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From pipe dream to production ready: Aptera solar-powered EV

Scania explores extended-range electric trucks | What EV tech doesn't receive enough attention? | **Donut Lab** consolidates electric drivetrain in wheels | **ProLogium** develops lithium-ceramic batteries | Medium duty is perfect EV segment, says **Harbinger** | **Vianode** highlights importance of synthetic graphite

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Cover image courtesy of Aptera

In this issue

Editorial summary

Because it plays a key role in an electric vehicle's (EV's) range, performance, safety and cost, battery technology receives considerable industry attention. Researchers continue to develop new, commercially viable chemistries and innovative designs that could offer faster charging cells with more range and fewer safety risks.

In a shifting geopolitical landscape, suppliers are considering how to procure the highest quality materials that add up to cleaner and better EVs. For vital materials like graphite, which constitutes 95% of lithium-ion battery anodes, synthetic production processes could be a major asset for regional industries with limited access to natural deposits.

However, the battery alone won't determine the long-term success of electric transport. Electrification is a broad and multi-faceted challenge that requires OEMs to consider practically every aspect of a vehicle–from tyres to thermal management systems, lightweighting, connectivity tech, and hybrid powertrains.

Through new modular platforms, engineers can completely change how EVs are built. Advances in e-motor design, for example, could consolidate the drivetrain entirely in the wheels for lighter, cheaper, and more spacious vehicles without sacrificing power or torque.

Automakers continue to focus on boosting overall EV system efficiency. By combining a lightweight and aerodynamic chassis with cutting-edge electronics and solar recharging capabilities, EV start-ups could enable customers in sunny climates to drive a large percentage of their annual mileage for free.

Extended-range EVs, already gaining momentum in China's passenger vehicle market, could be valuable in the long-haul truck segment. Adding a small gas-powered generator could help these vehicles conform to service capacity requirements that batteries alone have struggled to meet. Development is still in its early stages, but logistics operators and their customers are already reacting positively to the possibilities.

Perhaps the most important thing is for OEMs and suppliers to identify applications in which electrification already makes sense in today's market. By leveraging the latest material innovations and construction techniques, the industry can produce models that are more comfortable and desirable than gas-powered equivalents.

Ultimately, EVs will likely struggle to enter the mainstream in every segment while the technology is economically or logistically difficult to incorporate. The goal for all stakeholders should be to create an ecosystem that produces the best vehicles on the market, which just happen to also be electric.

Zeekr outdoes BYD, announces 1.2 megawatt chargers

31/03/2025

Chinese automaker Zeekr has unveiled new charging technology that is touted to offer faster recharging speeds than the recently announced one-megawatt chargers by compatriot brand BYD. Details about the technology are currently sparse, but the automaker has confirmed a full reveal will happen at the upcoming Shanghai Auto Show in April.

Northvolt hacks away another 3,000 jobs, leaving 1,700

01/04/2025

Embattled Swedish battery manufacturer Northvolt has announced massive cuts to its remaining workforce: 3,000, leaving only 1,700 still working at its Skellefteå factory. Once hailed as the jewel in the crown of Europe's electric vehicle supply chain, the company must now make increasingly difficult decisions as it reckons with bankruptcy.

European Commission formalises softened emissions rules

02/04/2025

Weeks after first indicating its change in plans, the European Commission has formally published its amendment to rules on how automakers can meet emissions targets for the years 2025-2027 and avoid hefty fines. Instead of assessing automakers' emissions performance on a per-year basis, the average is what counts—in other words, if a company falls short in 2025, it can make up the difference over the following two years.

McLaren merges with EV supercar startup Forseven

04/04/2025

British supercar manufacturer McLaren is set to merge with compatriot electric vehicle (EV) start-up Forseven, in a move that will see its model lineup expand to potentially include an SUV. The merger was announced on 3 April after Abu Dhabi investment group CYVN completed its acquisition of McLaren's automotive business from Bahraini sovereign wealth fund Mumtalakat.

India weighs a total ICE ban in Delhi

07/04/2025

The Indian central government is considering drastic measures to curb severe air pollution in capital city Delhi, including permanently banning internal combustion engine (ICE) vehicles. Reporting from local newspaper The Economic Times indicates this tentative plan would be implemented in a phased manner and could begin within FY 2025, concurrent with a wider push to adopt battery-electric vehicles across multiple transportation segments.

Nikkei: Toyota to expand EV lineup, diversify global production

07/04/2025

Toyota, the world's largest automaker by volume, aims to expand its electric vehicle (EV) model lineup to 15 distinct offerings, according to a 7 April 2025 report by Nikkei. The automaker also plans to expand its manufacturing footprint into Thailand, Argentina and the US - a major shake-up given that its historic EV production base has occurred exclusively in Japan and China.

UK updates its EV mandate as auto industry is rocked by tariffs

07/04/2025

As countries around the world try to navigate around the US' new tariffs regime, the UK is relaxing electric vehicle (EV) transition rules to make it easier for domestic brands to remain competitive. While the 2030 ban on new internal combustion engine (ICE) cars remains in place, the government will increase the flexibility of the mandate in a similar vein to the EU's recent rules change.

BYD launches Denza premium brand in Europe

08/04/2025

Chinese new energy vehicle giant BYD has ramped up its steady expansion into Europe with the launch of its premium Denza brand, intended to serve as a rival to local automakers BMW and Mercedes-Benz. Over the last few days, the automaker has also launched its products in Switzerland, Slovakia and the Czech Republic.

Reuters: CATL in talks to buy controlling stake in Nio Power

08/04/2025

Chinese battery giant CATL is reportedly in talks to acquire a controlling stake in Nio Power, the electric vehicle maker's battery-swapping and charging subsidiary. Four sources familiar with the matter told *Reuters* that the move would give CATL control over Nio's ever-expanding swap station network.

GOP efforts to reverse California ICE ban thwarted—for now

08/04/2025

US Republican lawmakers have hit a speedbump in their efforts to overturn California's 2035 ban on the sale of new internal combustion engine cars. The Senate parliamentarian ruled that the waiver granted to California, which allows the state to set stricter vehicle emissions standards than federal regulations, is not subject to reversal under the Congressional Review Act–thereby taking a fast-track legislative process off the table.

Kia revises EV forecast downwards, details new CV software

09/04/2025

At its 2025 Annual Investor Day, Kia revised its electric vehicle (EV) sales target for 2030, reducing its annual projection from 1.6 million units to 1.26 million–or around 30%. This adjustment corresponded with a revision of its total global sales: it now anticipates total sales of 4.19 million vehicles by 2030, down from the previous target of 4.3 million.

Stellantis halts Polish Leapmotor production, looks elsewhere

09/04/2025

Stellantis has confirmed that production of the Leapmotor T03 electric city car has ceased at its plant in Poland as of 31 March 2025. While the automaker has not disclosed a specific reason for the stop, it has indicated that alternative production locations within Europe are currently being evaluated.

Scania confirms buyout of Northvolt battery division

11/04/2025

Scania confirmed on 11 April that it has acquired Northvolt Systems Industrial, the sole profitable division of embattled Swedish battery manufacturer Northvolt. The deal was finalised with the bankruptcy trustee overseeing Northvolt's restructuring process; financial terms of the transaction were not disclosed.

MAN launches in-house battery production in Germany

14/04/2025

In a significant expansion of its electrification ambitions, MAN Truck & Bus has launched in-house battery production at its Nuremberg plant in Germany, marking a significant expansion in its electric vehicle operations. The Traton-owned truckmaker stated the plant will be capable of producing 50,000 battery packs annually, with the option to double to 100,000 depending on future demand.

All news articles by **Stewart Burnett**

What pivotal EV technology doesn't receive enough attention?

From tyres to connectivity, innovators are addressing EV performance and appeal from a variety of angles. By Megan Lampinen

In the shift to e-mobility, battery technology has received considerable press and R&D attention. That's understandable, as it plays a key role in an electric vehicle's (EV) range, performance, safety and cost. But the battery alone won't determine the long-term success of electric transport.

"It's clear that battery tech advances will be incremental and not result in large improvements over current state-of-the-art units unless a major breakthrough is achieved," says Bilin Aksun-Guvenc, a member of the Institute of Electrical and Electronics Engineers (IEEE) and a research professor in the Department of Mechanical and Aerospace Engineering at the Ohio State University. "This means that the R&D focus on battery technology could be shifted in other directions receiving less attention."

So if not the battery, where else should innovators turn their attention?

