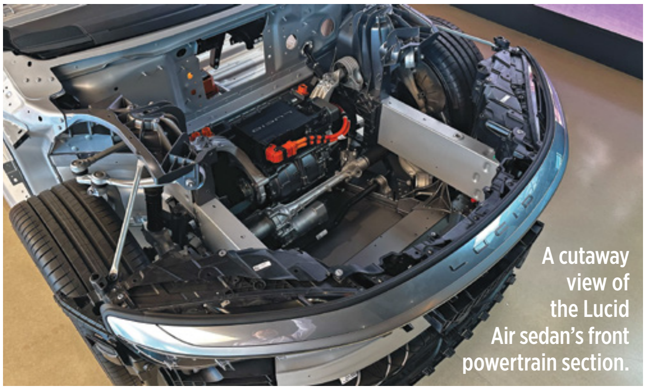


A cutaway view of the Lucid Air sedan's front powertrain section.

redwoods outside San Francisco, the extra oomph was an unquestionable high. No EV – or any new vehicle of any type – has impressed me quite as much as the Sapphire did. That's what a 0-60 mph (97 km/h) time of just 1.89 seconds is meant to do. But all of that extra power comes at a price. The Pure starts at $69,900, compared to the $249,000 for the Sapphire. As breathtaking as they are, the extra thrills that come with each accelerator push are not worth the extra $180,000. As the rare car reviewer who believes a 4.5 second 0-60 time is more than enough, I found the Pure to be simply delightful and for sure the one I would choose.

Compared to the popular (in the right zip codes) Mercedes-Benz EQS and the now-plentiful Tesla Model S, the Air brings with it a whiff of exclusivity. But Lucid stands out as an engineering marvel, as well, and offers a worthwhile driving experience. The adaptive damping suspension has less to balance in the 4,564-lb (2,070-kg) Pure than in the 5,336-lb (2,420-kg) Sapphire, but all trims felt entirely planted and connected to the roads zipping by underneath. Advanced torque vectoring gives all Air variants impressive wheel grip, and steering feel is appropriately tight and responsive across the board.

Design meets engineering

Engineers for Lucid work just steps away from where the company's designers create. Lucid's Silicon Valley headquarters features a two-story lab that can hold up to four full-size clay models on the design shop floor, where the CAD team also works. Other engineers work upstairs, in an open loft overlooking the models, and the layout is meant to stimulate organic interactions that should end up creating a better EV.

"People don't realize this, but engineers design the car as well," Rawlinson. "Often, you see a concept car and it never reaches the light of day because the engineers 'ruin it.' Well, maybe it was never designed to be feasible in the first place. We've got advanced engineering upstairs and design downstairs. And we're truly designing cars, engineering and design together."

Rawlinson said Lucid engineers have "explored pretty close to the limit" what they can do for now to improve the efficiency and miniaturization of components in the Air and Lucid's upcoming Gravity SUV.

Sebastian Blanco

Refreshed 2025 Cadillac Escalade features 55-inch dash display

Amid its constant rollout of new battery electric vehicles, **Cadillac** announced a refreshed and tech-laden 2025 version of its flagship internal-combustion SUV, the Escalade.

In a few months Cadillac will launch the all-electric Escalade IQ. The showstopper of an array of design and interior improvements is a 55-inch (140-cm) diagonal display that runs the width of the dashboard. Part of that display, a 25-inch (64-cm)diagonal area, is reserved for items the passenger can access and control.

Asserting that the Escalade has always been known for craftsmanship, technology and performance, John Roth, vice president of Global Cadillac, said it is the standard-bearer for full-size luxury SUVs. "Escalade … has continuously raised the standard of full-size SUV luxury since it was introduced 25 years ago," he said, adding that it is "the best-selling luxury full-size SUV in North America since 2014 and has sold more than 1 million units globally."

On the outside, the 2025 Escalade inherits lighting technology from the coming Escalade IQ, while other details come from the design language common to Celestiq and Lyriq EVs. Thin and bright horizontal signal lamps are more cohesive with the iconic vertical LED daytime running lights and headlights. A larger grille is available in three patterns depending on trim level. Adding more visual effects after dark are an available lighted brand crest and LED lighting around the grille.

At the rear, the crest has been repositioned slightly and trim below the window has been simplified. Revised taillights include a second vertical LED element. Cadillac rounds out the exterior changes with available 24-inch (61-cm) wheels, the largest ever offered on the Escalade, and power open-and-close doors.

On the inside, the seating surfaces still feature the quilted and perforated surfaces that Cadillac is known for. An available

The 2025 Cadillac Escalade in Sport Platinum trim. The horizontal signal lamps and available lighted crest and lighted grille surround are new.

FROM TOP: SEBASTIAN BLANCO; CADILLAC

Executive Second Row package includes stowable tray tables, 12.6-inch (32-cm) diagonal personal screens, a rear command center, dual wireless charging pads, massaging seats and speakers in the headrests. Ambient lighting can be personalized in 126 colors and two lighting zones. The V-series features a (real) carbon-fiber, performance-focused interior.

Martin Hayes, chief engineer for the 2025 Escalade, said the model has always been the brand's technology flagship, "starting with the 1999 Escalade that offered the safety and convenience of OnStar hardware as standard equipment. The 2025 Escalade features the best technology Cadillac has to offer," he said.

Among the highlights are the previously mentioned enormous pillar-to-pillar curved display. It includes voice control, navigation, an app store and more, including available Apple CarPlay and Android Auto. What else?