Tyres

Tyres are central to both electrification and the move towards a more sustainable industry. As combustion engine technology advances and EV numbers grow, tyre wear has become the biggest source of particle pollution in modern cars. EVs are generally heavier than their gasoline and diesel counterparts and have more torque, which means they have even higher tyre emissions. “It is a classic unintended consequences situation,” says Nick Molden, Founder and Chief Executive of Emissions Analytics. “The headlong rush to EVs is going to make the biggest pollutant from cars significantly worse, so it’s not a trivial matter.”

The problem isn’t so much in regulated air pollution, as this considers PM2.5 and PM10, of which tyres don’t produce much. However, they do produce a lot of ultra-fine particles, which are unregulated, and bigger particles that can leach chemicals into the surrounding environment. “The big impact will be on soil and water,” Molden tells *Automotive World*. “You will damage air quality, but not in a way that the official monitoring picks up. That’s the problem. Policymakers will erroneously take a relaxed attitude, because their PM10 and PM2.5 sensors won’t flag any problem. That doesn’t mean there isn’t a problem.”

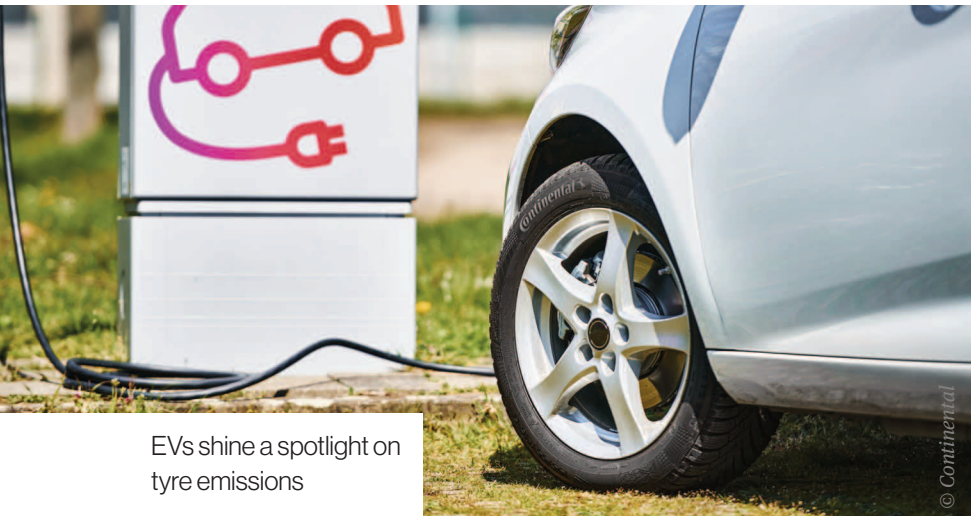
A handful of players currently offer tyres marketed as specifically for EVs, though Molden is sceptical of their real-world impact, suggesting many of the claims are “marketing nothingness.” The challenge, in his view, is to more fundamentally re-engineered tyres for EVs to reduce their emissions. “The consensus at the moment is that the manufacturers haven’t come up with miraculous new compounds for EVs. There are some, but they’re much more expensive. Tyre technology needs to be stepped up massively. I strongly believe the manufacturers can do something about it, but they are not doing much at the moment because it makes the tyres considerably more expensive.”

Molden is not the only voice calling for greater attention on tyre emissions. Mark Robinson, Chief Executive of Flint Engineering, also flags this area as one that is under-represented on the innovation front. “All EVs are heavy,” he says. “Some companies are developing tyres better suited for heavier vehicles, but I don’t think it’s getting enough media time.”

Thermal management

Flint Engineering doesn’t have anything to do with tyres, but it hopes to revolutionise the EV industry with its innovative isothermal energy management system. The company’s IsoMat technology could transform the management of heat and cold in EV batteries, extending their lifetime and facilitating faster charging capabilities. Thermal management in general, according to Robinson, deserves greater attention.

EVs can lose a considerable chunk of range in cold or hot weather, when occupants use the heating and air-conditioning. He believes more can be done with thermal management strategies to avoid that range deterioration. “The heat that you are taking out of the batteries should be made available to the car. You should be able to harvest that energy



EVs shine a spotlight on tyre emissions

© iStock/coldsnowstorm

and put it into something like the seating area whenever you want." Flint Engineering claims that its IsoMat technology could facilitate this approach to thermal management. "I don't think people have looked at it from a system point of view, taking into account the real-life consumer requirements," adds Robinson.

The Dacia Spring is the lightest EV on the market in Europe

Weight loss

Vehicle weight is another pivotal aspect of EVs that doesn't necessarily grab the headline space it deserves. "If you could only have one piece of information to convey the environmental credentials of an EV, weight is an extremely good proxy," says Molden. He wrote an entire book on the subject, 'Critical Mass', which explores this topic in much greater detail. "Most of the pollution from a car–emissions, road wear, infrastructure impact, CO2, etc.–which is problematic today is mass dependent."

The lightest electric passenger car in Europe at the moment is the Dacia Spring, weighing in at 975kg. The Pop-Car initiative, under Capgemini and Movin'on, is working to introduce a new featherweight category of EV that is affordable, sustainable, safe and appealing. "Our proposal with Pop-Car is to introduce a target vehicle weight of 850kg in 2028 without changing any safety regulations," says Capgemini's Emmanuelle Bischoffe Cluzel, Vice President and Sustainability Lead for the Global Automotive Industry. "It would be as safe as any car in the street today." Notably, this is not a microcar and would require the usual driving license and meet all existing safety regulations. The weight reduction is intended to come from using smaller batteries.

> **"If you could only have one piece of information to convey the environmental credentials of an EV, weight is an extremely good proxy**

In the push towards lightweighting, Cluzel highlights the importance of smart design software within the engineering toolkit. "Product Lifecycle Management (PLM) tools have long existed, but we are now integrating that tooling with eco criteria," she tells *Automotive World*. "These tools can take into account a wide range of criteria from the very start and help with comparisons. They allow teams to optimise for lifecycle carbon footprint."

Weight is also top of the priority list at Everrati, an OEM that specialises in redefining iconic models of the past with sustainable, electric propulsion, and in a way that avoids the usual massive weight gain that comes with a switch to battery power. "Weight savings is one of

the core Everrati brand traits," explains Co-Chief Executive Rhodri Darch. "It's really unusual to be able to swap out powertrains for an equivalent weight or even a reduced weight. One of the enablers for that is fast-charging batteries. Your battery doesn't need to be so big if you can charge it in five or ten minutes. That means that the overall vehicle can be lighter. When the battery is lighter, you get this virtuous cycle: now my suspension doesn't have to be so heavy, and nor do my brakes. It just goes on and on."

Hybrids

For the IEEE's Aksun-Guvenc, hybrids and extended-range electric vehicles (EREVs) merit greater attention. "Hybrid technology has been around for a long time, and users have come to accept it. They are still green but do not have the limited range problems of EVs," she notes. "It would have been wiser to keep improving from mild hybrids and progress to EVs with range extenders gradually, at an affordable cost, while waiting for user acceptance."

She believes that not only would the foundational technology have improved in reliability during a slower transition, but the measured pace of developments would have helped automakers avoid the huge economic impact of quickly pivoting to EVs. "It is not too late, and some companies have let go of this aim of all-electric vehicles and are now using this approach," she adds.

Connectivity, automation and emotion

Aksun-Guvenc also flags connectivity and automated driving as technology that can augment EV performance, noting: "These technologies could improve vehicle range close to or more than the incremental improvements in battery technology."

Nio's Chief Engineer Danilo Teobaldi also flags digital technology as an area meriting greater focus, but for a different reason. "The important topic missing from the EV discussion is the vast potential these vehicles offer. Essentially, you're driving around with a massive energy source at your disposal, unlocking incredible opportunities for the car to become a second living space–whether for gaming, movies, camping, or more."

The Chinese brand prides itself on offering industry-leading connected and smart experiences in the vehicle. When Nomi launched, it arguably set the bar for in-car assistants. "The more that this potential is unlocked, and users discover what they can do in an EV, the more OEMs will need to be creative in incorporating the right features, as well as dropping ones that are no longer appealing," notes Teobaldi. The key for success within EVs, he adds, is "fostering an emotional connection with users."

Cupra Chief Executive Wayne Griffiths promoted a similar message during a March 2025 media roundtable, stating that emotional connection to consumers has become pivotal to brand differentiation: "You need an emotional appeal, and that covers design, what you see, and the way the car sounds and feels. Those are the things we're working on–emotionalising the Cupra brand–and not just the 'zero to 100' acceleration in three or four seconds that many electric cars have."