- Power- and flat-folding third row
- AKG Studio 19-speaker auto system standard, and an available 36-speaker system (40 speakers with the Executive Second Row package)
- Standard Super Cruise driver assistance with a three-year complimentary subscription to OnStar Super Cruise. A paid subscription is available after that.
- Available 5G Wi-Fi hotspot capability that connects through OnStar.
- Passenger entertainment options including HD streaming and browser compatibility, meaning users can log into the services they already subscribe to at home.
- Available night vision that is standard on V-Series and Platinum trim levels.
- Full-color head-up display is standard for Premium Luxury, Sport, Premium Luxury Platinum, Sports Platinum and V-Series trims.

The 2025 Escalade is still powered by a direct-injected 6.2-L V8 that makes 420 hp (313 kW) and 460 lb-ft (623 Nm) of torque. It is mated to a 10-speed Hydra-Matic transmission. The Escalade-V is powered by a supercharged version of the same engine that makes 582 hp (508 kW) and 653 lb-ft (885 Nm).

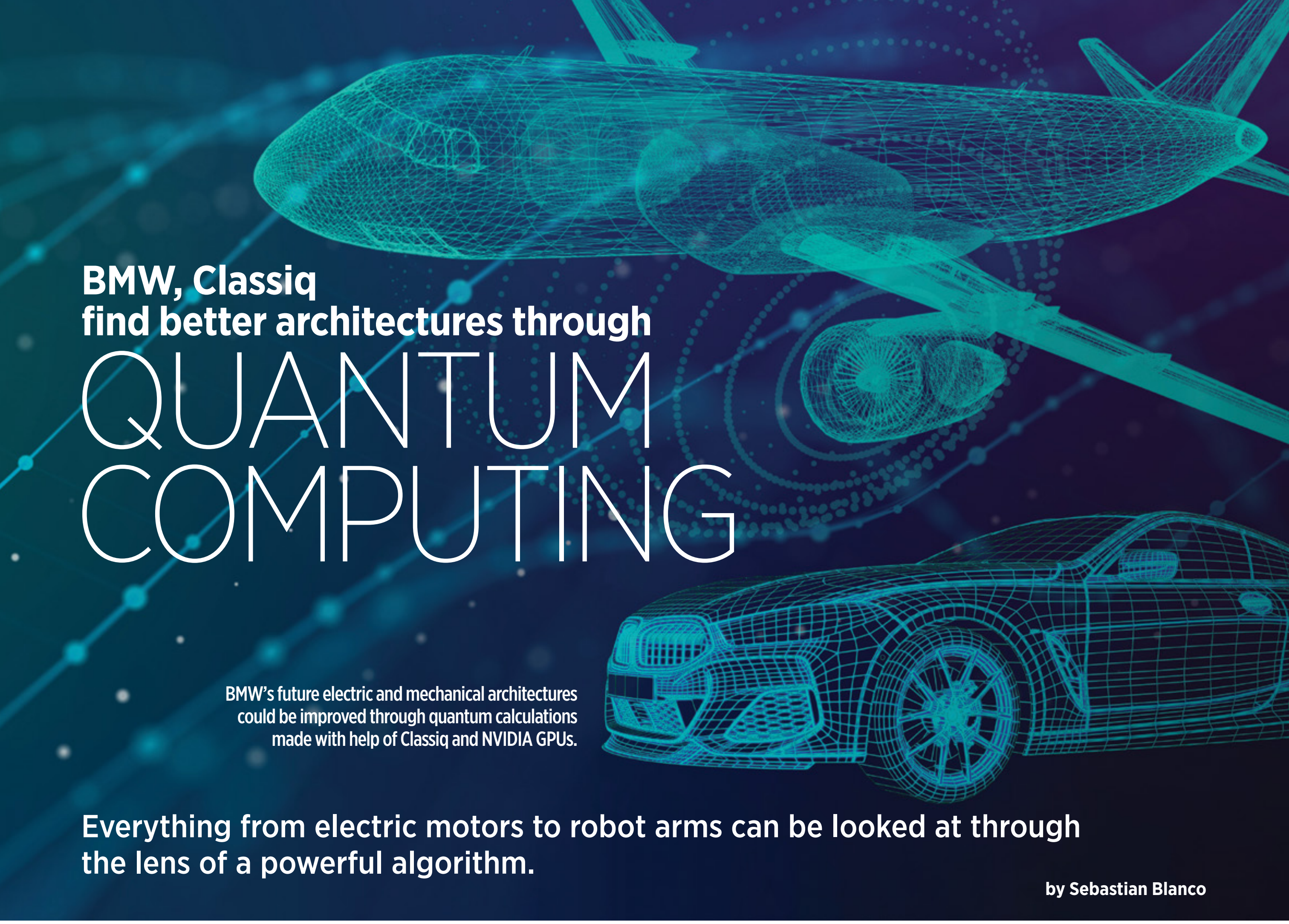
CADILLAC

Screens abound in the 2025 Escalade. The 55-inch diagonal curved display on the dash is joined by a 12.1-inch Command Center display below.

Premium Luxury, Sport, Premium Luxury Platinum, Sport Platinum and V-Series trims are equipped with Magnetic Ride Control 4.0 and Air Ride Adaptive Suspension.

All Escalades receive Cadillac's suite of standard active safety and driver-assistance systems. Production of the 2025 Escalade will begin later this year in the Arlington, Texas, plant that is celebrating its 70th anniversary. Pricing will be announced just before the model hits North American dealerships.

Chris Clonts



BMW, Classiq find better architectures through QUANTUM COMPUTING

BMW's future electric and mechanical architectures could be improved through quantum calculations made with help of Classiq and NVIDIA GPUs.

Everything from electric motors to robot arms can be looked at through the lens of a powerful algorithm.

by Sebastian Blanco

As part of **BMW**'s Emerging Technologies team, Lukas Müller picks apart new ideas to evaluate if they are relevant for the automaker. He wasn't the first at BMW to look into how quantum computing might change the way the German automaker builds cars, but he told SAE Media that the work he's doing is just the tip of the iceberg when it comes to harnessing more powerful computers that will help build the better cars of tomorrow.

In June, BMW announced it would collaborate with **Classiq** and **NVIDIA** to find optimal architecture designs for electrical and mechanical systems in future vehicles. The idea was to use quantum computing to develop a real-time solution that would make a vehicle's architecture more efficient by analyzing a series of potential motors, batteries, cooling systems and other components by looking at the drive train as a series of linear equations.

"It's a really complex system," Classiq's technical marketing manager, Erik Garcell, told SAE Media. "When you get into the data, you have to worry about the phase of the power going into these systems, too, and timing that and making sure it's all good."

Garcell said any eventual product would be an on-board device that calculates what to turn on and off in which sequence based on real-time data. Since scalable quantum systems are not yet available, the difficult analysis would be done by the quantum computer before the vehicles are built. Then, simpler onboard systems would use the learnings to control powertrain devices based on the rules the quantum system came up with. Garcell said the next step was to apply a quantum approximate optimization algorithm (QAOA) to the problem.

"We were trying to optimize the system of linear equations, that drivetrain we're talking about of electrical components," he said. "How do you optimize this huge and complex neural network? It's not just the one pass. It's feeding data into itself. You could think of it almost like a graph theory problem. By optimizing this using this QAOA algorithm, they're able to figure out a more efficient system of linear equations which they can then backtrack out to the original system and say, this is the more optimal drive train. If this is connected to this, connected to this, connected to this, in this way, and the data is feeding to each other in this way, that would be the most efficient linear equation, the more efficient electronic drive train that would more often than not save energy."

Step one of the whole process was understanding what quantum computers can and can't do to solve this problem, according to BMW's Müller. Figuring out how the robots might shave a few milliseconds off of their job time — another detail BMW is using quantum computing to calculate — is different than running simulations to discover which pipe thickness will work best or how to optimize the flow of the cooling liquid inside a vehicle.

"We decided on, as a very basic problem, taking four components that would exist in a car and asking,

BMW

The BMW iX xDrive50 presented one version of the automaker's future. Upcoming BMW vehicles could be enhanced with a more efficient architecture developed using quantum computing calculations.

Classiq previously applied its quantum computing efficiency technology to Rolls Royce's aviation efforts.

FROM LEFT: BMW; CLASSIQ

"Quantum computers are supposed to be, essentially, the game changer for optimization."

for example, how do we transfer heat between them and how do we connect them together," Müller said. "Maybe you could put into the solution space a range of different coolers which have different powers but, of course, they might be more expensive. In the end, the algorithm would spit out, 'the most efficient one is taking these three and connecting them together in that way,' or 'take these four, but connect these three and this one only to this component.'"

Classiq previously worked with **Rolls Royce** on jet engines and has done work with other automotive OEMs. The work with BMW is the first automotive endeavor that Classiq can talk about publicly.

"Quantum computers are supposed to be, essentially, the game changer for optimization," Garcell said. "A lot of companies are looking at them, not just to make their electric cars more efficient, but to build better batteries themselves, through quantum simulation, to create kind of new compounds for the battery that can either charge faster or hold more charge overall. There are a lot of different places people are looking into quantum computing for the automotive space."

BMW has a small number of people working on quantum computing, doing their own research, writing papers and working with external companies, Müller said. In early 2024, BMW partnered with **Airbus** for the Airbus-BMW Group Quantum Computing Challenge (ABQCC) which was designed to "harness quantum technologies for real-world industrial applications."

Before investigating electrical architectures using quantum computers, BMW used the technology to test out factory improvements. Specifically, Müller was involved in quantum work on robot path planning in a manufacturing facility. BMW hasn't yet put quantum computing's solutions to work in its plants, with optimized robots cruising around actual production lines. Instead, BMW is investigating which problems are amenable to quantum computer solutions and how much speed and efficiency might be gained.

"Optimization problems are one of our key areas because we have quite a lot of them," Müller said. "Producing and designing vehicles is one of the most complex tasks there is. Nowadays, there are more and more robot arms that work in the factory. And you always want to decrease the time they need to finish a certain task, because this can have big influences on how quick we are able to produce the cars."

BMW also used quantum computing to investigate its PVC application strategy, Müller said. "The main question is, 'what's the best order for one or maybe multiple robots to do this?' The number of possibilities of the order that you can do increases exponentially with the number of seams that you have. It gets more complex if you have different kinds of tools that the robot can use, maybe corner nozzles or ones with two nozzles. Even if you [just] get a couple of seconds, or less than a second improvement, this can have influences down the line." ■

BLAZER EV IS A STEEL-INTENSIVE SHOWCASE

Blazer EV white body showcases innovative materials solutions to balance mass, structural performance, cost and occupant safety.

LINDSAY BROOKE

GM elevates the ferrous state-of-art with new body and battery structures.

by Lindsay Brooke

Chevrolet Blazer EV customers are likely to cite the Ultium battery and dual-motor driveline as their vehicle's most advanced technologies. But in doing so, they'd miss an equally key aspect of **GM**'s sporty midsize electric SUV: its steel-intensive body structure featuring a broad mix of alloys and an impact-defying battery enclosure.

The words 'steel' and 'BEV' seem incongruent, given the widely forecasted trend toward aluminum architectures based on two or three large castings. GM itself has invested heavily in the Tesla-pioneered 'gigacasting' tech and will deploy it first in **Cadillac**'s new, ultra-exclusive (and much-delayed) Celestiq flagship. But GM's electrification strategy depends on a variety of material and body-structure solutions. It's a horses-for-courses approach aimed at balancing performance and product affordability, explained Blazer EV's chief engineer Hoda Eiliat.