Donut Lab: in-wheel motors help automakers build better EVs

By consolidating the EV drivetrain, Donut Lab believes the industry can unlock next-gen performance and significant cost savings. By Will Girling

Since the electric vehicle (EV) powertrain and drivetrain have significantly fewer moving parts relative to internal combustion engine models, it is simpler and more cost effective to manufacture and maintain. Nonetheless, some players believe it is still far from optimal. "Everyone in the industry hates the drivetrain and power transmission," states Marko Lehtimäki, Chief Executive and Co-Founder of Donut Lab. "From motor to wheels, there's up to 200 parts taking up a lot of space and adding cost, weight, and complexity."

His company originated with the goal of developing a modular platform that could fundamentally change how EVs are built. Around 2019, Lehtimäki determined that an electric two-wheeler presented the ideal starting point: a challenging form factor that requires squeezing a lot of power, torque, and range into a small package. This led to the formation of Verge Motorcycles, which developed a streamlined and powerful in-wheel motor to eliminate the complexities of modern powertrains.

By November 2024, following discussions with "leading OEMs", Lehtimäki recognised the opportunity of broadening this motor's applicability across the automotive industry. Donut Lab was subsequently spun off to accelerate and advance a range of next-gen powertrain technologies, including hardware and software.

Changing vehicle dynamics

Until recently, the EV segment had avoided incorporating in-wheel motors due to their unfavourable power-to-weight ratio, which increased unsprung mass and negatively impacted handling and performance. "Our thinking was that if this could be solved, then we could change the whole concept of motor-to-wheel power transmission," explains Lehtimäki. This led directly to the creation of the Donut Motor.

Comparing the iterative process to semiconductor optimisation in digital systems, he states that Donut Lab has been able to increase the Donut Motor's

Donut Lab claims the Donut Motor is one of the most power and torque dense products of its kind

Images © Donut Lab

performance while making the unit progressively smaller. “We’ve boosted efficiency relative to weight and done so with a smaller bill of active materials—the ones that create all the cost.” The 21-inch ‘Automotive spec’ in-wheel motor outputs 630kW of power and 4,300Nm of torque from a 40kg unit. In an industry where competitors generally prioritise either power or torque density, the company claims its solution excels in both, making it one of the most powerful e-motors in the world.

It didn’t take long to establish the real-world potential for passenger cars. During a hyper car project with an unspecified automaker, the Donut Motor shaved 108kg from the vehicle’s original weight (1,450kg), reduced powertrain expenditure by 55%, and unlocked 200 litres of extra space. “Hyper car manufacturers pay a lot of money to save 100g, let alone 100kg,” Lehtimäki emphasises. Similar results were also achieved in a compact SUV project.

The design, he adds, is fully patented and wholly unique in its capabilities. “We’re able to achieve highly advanced motor control—more than 100 times per second, or up to ten times faster than ABS in either accelerating or braking.” Lehtimäki proposes that this level of performance could fundamentally alter how engineers consider driving dynamics: “In the future, we could see fully digital, software-defined dynamics that could make an SUV handle like a sports car.”

Out of the box functionality

In addition to cars, the Donut Motor’s symmetrical design means it can be scaled up and down linearly for a variety of EV specs: drones, scooters, motorcycles, and semi-trucks. Regarding the latter, a case study found that using six 21-inch in-wheel motors with 200kW of power and 3,000Nm of torque each could significantly impact the operational value of e-trucks. Donut Lab managed to reduce the vehicle’s bill of materials by €15,000 (US$15,525) and remove around 1,100kg of weight from the drivetrain, motors, inverters, and battery.

The ability to carry more cargo and improve margins could prove vital for the transport segment as it electrifies—the electric powertrain’s added weight compared to diesel currently makes it less attractive for certain use cases. Furthermore, Lehtimäki believes all segments could benefit from the “design freedom” that Donut Motor affords. “EV platforms can have a highly desirable flatbed design. Automakers place the battery modules where they want and motors in the wheels—all that’s left is wiring, and the core vehicle is ready.”

He reports that industry interest has been strong so far, and production on the ‘family’ of in-wheel motors is already underway. However, Donut Lab also strives to provide a complete EV technology ecosystem for automakers that might require a more holistic solution. This product stack will include a high-efficiency, modular architecture battery; a “next-gen, high-performance” compute unit ready for artificial intelligence, advanced connectivity, and sensor tech; and smart software to facilitate over-the-air updates and cloud-based telematics. The idea, according to Lehtimäki, is to provide “out of the box” functionality that boosts automakers’ go-to-market strategies by saving time and money on R&D.

Building better EVs

While Donut Lab holds an ambitious vision for the future of e-mobility, Lehtimäki concedes that there will likely be

Beyond just e-motors, Donut Lab aims to create a product ecosystem that could make EVs cheaper and better, including batteries

obstacles. The global electric powertrain market is forecast to grow from US$97bn in 2023 to US$230.5bn by 2030, according to MarketsandMarkets. A large and growing sector may not react well to the prospect of component consolidation, and suppliers may lean on their relationships with OEMs to oppose the technology. He also believes some companies might initially reject in-wheel motors that were not developed in-house. “But that’s a general industry attitude unrelated to our specific products.”

Nonetheless, enthusiasm for the Donut Motor continues to grow, with many media outlets highlighting its appearance at CES 2025 in January. “I’m predicting a snowball effect: in 18 months, when some smaller volume OEMs have integrated our technology, I think bigger players will take more notice,” says Lehtimäki. As US and European automakers search for opportunities to equal and surpass China’s achievements in EV manufacturing, they may find the value proposition of in-wheel motors highly compelling.

Indeed, aside from Tesla, few Western brands can produce EVs profitably, with e-mobility business arms sometimes haemorrhaging billions of dollars per year. This is primarily because EVs remain too expensive to generate the sales volumes necessary to capitalise on high margins, causing some to initiate strategic reversals in 2024. “This is a challenge that nearly all manufacturers are facing, and saving 20% on the bill of materials for the powertrain could be enough to determine whether an EV is profitable or not,” concludes Lehtimäki. “Going after higher efficiency is ultimately how the industry will build better EVs.”

Images © Aptera

From pipe dream to production ready: Aptera solar-powered EV

With 50,000 orders secured, Aptera is on track for initial deliveries in late 2025. By Megan Lampinen

Electric vehicles (EVs) are central to the vision of zero emission transport, but charging remains a huge obstacle. Common concerns include lack of public chargers, long wait times, a dirty electrical grid, and a lack of grid capacity at peak times. Solar-powered EVs could address many of these, and automakers have been exploring the technology to one degree or another for some time.

Solar panels in the roof of the Hyundai Ioniq 5 offer a small boost to the battery, extending the range by 5-6km a day in sunny regions, while the Toyota Prius plug-in hybrid's solar roof promises an extra 8km. But such small scale applications

have failed to address the charging and grid challenges in any meaningful way. Then came Dutch manufacturer Lightyear with its solar-powered Lightyear 0 EV, offering 70km of range per day, weather depending. The model launched in late 2022 with a hefty €250,000 (US$258,000) price tag. Within weeks of starting deliveries, Lightyear halted production and declared bankruptcy.

Now the solar baton passes to California start-up Aptera, which is promising up to 40 miles (64km) of solar powered driving a day with a much more affordable US$25,900 three-wheeler. It's poised to become the world's first mass market solar EV and could redefine how the industry approaches mobility solutions. "We're creating a whole new vehicle segment," declares Co-Founder and Co-Chief Executive Chris Anthony. "We think it's unlike anything the transportation industry has ever seen."

Production of the new model will begin later in 2025

The most efficient form of transportation

The Aptera Motors team have been working on the first model, also called Aptera, since 2019. "We started with the question: how do you build the most efficient form of transportation?" says Anthony. Aerodynamics is the cornerstone, and the team believe it's pivotal to maximise this aspect of design to justify the added expense and complexity of the solar panels. "At highway speeds, modern vehicles use about 70% of their energy just pushing air out of their way. People don't realise how much energy is used simply in aerodynamic losses," he tells *Automotive World*.

To minimise drag and hence energy usage, Aptera designed a teardrop-shaped central body that allows the air to flow around it. The only significant source of drag is the tyres, which are positioned slightly out from the vehicle body to reduce their impact. "You're basically sitting in an aerodynamic wing," Anthony says. "The main body of the vehicle has less aerodynamic drag than the sideview mirrors on a truck."

The final design–interior and exterior–was shown at CES in January 2025, where a production-intent validation vehicle was available for test drives. "This model marks a significant leap forward from our earlier prototypes," he observes. Key differences include the integration of Aptera's in-house battery pack and production drivetrain alongside the complete solar array and production-intent body structure. The body structure is built from carbon fibre sheet moulding compound and requires fewer than one-tenth the parts of traditional vehicles. The complete solar array consists of four panels located on the bonnet (hood), dash, roof and hatch.