"In GM's materials position, steel is obviously the most cost-effective approach," Eiliat declared in her keynote at the 2024 Great Designs in Steel conference. Innovations in new alloys, metal forming and joining technologies continue to drive steel's competitiveness, she told SAE Media following her presentation, adding that "obviously, we have to look elsewhere when we have mass and parts-consolidation priorities."

The breakdown of Blazer EV's body materials shows increased adoption of tougher, more mass-efficient steels. Forty-five percent of the 5,337-lb (2,421 kg) all-wheel drive vehicle's total materials composition is in medium-high-strength alloys boasting a yield strength of 180-580 MPa. Thirty percent of the total is split evenly between mild steel (mainly body outers) and ultra-high-strength alloys, the latter including multi-phase, Martinsitic and Gen-3 products rated at 980 MPa or above. Dual-phase advanced high-strength steels (590-780 MPa) constitute 9% of the total.

The most prominent use of aluminum is in the extruded side rockers in 6082 alloy with a T6 heat treatment.

Managing mass and impact load

Beyond steel's cost superiority, GM considers the ferrous metal to be vital for optimizing product diversity, rapid refreshes, and achieving production scale. All are essential for democratizing EVs, Eiliat said. The Blazer EV is one of eight vehicle programs that are currently on GM's so-called BEV Crossover platform, with more in development. The basic architecture accommodates two major variants serving **Buick**, Cadillac, Chevy, Honda and Acura nameplates. They're differentiated by long and short distances measured from the driver's ball-of-foot to the front axle centerline. Blazer's all-new steel upper body structure also has two variants: base roof and sunroof. Much of the lower structure carries over parts from the Cadillac Lyriq.

Blazer's underbody structure is engineered to accommodate front- or all-wheel drive and two different battery enclosures, depending on whether the vehicle

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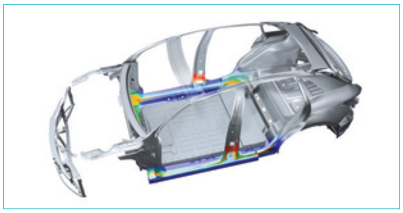

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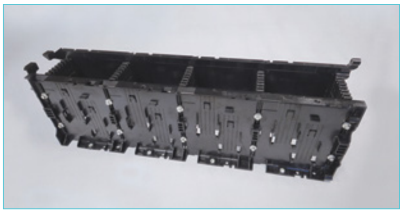
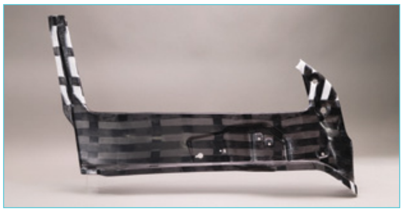


Module Lightweighting
Syensqo, General Motors

Enabling Technology
CompositeEdge GmbH



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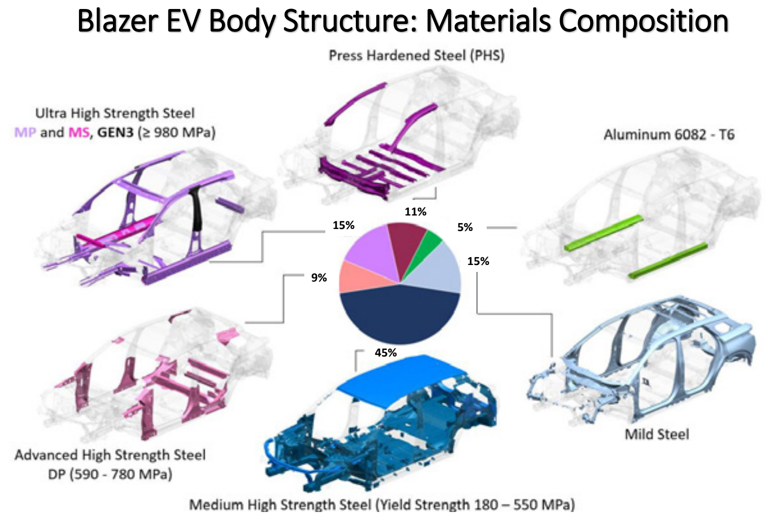
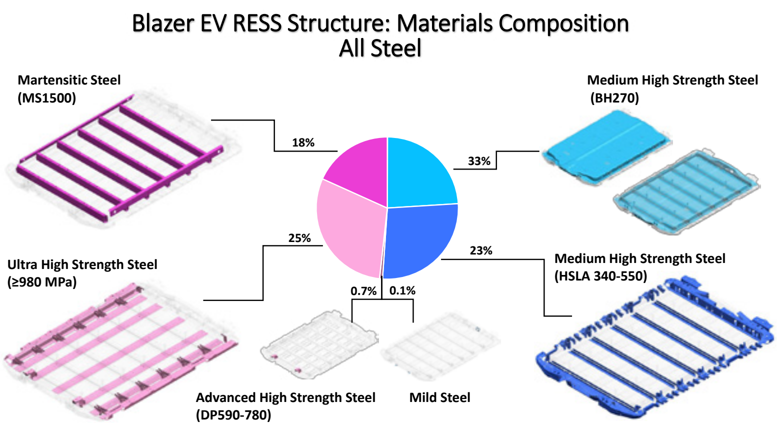
#ONLYFORWARD

BLAZER EV IS A STEEL-INTENSIVE SHOWCASE

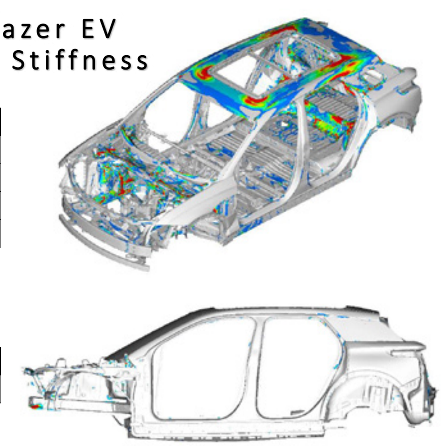


Strategic selection of Blazer EV metals led by steel with aluminum side rails playing a vital supporting role.



The Blazer EV's steel-intensive battery enclosure is unique among aluminum-intensive competitors.

Blazer EV
BIW Stiffness



Torsion KN-m/deg	
12 MOD Base Roof (Target>31)	34.9
10 MOD Base Roof (Target>28)	32.4
12 MOD Sunroof (Target>31)	31
10 MOD Sunroof (Target>28)	28.4

Bending Hz	
Performance	25.4

GM's body engineers exceeded their stiffness targets in developing the Blazer EV.

Blazer EV chief engineer Hoda Eiliat shares insights into the new SUV at GDIS 2024.

uses a 10-module or 12-module Ultium battery pack (what GM calls the RESS, or rechargeable energy storage system). The all-steel RESS is unusual in an industry that has thus far favored aluminum battery enclosures. It is carried over entirely from the Lyriq and employs press-hardened steels (PHS), which are key to its structural role in the vehicle and its impact performance. PHS makes up 11% of the total.

The EV's small-or-large battery sizing required a new approach to managing the 500 kg (1,102 lb) mass. Special stamped-steel front rails were developed "to bring the total mass variation of the two RESS packages into one front subsystem," Eiliat said. "And we still managed to commonize parts between the two."

Blazer EV's frontal- and side-impact load management strategies use the body and RESS in unison. "Our strategy was to manage the load between battery and body in one-third and two-thirds proportions, with two-thirds of the load transmitted through the body and one-third through the battery," Eiliat explained. "In the event of a full flat barrier engagement, the load transmits from the front rail then into the first crossbar in the RESS, then splits into the center tunnel and also into the rockers. The same thing happens in the rear, where forming the crossbars in press-hardened steel helps minimize intrusion."

Enabling the body and RESS to "talk to each other" is what GM calls a Cradle Bolt Stabilizer, basically a shear plate that connects the front cradle with the body at one point and connects the body and the rails at two points.

CLOCKWISE FROM TOP LEFT: CHEVROLET; LINDSAY BROOKE; CHEVROLET; CHEVROLET;

Frontal and side impact loads are uniformly transferred into the RESS's transverse cross members that are bordered with longitudinal 'ski rails.' Eiliat said the extruded aluminum rockers enable a uniform transfer of about 30% side-impact loads into the ski rails.

Bolstering the B-pillars

In her presentation, Eiliat revealed the Blazer EV's body-in-white bending stiffness to be 25.4 Hz as measured by GM. The body's torsional stiffness increases as a function of the RESS pack. The 10-module battery pack has five bays (space between crossmembers where the cell modules reside), while the 12-module RESS has six bays. "As your battery gets bigger and the roof structure gets stronger and stiffer, your stiffness numbers go up," she said.

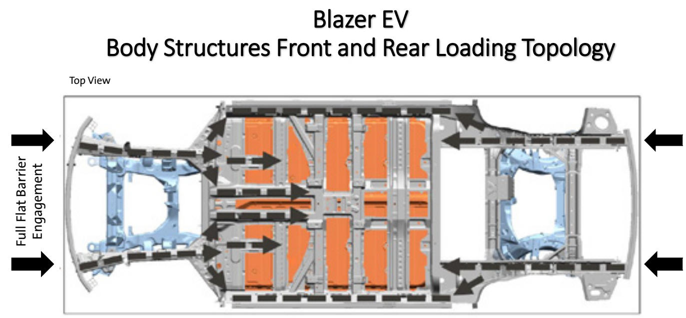
For the GDIS conference, GM brought a Blazer EV white body and RESS for display. Both properties were closely examined, photographed, and measured by attendees throughout the event. Of particular focus was the impact-critical B-pillar, constructed in Gen-3 AHSS.

"We decided to use Gen-3 to reduce mass with equivalent performance in IIHS 2.0 and roof crush [testing]," Eiliat noted. "We save on cost using Gen-3 steel. To facilitate this application, we created a unique material spec, GMW17627, which remains an industry benchmark. We use unique forming processes that compensates for springback while adding stiffness. We also have a specific welding schedule."

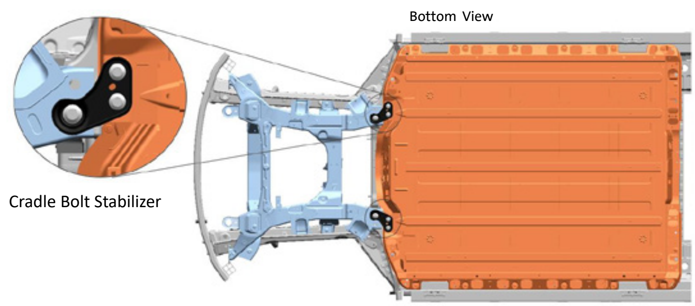
The GMW17627 specification, titled "Retained Austenite Bearing Advanced High Strength Sheet Steel," was published in 2018. It covers the requirements for continuous cast, cold rolled, retained austenite bearing sheet steel with specified minimum tensile strengths from 690 MPa to 1180 MPa.

This specification applies to uncoated and coated retained austenite-bearing advanced high-strength steels that rely on one or more induced plasticity mechanisms to achieve enhanced combinations of strength and ductility relative to high-strength steels. Typical applications include body panels, body structure members, and reinforcements for enhanced strength and vehicle impact performance.