A minimalist interior keeps down weight: "We reduce all the connectors and buttons because those are the leading areas for product failure in new vehicles," Anthony explains. As a result, the wiring harness

A minimalist interior helps reduce overall vehicle weight and improve efficiency

weighs a mere 30 pounds. The centre display will offer over-the-air updates and refresh the user experience and vehicle functionality—"hopefully every couple of months," he adds. All the code running on the vehicle was developed in-house, from the battery management system to the low voltage power distribution unit.

Rightsizing

The Aptera seats two people side by side and measures 172 x 88 x 57 inches. Total weight comes in between 1,800 and 2,200 pounds.
"Transportation needs to be rightsized," asserts Anthony. "The industry is heading towards bigger and bigger EVs: luxury sedans and SUVs that are using 800 and 900 watt-hours per mile. That's the wrong direction for environmental responsibility. We're using 100 watt-hours per mile."

But can this meet driver expectations? He points to statistics showing that about 70% of the driving in California is done with less than two passengers, with an average daily mileage of around 30 miles. In sunny regions, the car's solar panels will charge enough to provide about 40 miles of range a day. "For the average person, over a year, it's roughly net neutral. In Southern California you might never have to plug in the Aptera."

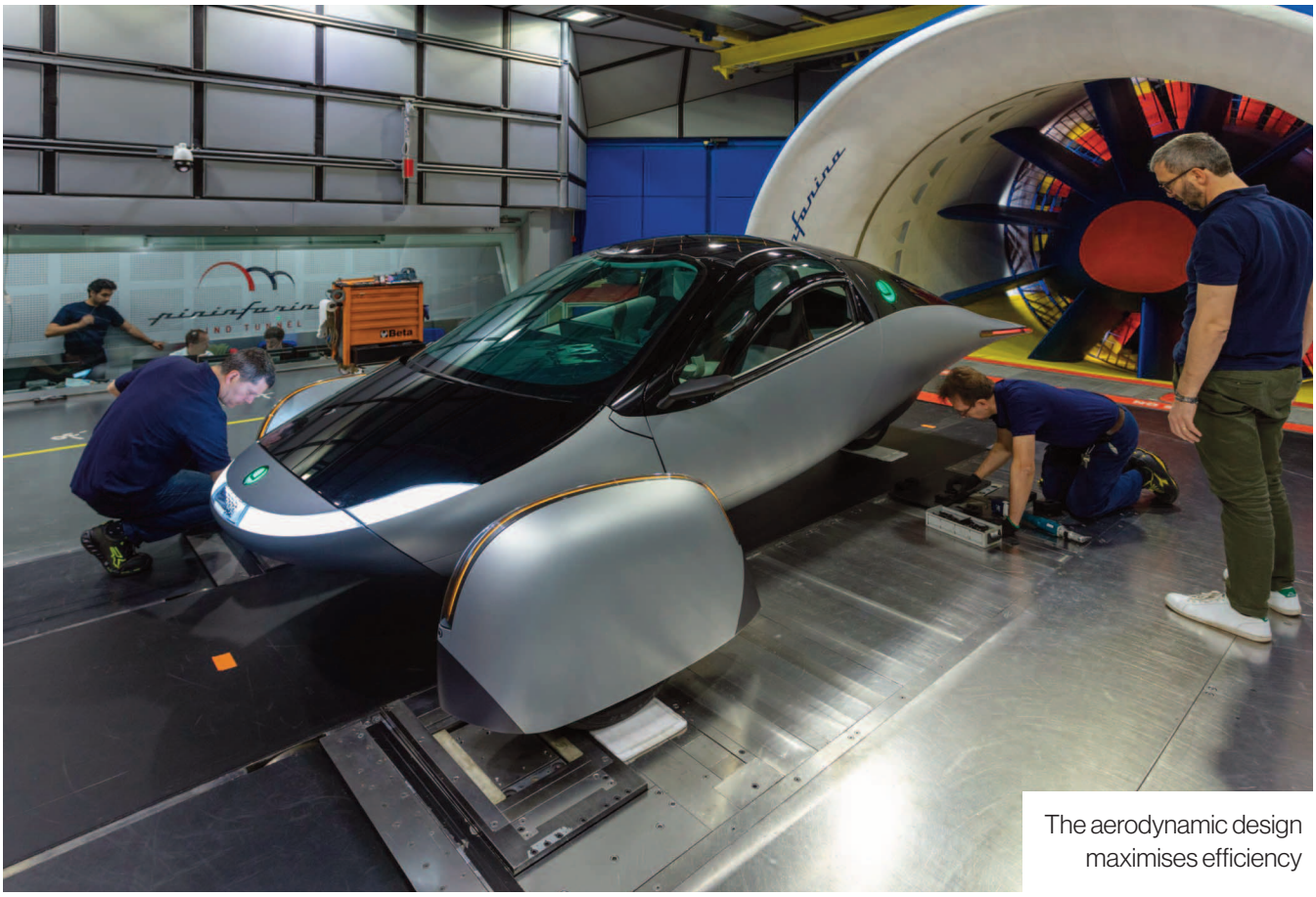
For those drivers looking to extend the range, charging can be done at home using a traditional 110-volt outlet or public charger. This can add between 400 and 1,000 miles depending on the battery option. "It charges so quickly and needs such little power, you're probably not taxing the charging infrastructure like other EVs would," Anthony points out. This is pivotal, as some industry watchers have raised concerns about the grid's ability to cope with EVs during periods of peak charging demand, such as after work and during holidays.

"California has an all-EV sales mandate by 2035, but it has nowhere near the grid infrastructure to support that switch," he warns. "With the Aptera, anywhere the sun's out is your charging infrastructure. It's the most ubiquitous charging infrastructure in the world."

Critics, competition and cargo

Production will take place in Carlsbad, California, with the first deliveries to begin in late 2025. So far, Aptera has secured about 50,000 orders, the majority of which come from California residents. The first 2,000 delivery slots were allocated to individuals that invested heavily in the company, ranked by the amount of their investment. This group will become part of the vehicle's long-term validation and testing, sharing feedback on their experiences.

"It's not a vehicle for everybody," Anthony admits. "It's unique, and some people don't want to be unique."
Aside from aesthetics, detractors have objected that



The aerodynamic design maximises efficiency

the safety of a three-wheeler can't compare to that of a four-wheeler. Anthony points out that "when front-wheel drive race cars take aggressive corners, they lift their inside rear wheel. In dynamic handling situations, you don't even use all four traction pads anyway. This has basically the same suspension handling characteristics as a VW Golf; it's pretty sporty."

The lightweight construction may also raise safety concerns about how the model would fare in a collision with a heavy truck. "This vehicle has curved surfaces, so most of an impact would be a glancing blow," he says. With a carbon fibre safety cell surrounding the occupants, he adds: "It's built much more like a Formula 1 car." The company claims that recent crash tests found the model has the highest roof crush strength of any passenger car on the market today.

The next evolution is to introduce a cargo hatch variant with more storage. "A Sprinter van delivering Amazon packages only has slightly more than 80 cubic feet of storage in the back," he says. "We can get about 60. Most of the Sprinter's storage space is wasted because you have to walk down the centre aisle. If we had a hatch that opened side to side, you could get pretty close to what a Sprinter van has in terms of cargo space."

Within five years, Anthony expects Aptera's commercial applications to outnumber consumer applications. That's partly down the total cost of ownership, which he puts at one-fifth that of a Toyota Camry. "A million-mile brake service life, a million-mile drivetrain, the only thing you need to replace are the tyres and the windshield wiper fluid."

For now, Aptera has the solar-powered EV market pretty much to itself. "Being the first to do anything is difficult," Anthony concedes. "We'll have a couple of years head start, so we'll make as much of it as we can." The aim is to deliver a million vehicles by 2033.

Images © ProLogium

ProLogium redefines next-gen EV batteries

ProLogium's lithium-ceramic batteries tackle range, charging and safety obstacles. By Megan Lampinen

Taiwanese start-up ProLogium Technology believes its lithium-ceramic battery (LCB) could reset the bar for electric vehicle (EV) performance and safety. It claims to have developed the world's first fully inorganic electrolyte solid-state battery (SSB) and plans to begin pilot production for automakers by the end of 2025.