Highlighting the joining strategies employed by GM at its Ramos, Mexico, plant, Eiliat said the Blazer EV body features roughly 6,000 resistance spot welds. There are over four linear meters (13.1 ft) of laser brazing between the vehicle's roof panel and bodyside outer. The lower body structure is MIG welded. Structural adhesives are used in the upper section. The aluminum side rails attach to the steel body structure using brackets, rivets, and are isolated with adhesives and tapes. ■



Body and integrated RESS are engineered to handle front, rear and side impact loads.



To minimize intrusion into the battery space during the front crash event, the integrated battery structure is utilized to manage transfer of about 30% of the load, according to Hoda Eiliat. Note the Cradle Bolt Stabilizer shear plate, which attaches body, cradle and RESS, provides secondary shear and stabilizes load transfer.

BOTH IMAGES: CHEVROLET

STEEL targets EV structures, battery boxes

GDIS 2024 keynoter Brad Davey, executive VP of corporate business optimization at ArcelorMittal.

LINDSAY BROOKE

The industry fires back at aluminum's growing 'gigacasting' threat.

by Lindsay Brooke

The steel and aluminum industries are waging a new materials war that could determine which of the long-time competitors dominates EV structures in the next design cycle. Feeling the heat from new aluminum applications, steel companies are aggressively moving to defend their reign as the material of choice in vehicle body structures. They also aim to conquer the EV battery enclosures market, currently dominated by aluminum extrusions. (See AE March 2023 feature: https://www.nxtbook.com/smg/sae/23AE03/index.php#/p/CVR2.) Steel executives are bullish on their new technologies and their approaches to winning on both fronts.

"Today, many automakers are talking about high-pressure die-cast aluminum, especially for BEVs," Brad Davey, executive VP at steel giant **ArcelorMittal** said. Speaking with SAE Media following his keynote address at the recent 2024 Great Designs in Steel (GDIS) conference in Novi, Michigan, Davey acknowledged that giant HPDC aluminum 'gigacastings lend themselves to 'skateboard' EV platforms due to their potential to consolidate parts and simplify manufacturing. The end benefit, he said, "is capital-expense assembly line savings," particularly for EV companies.

"If you can reduce floor space and the number of welding robots in assembly, by using one large casting, it can be an attractive solution – compared with traditional processes, that is," he said.

Pioneered by **Tesla** on the Model Y, gigacastings are designed to ultimately form a battery-electric vehicle's entire underbody in a single aluminum component. The Model Y uses two castings, front and rear, connected by a steel/aluminum battery box. See AE June 2020 feature: https://www.nxtbook.com/nxtbooks/sae/20AUTP06/index.php#/p/Intro). The potential benefits have sparked industry-wide interest, especially in tooling suppliers like **IDRA**, **LK Group**, **Buhler**, and **Yizumi**. In late 2023, GM acquired Livonia, Michigan-based **Tooling & Equipment International** (TEI), a leader in foundry mold technology. GM engineers used TEI's expertise to prototype and validate the large underbody castings for the **Cadillac** Celestiq due later this year.

Despite recent reports that Tesla scaled back its effort to produce a low-cost Model 2 using an industry-first single underbody casting, steelmakers are also concerned about Chinese OEMs using aluminum gigacasting to help drive radical new EV architectures. S&P Global has reported development in China of enormous 12,000- to 16,000-metric-ton HPDC machines.

Gigacasting downsides

Not so fast, the steel stalwarts say. ArcelorMittal's Davey highlighted gigacasting's downsides. "The part costs are higher. If you're not offsetting the part costs with manufacturing savings, you're going to end up with a higher cost design or no cost improvement," he said. "There are many issues on yields, defects related to high tooling cost and trying to extend tooling life, and also cracking [of the castings]. He also noted casting's crash-energy absorption characteristics and questioned OEMs' ability to refresh/change exterior body styling as quickly and efficiently as on traditional structures.

"Typically, in the past, aluminum solutions have been lower weight, but these are not compared to the optimum steel solution," Davey said. Optimizing mold flow through the large die-cast parts has, in many cases, required increased wall thickness and larger/heavier castings overall, he said. He also claimed that

STEEL
targets EV structures, battery boxes

- High Pressure Die Casting is a competing process
- Process was deeply investigated
- Steel based rear module with **MPI outperforms** aluminum HPDC design in part **cost**
  - Full steel module assembled is cheaper than only the raw aluminium (** and ***)
- Megacasting HPDC is heavier than an AHSS based steel solution

	Reference Standard design	Multi Part Integration	High Pressure Die Casting
Material	Steel	Laser Welded Blanks – other flat Steels	Cast Aluminium alloy
Mass position	Ref.	Lightweighting if material upgrade	- (10% heavier for rear module Gigacasting*)
Part integration	Ref.	+	+ +
Module cost **	Ref.	=	- - ** From +13% to +74% ***

* Benchmarking activities done on A2mac1 on car with both steel based and aluminium HPDC based rear module. Analysis done as the function level
** ArcelorMittal cost assessment done with consideration of amortizations, material and process costs
*** Calculation done by S&P Global Mobility

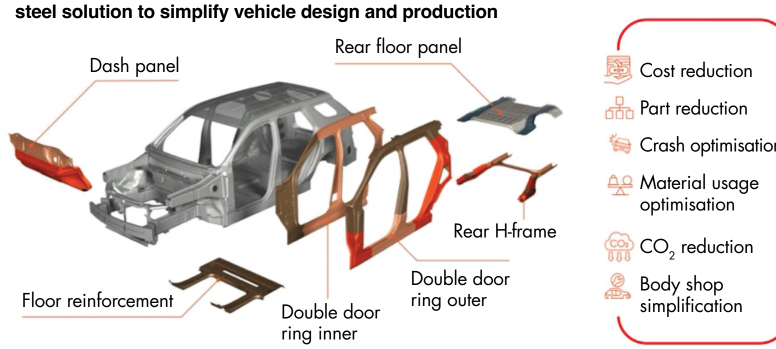
An analysis conducted with S&P Global looked at traditional single-part manufacturing and the improvements offered by new steel multi-part solutions. The reference single-part design was compared quantitatively to the steel multipart and then to the aluminum die casting, which was found to be heavier and more costly.