Organic electrolytes have traditionally suffered with poor thermal stability and are easily affected by water. On the other hand, inorganic electrolytes are not sensitive to

high temperature, high pressure, or moisture. The company has gone with the latter approach, pursuing a lithium-ceramic chemistry for both consumer applications and EVs since its founding in 2006. At CES 2025, it unveiled its fourth generation LCB, offering impressive metrics in terms of safety, energy density, charging speed, recyclability, and low-temperature reliability.

"This is totally different from what the market has seen so far," declares Founder and Chief Executive Vincent Yang. "We are trying to redefine the next-generation EV battery."

Vincent Yang,
Founder and Chief Executive, ProLogium Technology

Easing the transition

The idea is that this battery technology will allow EVs to offer a similar consumer experience to internal combustion engines (ICE) in terms of range, safety, and charging. "ICE cars don't give people range anxiety," Yang tells *Automotive World*. "You can easily predict how far you can get on the fuel in your tank. We want to do the same with EVs. With this technology, fast-charging offers almost the same refuelling time, meaning the consumer can have the same kind of experience."

The company claims its LCB can cut charging time to just four minutes for 60% capacity and six minutes for 80% capacity. "In five minutes of charging, we can give you more than 500km of range," says Yang. That's good news not just for consumers but also charge point operators, as faster charging opens the door for greater asset utilisation. As many industry watchers have pointed out over the years, the EV market's long-term viability partially depends on

ProLogium's first mass production line for next generation lithium ceramic batteries in Taiwan

whether there's a profitable business case for charging point operators.

The fast charging is made possible thanks to improvements in energy density, which top lithium-iron-phosphate (LFP) batteries by up to 150%. The latest generation LCB achieves 380Wh/kg and 860-900Wh/L. By 2026, the company aims to surpass 450Wh/kg and 1,000Wh/L.

Perhaps most important of all, the fully inorganic electrolyte is inherently non-flammable. "Safety is our biggest advantage, and it's much better than the existing traditional lithium batteries," he states. In overcharge tests that evaluated the battery at 300 degrees Celsius and 250% capacity, it consistently remained fireproof and non-combustible, achieving a Hazard Level of 2-3. An advanced Active Safety Mechanism further prevents thermal runaway by activating automatically at high temperatures.

Another key advantage is that the battery performs well in extreme temperatures, providing consistent range performance. ProLogium figures suggest it has two to three times the ionic conductivity of traditional liquid batteries at room temperature. "With today's EVs, once the temperature drops to negative ten or 15 degrees, nobody knows what the battery will do," notes Yang. "In some cases it can drop to just 40% capacity. But with our batteries, there is less then 10% difference in performance."

Cost and manufacturing

Generally speaking, SSBs carry a price premium over lithium-ion, though costs are steadily falling and should continue to do so as volumes scale. Nissan has stated that it believes SSB costs can drop to US$75/kWh by fiscal year 2028, further declining to US$65/kWh after that, which would put EVs on the same cost footing as gasoline vehicles. While ProLogium hasn't publicly shared what its battery will cost, Yang implies other SSB players are still too expensive for market acceptance: "With new technologies, you cannot make the cost very high." The LCB features a 100% silicon composite anode, and Yang points out that this material "has a much better unit energy price than graphite."

ProLogium's ceramic separator and advanced wet film coating technology deliver three times the thermal conductivity of traditional liquid batteries

The design also lends itself to easier manufacturing, with fewer steps involved thanks to a simplified structure and lower safety risks. The dry room, for instance, can be just 25-30% the size of what's usually required for EV batteries. That means less capex. "The manufacturing becomes simple and we spend less, so the cost will be competitive," he says. "A good cost structure is just as important as technical performance."

ProLogium currently has one plant up and running in Taiwan, with yearly capacity for 2GWh. A second plant is under construction in Dunkirk, France, and is slated to begin mass production in 2027. However, output from the Taiwanese plant is currently going into small consumer products such as wearables but not EVs. "We are still in the early stages of development," emphasises Yang. "We expect the majority of our batteries to go into EVs [eventually]."

The company has shipped more than 12,000 SSB sample cells to global car manufacturers for testing and module development. Once demand picks up, ProLogium will be ready with the capacity. "Manufacturing takes time to ramp up," he adds.

Spotlight on Europe's passenger cars

As for future vehicle applications, passenger cars will likely be the first for this potentially game-changing battery. "This is where range anxiety, cost, and safety issues are the most pressing," says Yang. Trucks may also be a good fit, as the fast-charging aspect would make a huge difference in uptime and operational efficiency. The LCB may also find a solid market in electric school buses, where its safety benefits could be particularly appealing. The same could be said for off-road applications like

mining, where there may be exposure to explosive materials.

Regionally, the company is primarily targeting European carmakers as well as American. While the Chinese may have taken the lead in the EV race, ProLogium is not going after this segment. "We don't want to go to mainland China. It's very clear and simple: they have their own way of doing it, their own solutions," says Yang. He also notes that plug-in hybrid sales are accelerating in China, and the market may be temporarily diverted away from EVs.

Europe has seen a similar trend but remains a more attractive—or perhaps just more accessible—market for the start-up. "Regulations are pushing Europe to EVs, and we can help them," Yang states. To this end, ProLogium has been working with German engineering services provider FEV on development and validation. Thomas Hülshorst, FEV's Global Vice President for Electric Powertrain, recently suggested that this technology could "make a significant contribution to preserving the value of future EVs."

Images © Vianode

Vianode dubs synthetic graphite the "e-mobility workhorse"

Synthetic graphite could help manufacturers realise more resilient supply chains and produce cleaner and better performing EVs. By Will Girling

Automakers in the US and Europe have been keenly aware that China is the global electric vehicle (EV) battery supply chain hegemon. Most lithium-ion chemistries currently use graphite for the anode due to its low cost, high energy density, and long cycle life. Graphite-based anodes contain up to 95% of the mineral, constituting 20-30% of an EV battery's mass. China extracted 1.23 million metric tons of graphite in 2023—more than the other global top ten producers combined, according to Nasdaq.

As global trade constricts, there is precedent for bans on the export of raw minerals from China, which could leave OEMs in a vulnerable position. In January 2025, General Motors sought to extricate itself from

Burkhard Straube,
Chief Executive, Vianode

this risk through a six-year, multi-billion-dollar contract with Vianode, an advanced battery materials company developing synthetic graphite.

Originally part of Norwegian industrial conglomerate Elkem, Vianode began to take shape in 2016 and completed a lab pilot three years later. The company was carved out in 2021, with a 2,000-tonne full-scale production facility–Via One–opening in Q3 2024 in Kristiansand. With Vianode making rapid progress, Chief Executive Burkhard Straube informs *Automotive World* why he believes synthetic graphite is a better and more secure basis for the EV industry's future.

What are the advantages of using synthetic graphite instead of natural graphite?

Since it's a synthetic man-made product, we can play around with different elements, raw materials, and process parameters to tweak synthetic graphite's properties according to use case. For EV batteries, that could mean boosting a unit's fast charging capabilities, range, safety, and lifetime. This level of control also makes it a highly quality controlled and reproducible product, whereas mined graphite will naturally contain variances.

Scalability is also of the utmost importance in e-mobility: growth will be tremendous, even if it's been slower than some anticipated so far, and battery material supply chains need to move with it. Opening a new graphite mine can take more than a decade, but a synthetic graphite manufacturing plant can be operational in two or three years. At a time when automakers need to establish resilient material sourcing, moving away from natural graphite enables them to build up capacity in their home markets.

How can Vianode's product help OEMs meet their sustainability goals?

The largest 'burden' of CO2 in an EV is the battery, and the anode by itself represents about up to 40% of the total emissions. By

Vianode's 2,000-tonne per year full-scale graphite production facility—Via One—in Kristiansand, Norway

focusing on this one component, we can make EV manufacturing far more sustainable than it has been so far.

Around 60-70% of the graphite used in batteries today is synthetic, but most producers use huge, open pit furnaces. Vianode uses closed induction furnaces instead. This method eliminates diffused emissions, but it also grants us better control over the temperature and overall process. This results in a higher A-grade yield with less waste, reduced material consumption, and 40% less energy used. All of this combined with the use of 'green' energy at our plants means that Vianode's graphite is 90% lower in CO2 emissions than comparable offerings on the market.

Is there any broader strategic value to choosing synthetic graphite?

The Western automotive industry is investing hundreds of billions of dollars into the e-mobility value chain, but all that funding hinges on reliably importing one product: graphite. In 2024, China limited export on several occasions, so building resilient local EV supply chains factors into what I call 'strategic sustainability' for automakers.

Are any automakers besides GM interested in working with Vianode?