> "If you're not offsetting the part costs with manufacturing savings, you're going to end up with a higher cost design or no cost improvement."

large die castings are difficult to repair after road accidents, leading to higher auto insurance costs.

Davey prompted chuckles from the GDIS audience when he reported that some automakers are discussing the need to redesign load paths in their vehicles to avoid damage to the large, expensive die castings. "If you didn't have enough challenges keeping the occupants and batteries in BEVs safe, now you've got to protect the die castings as well," he quipped.

ArcelorMittal Multi Part Integration™ is a sustainable steel solution to simplify vehicle design and production



ArcelorMittal engineers believe steel-intensive 'multipart solutions' are superior overall to large aluminum die castings in performance and cost. A recent analysis showed this steel approach offers significant reductions in operators in assembly, the body shop area, the number of robots, hours per vehicle, part count, the number of spot welds, and improved material utilization.

Steel's multi-part solutions

The "optimal steel solutions" that Davey and other steel execs believe will parry aluminum's assault are rooted in the industry's innovation and R&D awakening in the 1980s, when steel fought back against the plastic body panel challenge. New lighter and stronger high-strength, advanced high-strength, and high-strength low-alloy products, combined with new manufacturing processes, co-design services and cost advantages halted the advance of aluminum-intensive bodies.

Even after losing **Ford**'s F-Series to the light metal in 2012, steel today still makes up over 50% of an average vehicle's mass. At GDIS, **American Iron and Steel Institute** CEO Kevin Dempsey noted that 75% of modern steel alloys have been developed in the last 20 years; more than 3,500 steel grades are available today.

Steelmaker engineers who "sit at the design table" with vehicle OEMs are using that portfolio, along with tailor-welded blanks, new fabrication techniques, and what Davey calls "multi-part solutions" to expand steel applications in EV body structures, conquest the battery enclosures business, and improve the EV cost structure overall.

Steel industry analyses reveal that nine of the top 10 vehicles with the highest utilization of high-strength steel are EVs, Davey said. He added that the adoption rate of laser-welded, press-hardened steels is running 50% higher in EVs than in hybrid and ICE vehicles.

"We're winning back the battery boxes," he said. "Nearly every automaker is in discussion with us and others about how to utilize steel in battery structures. One North American OEM has told us their future for battery boxes is 100% steel, or highly steel-intensive."

Bring on the competition, Davey said, echoing his industry colleagues at GDIS. "The competition is good for all of us." His keynote concluded with a warning: "China is adopting these steel solutions at about two times the rate of the Western world." ■

BOTH IMAGES: ARCELORMITTAL

PRODUCT
BRIEFS

SPOTLIGHT: TESTING TOOLS

Digital testing

VI-grade (Darmstadt, Germany) announced its Virtual Proving Ground for VI-WorldSim, a comprehensive digital replica of a testing facility designed to meet the needs of automotive engineers. VI-Grade states that WorldSim features an array of features and testing scenarios and promises to significantly reduce development time and costs while enhancing the overall quality and safety of vehicles. Scenarios include a high-speed ring with an 8.6 km (5.3 mile) track with four lanes and a maximum banking angle of 11 degrees, simulations of both European and American highway conditions, specialized testing areas such as ride lanes with various surface types, a handling track, a rally track, and a country road based on real-world laser scan data and a dedicated area for ADAS evaluation.

https://www.vi-grade.com

SPOTLIGHT: SENSORS

Pressure sensors

Melexis (Tessenderlo, Belgium) launched the MLX90830 miniaturized MEMS pressure sensor. Melexis states that the MLX90830 can manage gas and liquid media measurement from 2 to 70 bar (29-1,015 psi) and measures the absolute pressure to deliver a proportional analog output signal. Melexis also claims that the MLX90830 makes the module cost-effective by simplifying the system integration into the latest electric vehicles (EVs) thermal management systems. The sensor is equipped with protective mechanisms against overvoltage (above +40 V) and reverse voltage (below -40 V) and has been developed as a Safety Element out of Context (SEooC) enabling up to ASIL B system integration ensuring it meets the latest EV safety demands.

https://www.melexis.com

Engineering platforms

MikroElektronika (Belgrade, Serbia) announced a Click Shield for the Red Pitaya engineering platform. Red Pitaya is an open-source software-defined instrument and an FPGA development tool. Red Pitaya combines the functionalities of multiple lab instruments with programming capabilities and open-source software. Click shields are adapters that bring Click board connectivity to popular development platforms such as Arduino, Raspberry Pi, STM32 Nucleo, and now, Red Pitaya. The Red Pitaya Click Shield can be powered through an external power supply, supporting a wide voltage range from 12V to 24V, or via a USB Type C connector, ensuring set-up flexibility. Click board can be used with existing bi-directional level-shifting voltage translators, regardless of whether the Click board operates at a selected 3.3V or 5V logic voltage level.

https://www.mikroe.com

Touchscreen controllers

Microchip Technology (Chandler, Arizona) launched the MXT2952TD 2.0 family of secure touchscreen controllers. These controllers were reportedly designed to encrypt touch data and cryptographically authenticate software updates to minimize risk and meet PCI certification compliance standards. Microchip states that when the RFID reader IC and the touchscreen controller are on different printed circuit boards (PCBs), it is especially difficult and expensive to build physical barriers for hack protection. Embedded firmware on the MXT2952TD 2.0 reportedly provides a more easily implemented solution for EV charger manufacturers to remain compliant with security regulations and avoid the cost of adding a second, expensive touchscreen payment module to the charger.