Yes, although those talks are confidential at this time. We are going to build a plant in North America, which will go live in 2027,

> **I think synthetic graphite is the only solution that can ensure Western supply chain resilience in an acceptable timeframe: years, not decades**

but we cannot disclose the location yet, as we are in final negotiations.

I believe the market for synthetic graphite will grow substantially in the near term. The first wave will focus on providing virgin material, but recycling will become more and more important from the mid 2030s. By the start of that decade, Vianode intends to achieve a capacity of 200,000-tonnes, which would be enough for three million EVs per year. From there, we plan to boost capacity even further in both North America and Europe.

What about the prospects for alternative anode materials like silicon?

Graphite is the workhorse of e-mobility; its main advantage is being battery chemistry agnostic, so it doesn't matter if OEMs move towards lithium-iron-phosphate (LFP) or continue with nickel-manganese-cobalt (NMC) cells. I don't think silicon can replace graphite. It's expensive and has inherent structural deficiencies that cause the battery to degrade very quickly, making it unattractive for automakers that want long cycle life. Despite decades of research, these issues have not yet been resolved.

On the other hand, even if industry-scale adoption looks unlikely, silicon does have potential as a 'range booster' by increasing battery capacity in some EV models, and Vianode is developing graphite materials with positive synergistic effects with silicon. On balance, silicon will probably co-exist with graphite, and that's where the future of anode technology really lies.

How could synthetic graphite play an important role in growing global EV adoption?

Whether automakers want to improve their EVs' charging abilities, safety or range, performance depends on the battery. Synthetic graphite can be tailored to brands' individual requirements and help improve all of these aspects. By doing so, it mitigates the concerns of consumers and makes EVs more attractive as products.

Global anode supply chains are highly distorted today: there is massive overcapacity in China, which is becoming economically unsustainable for other markets. North America is actively tackling this issue, but Europe is not sufficiently engaged with levelling the playing field. Based on the current geopolitical situation, I think synthetic graphite is the only solution that can ensure Western supply chain resilience in an acceptable timeframe: years, not decades.

Battery box innovation to de-risk supply chain, lower costs

The ALIVE collaboration saw BMW, Volvo, and Constellium tackle EV battery enclosure design challenges. By Megan Lampinen

The heart of the electric vehicle (EV) is its battery, which has been the primary focus of R&D efforts over the past decade. Not so obvious a research target but equally important is where the battery lives.

The battery box houses the cells and protects them from dust, water, and impact. These cases can also provide structural support for the cells and incorporate thermal management for optimised performance. As a protective enclosure, they make a pivotal contribution to vehicle safety but also pose significant design challenges in terms of performance, weight, cost, and manufacturing. This is where the collaborative research project ALuminium Intensive Vehicle Enclosures (ALIVE) has made promising developments.

The project kicked off in 2020 with the aim of developing improved structural aluminium battery enclosures for EVs. Led by aluminium specialist Constellium's University Technology Center (UTC) at Brunel University London, consortium partners also included BMW, Volvo, EXPERT Technologies Group, Innoval Technology, Powdertech, and WMG (University of Warwick). The £15m (US$19m) project was half funded by UK government subsidies through its Advanced Propulsion Centre.

"The main problem was that today's battery box manufacturing lines are bespoke to a single design," explains Martin Jarrett, Technology Director for Constellium's Automotive Structures & Industry business unit and UTC leader. "There isn't much ability to share

technology across different vehicle models or brands. At the same time, they are also highly capital intensive. We launched the ALIVE Project to tackle just that."

The target was a modular and scalable aluminium battery box design that could be used for a range of different vehicles. Harnessing the same basic technology in a flexible way could open the door to lower manufacturing costs and greater supply chain resilience. By the time the project concluded in May 2024, the team had a solution with some impressive metrics.

> **Today's battery box manufacturing lines are bespoke to a single design**

Flexible, cheap, light

The battery enclosure designs and associated manufacturing technologies developed under ALIVE enabled weight savings of 12% to 35% compared to existing OEM aluminium and steel designs, respectively, while meeting or exceeding performance targets. That's down to a combination of joining and forming technologies and Constellium's family of high-strength and high-crash alloys, Constellium HSA6 and Constellium HCA6.

The team also realised huge advances in terms of production costs. "We've demonstrated that we can produce battery boxes—both structural and non-structural—with 35-50% less capital than the equivalent standard battery box production," Jarrett tells *Automotive World*. Structural battery packs serve as part of the vehicle's load-bearing structure while non-structural ones do not.

"In the initial months of the project in 2020 and 2021, there was a lot of development from the OEMs in terms of cell-to-module and cell-to-pack designs," he notes. The different design approaches require various levels of structural integrity from the box itself, and the ALIVE solution's design needed to be flexible enough to accommodate all options.

"What started off as basically a fully structural battery box with integrated side cells suddenly became a non-structural battery box, where the side cells were displaced into the architecture of the vehicle," Jarrett explains. "As a consequence, we also developed innovative side cell technology."

Today's aluminium-extruded side cells tend to be large, multi-cell hollows, which can be made on a limited number of extrusion presses around the world. The team explored how they could produce side cells by extrusion on smaller presses, using a dual material approach. This consisted of a very strong inner material to protect the batteries joined to an outer portion made of more ductile material to absorb energy in a crash. "This gives us a much more flexible approach to side cell production," he emphasises.

Another important aspect to the solution stems from the use of a U-frame made from a freeform bender. "It negates what you would normally see in a battery box, where the front is stretch-bent, cut, and welded,"

> **We are making EVs more of an economic possibility for consumers**

states Jarrett. “With our approach, we eliminate all those step by producing a single profile and joining it at the one end.” This reduces the number of welds and fabrication steps, as well as the opportunity for potential leak paths frequently found at that front end, where the stretch-bent part is joined to the horizontals. “The weld there can often be problematic, but we managed to overcome that,” he points out.

From passenger cars to heavy trucks

This particular project focussed on passenger vehicles, working to design specifications for consortium partners BMW and Volvo, but the technology is transferrable to any OEM and any vehicle. “It’s basically a skateboard type design, but we’ve also taken that concept and developed it into more upright, chest-type battery boxes that can be used for larger vehicles, including heavy trucks and off-road vehicles,” says Jarrett. “They require a much larger battery box, but the idea and the concepts that have been designed through the ALIVE Project allow us to grow vertically and horizontally, so we can then accommodate much bigger battery capacities.”

The team is currently prototyping its designs for OEMs which, for now, remain unidentified. A battery box prototyping line is up and running in the UK, and the plan is to promote the technology to more industry players and eventually launch mass production. Building on the learning from ALIVE, Constellium has begun a follow-on collaborative R&D project exploring aluminium recycling within battery boxes.

For suppliers, the ability to provide different battery box designs off the same equipment could go far in improving their resiliency in an unpredictable market. EV sales projections have not played out as many expected, and the past year has seen several big name automakers dial back their production plans and launch schedules. A supplier that can only provide the battery box for one particular vehicle could find itself in a very risky situation if that original forecast doesn’t play out. “Our solution allows for greater flexibility when it comes to some of the EV production forecasts,” he points out.

By lowering the manufacturing costs of this pivotal component, savings could trickle down to the EV sticker price. There have long been calls for more affordable electric models, and this could contribute. “By helping the supply chain, we are making EVs more of an economic possibility for consumers,” Jarrett concludes. He estimates these new battery boxes could find their way into a production car within the next five years.

Scania and DHL assess extended-range electric trucks' value

In partnership with DHL, Scania is testing the world's first extended-range electric truck concept in Germany. By Will Girling

The debate about which powertrain will eventually replace diesel in commercial vehicles is still ongoing. Hydrogen is experiencing significant setbacks in Western markets, and some truckmakers opine that battery-electric must claw back industry enthusiasm after an initial period of inflated expectations. The challenge is building electric models with the practicality and performance to give fleet operators complete confidence in the technology.

In the passenger car segment, extended-range electric vehicles–battery-powered models that incorporate a small internal combustion engine (ICE) for recharging, not providing power directly to the wheels–are gaining momentum. Chinese OEMs are particularly enthusiastic about their ability to bridge the gaps in charging infrastructure in both mature and developed markets. But what about the commercial vehicle segment?

On 20 February 2025, Scania and DHL displayed the world's first extended-range electric truck (ERET): a 10.5m long vehicle weighing 40 tons, powered by a 416kWh battery and a 120kW generator. Although still early days, the company believes this concept could eventually be a valuable portfolio addition as it helps freight operators meaningfully cut down on CO2 emissions.