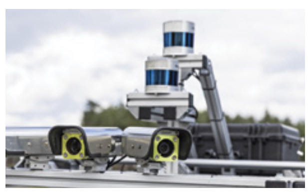
https://www.microchip.com

Tactile switches

Littelfuse (Chicago, Illinois) announced that their C&K Switches KSC2 Sealed Tactile Switch product line now incorporates electrical height enhancement. The KSC2 series of tactile switches for surface-mount technology (SMT) is a high momentary-action tactile switch featuring a soft actuator. The switches are available in several models and provide numerous electrical lifespans that can withstand various operating forces. The latest KSC2 switch reportedly outperforms other switches in the market, reducing the need for frequent replacements. Littelfuse claims the KSC2 provides clear tactile feedback, making it easier for users to know when an input has been registered.

https://www.littelfuse.com

ADAS Validation



ZF (Jeversen, Germany) has developed a cloud-based and AI-enabled validation service called ZF Annotate for passenger cars and commercial vehicles. ZF Annotate reportedly acts as a redundant setup that is independent of the sensor set to be checked and is confronted with the same information while driving on the road. The recorded data is then uploaded to the cloud and analyzed. All relevant objects are accurately marked, classified, attributed and assigned unique ID numbers and moving objects are tracked. This object information forms part of the complete description of the environment model. After this "annotation," the software provides a highly precise comparative measurement. This makes ZF Annotate a solution for testing and training systems from Level 2+ to Level 5.

https://www.zf.com

Converters

Eaton's (Southfield, Michigan) latest DC/DC converter takes power from a 48-volt system and steps it down to 12 volts to run accessories and other low-power systems. Eaton claims this design helps essential equipment, including antilock brakes and power steering, work even in the case of a power failure, making it unique among product offerings in this space. The converters are also designed to reduce weight and save space. Eaton's DC/DC converters provide flexibility through multiple power and voltage levels and can be optimized to work seamlessly with a manufacturer's charging system specifications. It also features a Controller Area Network (CAN) bus, which allows direct communication from the DC/DC converter to other vehicle electronic control units to transmit diagnostic information.

https://www.eaton.com

VW engineering chief on wireless charging at DC speeds

During the annual Management Briefing Seminars held by the Center for Automotive Research in Traverse City, Michigan, this year, SAE Media sat down with **Volkswagen North America's** Lyndon Lie. Lie is the company's EVP and chief engineering officer, overseeing VW's North American engineering teams focused on developing products for local markets. VW has over 2,000 engineers in North America, with teams in Chattanooga, Tennessee, working on high-voltage battery and electrification and HMI connectivity, and teams in Mexico responsible for more traditional body, chassis, and interior work.

Can you talk a little bit about how VW's 270 kW wireless charging technology was developed?
Volkswagen has programs where we sponsor PhD students, and we're partnered with the University of Tennessee, Knoxville, which also runs Oak Ridge lab. Some of them are working to develop a wireless charger that's as fast as DC fast charging. It's challenging, but this is one of those solutions that, when you look at us, you wonder, 'Why didn't I think of it?' The package is maybe 16 inches (41 cm) in diameter and uses three-phase charging with a rotating magnetic field between the three phases and the same size receiver on the car.

That's similar to what we saw from companies like Witricity 10 or more years ago.
Even the ones that are on the market now, the latest ones, are 22 kW. We're more than ten times that. It has DC fast charging speed, and the hottest it gets is 106 F (41 C). Because of the way this rotating field is set up, it never gets hot. Instead of heating one area, it's pulsing as it's rotating around so it never heats one physical location long enough to get hot. Typical chargers are single phase and it's a lot of current that you're trying to pass through. But because it's a single phase, you're heating it up for a longer period of time.


VW chief engineering officer Lyndon Lie at MBS 2024.

"I don't see any all-new engines coming for passenger cars. For trucks? Sure. But for passenger cars, we'll add electrification."

Where might we see this in the future?
We're looking at it with Porsche. Audi is looking at it. And it's a perfect application for heavy duty trucks, because they need a lot of power. I came from Nikola before coming to Volkswagen, and we had 730 kWh on-board power. That's a lot of power.

The battery work that's being done in Chattanooga and elsewhere is not just for the BEVs, but also hybrids and PHEVs, right?
In my battery team. I have cell experts, controls experts, thermal guys, and mechanical for the packaging. A lot of it's the same [across powertrains]. You need cooling, you need controls. But when you get to the actual software, that's where it starts getting different. Cell chemistry is different. Cooling may be slightly different. So, the team's the same. It's broken up by the engineer. You may be working on a BEV, I may be working on a PHEV, but you're talking back and forth, and you're sitting next to each other.

What can you tell me about continuous improvements to ICE?
I don't see any all-new engines coming for passenger cars. For trucks? Sure. But for passenger cars, we'll add electrification. We'll add enhancements to it, so you could take a 2-L engine and get 400 horsepower out of it because we've added an E-axle to the back end. That gives us all kinds of flexibility.

I also see range extenders as another option that's going to come toward the end of the PHEV cycle, because, really, it's a BEV with a gasoline generator. And it's a small engine, like a 1.5-L running a generator in your frunk. Instead of putting a lot more money in a whole new ICE that's got a very short life cycle, we can tweak what we have and put more money into the rest of the propulsion system. It gives us a lot of opportunities.

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