© Scania

The ERET was part of Scania's Pilot Partner, a programme designed to test new mobility opportunities in conjunction with clients

Over the borderline

The ERET was developed through Scania's Pilot Partner, a programme designed to accelerate sustainable transport by testing new market opportunities in conjunction with clients. In this case, the truckmaker collaborated with long-term partner DHL. "It perceived difficulties, complications and concerns about electrification; DHL didn't know if it had capacity to maintain its current service levels using e-trucks," Tony Sandberg, Head of Pilot Partner, told *Automotive World*. Of particular concern were lack of charging points, route length variability, and seasonal peaks in demand for electricity.

The logistics company introduced the ERET concept to Scania as a potential solution for its Post & Parcel Germany division. The truckmaker then used its knowledge of the e-truck market–Scania released its first battery-powered models in 2020–to explore how it could deliver the flexibility, range, and payload requirements necessary. "Most of the time, DHL delivers parcels in Berlin, but it also goes to Hamburg once a week," explained Sandberg–a round trip of approximately 600km. "That's on the borderline of what electric propulsion can manage by itself. If there's bad weather or a major traffic jam, the trucks might not make it."

Scania removed a battery pack from one of its fully electric trucks and replaced it with a gasoline-powered generator, which can be refuelled at any ordinary fuel station. Going forward, the ICE could also be powered by diesel or HVO, with software limiting fuel use to minimise emissions. The company estimates that the ERET can transport a load of 1,000 parcels at speeds up to 89kph over a maximum distance of 650-800km. This is appreciably further than both its own 550km all-electric models and comparable competitor offerings.

While this does not constitute a diminishment in the brand's commitment to an electric future, Scania Chief Executive Christian Levin has previously emphasised that "perfect must not be the enemy of good as we are getting there." Tobias Meyer, Chief Executive of DHL Group, also opined that it

> **Electrification isn't progressing how we expected**

would take a long time for the complete power and charging ecosystem necessary for supporting e-trucks to emerge in Germany. He called the Scania ERET a "pragmatic solution" for electrification in the current market, and one still capable of reducing DHL's operational CO2 emissions by more than 80%.

Proving the value of ERETs

Trial operations using the Scania ERET commenced on 3 March, with DHL reportedly "very happy" with the results so far. Now that the vehicle is on the road, Sandberg believes the extended-range concept could have significant implications for road freight operations. It's not immediately clear how ERETs would fit into the EU's broader decarbonisation goals, although the European Commission has recently demonstrated a willingness to be flexible with OEMs. With so many hurdles still to overcome, remaining open to new solutions might be crucial.

"Several years ago, everyone was convinced batteries would 'win the battle' quickly. However, the challenges the world faces today–including war, economic recession, and shortage of charging infrastructure–mean electrification isn't progressing how we expected," stated Sandberg. ERETs could play a vital role in the bridging the gaps that prevent e-truck technology from gaining a larger audience. However, much like Volvo Trucks, Scania believes in a 'portfolio approach' for cleaner transport: hydrogen, biofuels, battery-electric, and ERETs could all have a part to play.

Still a relatively young concept, ERETs must prove their operational value for customers like DHL, but Scania is receptive to exploring them further over the coming months. "Importantly, we need to understand if there's a market for this powertrain and quantify its value," said Sandberg. "Pilot Partner looks at what's happening in the industry today, defines the potential of certain technologies, considers how big the opportunities are, and brings those that exhibit scaling potential inside Scania."

With the possibility of so many powertrain combinations and cab shape variables, it will take time for Scania to evaluate the full potential of extended-range commercial vehicles. However, Sandberg confirmed that Scania has received positive feedback and interest in ERETs from other companies since the DHL partnership was announced. "If the truck industry wants to transform the market, it can't do that without collaboration," he concluded. "Scania isn't just going to invest a large amount of money and then wait to see if customers want it. Electrification has provided us a blank slate, and we must find new niches that meet operators' transport needs at a price point they're willing to pay for."

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Can EV fires be prevented at the chemistry level?

A team of South Korean researchers has designed a lithium-metal battery capable of instantly suppressing combustion processes. By Stewart Burnett

While electric vehicles (EVs) are touted as having many benefits over their traditional gasoline-powered counterparts, mass market buyers are yet to be fully convinced by the technology. A Deloitte survey from 2024 revealed that 29-32% of consumers across the US, Germany, and Japan were concerned about the safety of EV batteries. In China and India, this rose to 38-45%.

EV battery fires are unlike those of internal combustion engine vehicles. A single overheated cell can trigger a chain reaction, causing neighbouring cells to

overheat and ignite, leading to a self-sustaining fire that is difficult to suppress. This can burn at extremely high temperatures–up to 2,700 degrees Celsius–and release toxic and flammable gasses, posing a hazard to firefighters and the environment.

Automakers and suppliers have deployed various methods of mitigating fire risk, ranging from machine learning-driven analysis of sensor data to water mist suppression systems. However, South Korea's Daegu Gyeongbuk Institute of Science and Technology (DGIST) aims to address the problem at the chemistry level. A team lead by Jae Hyun Kim, Principal Researcher and Professor of Energy Science and Engineering, has created a "breakthrough" lithium-metal battery prototype with a triple-layer solid polymer electrolyte (SPE) designed to minimise the risk of thermal runaway and suppress combustion processes.

It's in the chemistry

One of the biggest causes of thermal runaway is the formation of dendrites: small, branching structures that sometimes occur during battery charging and discharging. As Kim explains to *Automotive World*: "Conventional SPEs suffer from low ion conductivity and poor interfacial contact with electrodes, which promotes lithium dendrite growth and therefore increases the risk of short circuits and fire hazards." The solution was to use a triple-layer SPE instead, featuring a "robust" middle layer that boosts the battery's mechanical strength. It has a "soft" outer surface on either side that ensures efficient electrode contact, facilitating the easy movement of lithium ions. By doing so, energy transfer rates also increase, thereby preventing the formation of dendrites.

"The triple-layer structure achieved mechanical strength, ion conductivity, and fire safety simultaneously–a significant innovation in material design and engineering," remarks Kim. At the same time, he acknowledges that dendrite formation is not the only risk factor in triggering EV fires: thermal runaway, mechanical failures, and electrical faults remain substantial problems. He also notes that overcharging a vehicle can generate excessive heat and cause incremental damage to cells.

While DGIST's solution does not address all of these issues at the design level, it can suppress the fires that occur as a result. This is achieved through the use of decabromodiphenyl ethane (DBDPE), a self-extinguishing and flame-retardant additive that the team incorporated into the electrolyte. "When exposed to high

The team at DGIST responsible for developing the lithium-metal battery prototype

temperatures, DBDPE releases bromine radicals, which interfere with the combustion process by interrupting the chain reaction of fire propagation," Kim explains. "This effectively suppresses flames and prevents the spread of fire, significantly reducing the risk of battery-related thermal runaway accidents."

He further sheds light on the approach taken: "When we fabricate a triple-layered solid polymer electrolyte, we initially mix beta-zeolite, DBDPE, and lithium salt according to the specified proportions in solvent. After that, we follow a specified fabricating process. This safe and reliable technique can solve the existing risks of fire and explosion due to uncontrolled lithium dendrite growth and the flammability of organic electrolytes in commercialised EV batteries."

Safety meets functionality

While DGIST's technology promises to prevent virtually all instances of fire, it does not do so at the expense of a viable, high-performance battery. The research team notes, among other things, that its proposed design boasts strong longevity characteristics, retaining roughly 87.9% of its performance even after 1,000 charging and discharging cycles. For contrast, a typical EV battery will lose between 20% and 30% of its capacity over the same number of cycles.

The longevity does not stem from the same technology that enables fire prevention. Rather, the team is combining two innovations in one battery to demonstrate their compatibility. "They're basically different mechanisms: DBDPE suppresses combustion, while high concentrations of lithium bis(trifluoromethanesulfonyl)imide improve ionic conductivity and stabilise the solid electrolyte interphase layer, reducing capacity loss during the cycles," Kim states. By incorporating these various additives into the triple-layer solid electrolyte, he argues that two birds have effectively been killed with one stone.

Commercialisation

"This research is anticipated to make a significant contribution to the realisation of lithium-metal batteries using solid polymer electrolytes," Kim emphasises. "Our ultimate goal for this technology in particular is commercialisation." While the team's research remains at laboratory scale, it is actively working on conducting additional stability tests and refining the electrolyte's design to accommodate the needs of larger-scale production. To this end, it intends to collaborate with industry partners to transfer the technology into real-world applications, including but not restricted to EVs.

Kim sees potential for the technology's use in wearables and large-scale energy storage systems intended to boost grid stability. He argues that advancements in battery technology like those offered by DGIST will be key to achieving net zero on several key fronts, including facilitating vehicle-to-grid. However, the immediate focus remains on commercialisation in the EV segment. "The future of the auto industry will be driven as much by safety as by sustainability or electrification," he concludes. "Our research findings provide a solid foundation for practical implementation in that regard."

Images © Harbinger

Is medium duty the perfect segment for electrification?

Harbinger aims to accelerate the electrification of medium-duty vehicles with innovative power and drivetrain technology. By Will Girling

Conversations around electrification often centre on light passenger vehicles and heavy-duty trucks, but what about medium duty? In 2024, approximately 22,000 medium-duty electric vehicles (MDEVs) were sold globally, according to IDTechEx. It remains an internal combustion engine (ICE) dominated market, although electric sales are forecast to exceed 650,000 units (+2,854.5%) by 2045, including both battery-electric and hydrogen fuel cell models.

For now, the segment is wide open for early pioneers. "There's basically no competition today," states John Harris, Chief Executive of Harbinger Motors. "Medium duty represents a rare instance in which incumbent OEMs aren't really making any effort; these vehicles are usually an afterthought."

Consequently, this lack of attention has led to swathes of outdated technology and poor value for money.

However, Harbinger is striving to turn the market around with a first-of-its-kind, vertically integrated EV platform that combines a new architecture with innovative e-axle and battery pack technology. Importantly, it believes that MDEVs are compelling products beyond the regulatory and environmental factors driving e-mobility elsewhere. "Electrification already makes sense for the medium-duty segment," claims Harris. "The usual hesitations around range anxiety don't typically exist in the medium-duty market, as it tends to focus on last-mile routes. The use case allows for trucks to charge overnight, and they do not require multiple shifts."

Resurrecting a 'dead axle'

According to Harris, most of the medium-duty vehicles on sale in North America today were designed in the 1980s and use solid steer axles and leaf springs at the front end. "That's crazy—those were outdated even in 1960. Driving these vehicles can be very unpleasant." This gave Harbinger a wide canvas for innovation in its own products. "Our goal wasn't strictly to design the best MDEV; it was to design the best medium-duty vehicle, period. It just happens to be electric," he says.

A walk-in van next to the Harbinger platform it was built on

When creating a MDEV, many OEMs opt to remove the prop shaft and install a large electric motor. This solution results in undesirable unsprung mass and is both heavy and expensive due to the quantity of copper and magnets used. "So many electrification efforts throw away the lessons of the past and don't learn from them," asserts Harris. Instead, Harbinger's e-axle is based on a resurrected 'de Dion' architecture originally developed for lightweight racing cars 100 years ago.

Called a 'dead axle' because it does not transmit power to the wheels, a de Dion design would have been too fragile for heavy vehicles without modern advances in metallurgy. Harris explains that Harbinger's component is forged from a single piece of "super strong" 900MPa steel. Torque is carried by articulated plunging half shafts, enabling the drive unit to be mounted to the chassis, isolating vibrations and reducing unsprung mass. Overall, Harbinger can replace an entire ICE transmission and differential with a compact e-axle that weighs 50% less and delivers 440hp.

Thinking holistically

Harris states that Harbinger's innovations are possible because it reappraises entire vehicle systems instead of improving them piecemeal. This far-reaching perspective also applies to the chassis and battery.

The company's chassis architecture is scalable and can support a wide range of popular medium-duty body shapes, such as commercial walk-in vans and box trucks. Tight integration of the frame and powertrain produce a low floor height, while steer-by-wire and brake-by-wire systems are not only adjustable to the driver but also futureproof for advances in automated and autonomous driving. Commercial vehicles are commonly cited as a viable early use case for deploying SAE Level 4 systems.

"Our battery is less a revolutionary new approach and more an optimised execution," says Harris. Harbinger's in-house team includes former staff from Tesla, Rivian, Toyota, and Volvo Trucks. The result of its seven generations of EV battery tech experience was an 800 VDC, liquid-cooled, nickel-rich lithium-ion battery that is scalable in 35kW increments. He adds that the unit's overall weight is also 50% lighter than industry standard. "Nickel batteries have gained a mixed reputation due to some of the low-quality examples on the market. But if the best quality cells are used in a well-designed unit, we don't believe there are any safety risks that can't be managed."

> **Harbinger is focused on where electrification makes sense economically and logistically today**

Harbinger's battery also accounts for the daily realities of owning MDEV fleets. "Medium-duty vehicles generally operate during specific portions of the day. In an overwhelming number of cases, they sit idle for 12-14 hours a day." This interval enables fleet operators to recharge slowly but effectively using Level 2 AC charge points. Harris notes that these can cost only US$500-1,000 apiece, with minimal associated installation expense. "That makes savings per vehicle easier to realise, as customers aren't constantly trying to dig themselves out of a hole of infrastructure costs."

Addressing the opportunity

At the time of writing, Harbinger has an order book of around 5,000 units, with prominent clients including Bimbo Bakeries USA and Thor Industries. With what it considers a winning electric power/drivetrain formula in place, the company is continually seeking to improve its margins in a bid to crystallise the performance and financial benefits of MDEVs. In January 2025, its Series B round injected US$100m of funds, which Harris states will be invested in tooling for high-volume production and in-vehicle automation technologies.

The future of electrification in the US is an increasingly open question, with many of the Biden Administration's pro-EV incentives likely to end. However, Harris doesn't believe this is inherently detrimental to his company's goal: "The industry needs to build EVs that are desirable–both technologically and in terms of cost–regardless of whether emissions reduction is considered important." In March, Harbinger put its money where its mouth is by offering 'Inflation Reduction Act Risk-Free Guarantees' to customers. These agreements will keep its pricing on par with comparable diesel vehicles regardless of whether federal subsidy schemes are wound down. Harris adds that vertical integration also shields the company from tariff-based market volatility.

In contrast to the viewpoint of some other commentators, he tells *Automotive World* that the industry "shouldn't expect EVs to be everywhere." By pushing this technology into segments before it's ready to compete with established products, OEMs may end up disappointing and discouraging the market. "Harbinger is focused on where electrification makes sense economically and logistically today. As we see it, 80% of medium-duty vehicles are primed to become EVs, so we don't need to twist peoples' arms to address the opportunity."

Have BYD and Zeekr finally solved range anxiety?

The advent of megawatt charging by BYD and Zeekr could resolve one of e-mobility's greatest customer uptake challenges. By Will Girling

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Deloitte's 2025 Global Automotive Consumer Study, a survey of 31,000 customers in 30 countries, found that 'driving range' is still among the primary concerns regarding battery electric vehicles (BEVs). It topped the poll in the US and Germany, as well as coming joint first with 'charging time' in China. These results will likely come as no surprise to automakers.

Deloitte found that the majority of customers expect charging to take between 21 and 40 minutes, considerably longer than refuelling with gasoline. Start-ups and luxury OEMs have been trying to eliminate this fundamental and perennial barrier to mass BEV adoption, but not even the fastest commercial solutions have been able to provide a sub-ten-minute wait time. However, two developments from China have the potential to solve range anxiety for good.

On 17 March, BYD announced that it would roll-out the world's first megawatt charger technology over the following month, with 5,000 units to be deployed over an undefined timeline. The company states it can bring a BEV from 10% to 80% state of charge–adding 400km of range–in around five

minutes, making it roughly equivalent to refilling with gasoline.

Importantly, BYD isn't just delivering a fast charge; it also claims to resolve pertinent infrastructure challenges. Its new charging unit uses a 315kVA transformer, around 80% smaller than previous generation megawatt charging would require. Combined with 225kWh of on-site battery storage to absorb peak load, BYD can provide ultra-fast charging without causing excessive strain on the grid. The automaker also stated that installation costs are 50% cheaper than previous solutions.

BYD Sealion 7

Li Yunfei, General Manager of Brand and Public Relations at BYD, noted that some in the industry would be sceptical of the company's technology and invited them to experience these charging capabilities first-hand. But any doubts as to the veracity of BYD's claims were wiped away when Zeekr—a premium BEV brand owned by Geely—announced around two weeks later that it too had cracked 1MW charging.

In fact, Zeekr claims to exceed BYD by stepping up the power to 1.2MW. The company has a track record of exponential charging speed gains: in three years, it went from 360kW to 800kW. Now, Zeekr might have the fastest BEV charging technology in the world. Vice President Zhao Yuhui stated that its new, liquid-cooled units will be rolled out from Q2 2025.

StoreDot, an Israeli start-up that has been chasing 'extreme fast charging' for years, commended the progress seen in China. Chief Executive Doron Myersdorf previously told *Automotive World* that the "holy grail" would be 100 miles of charge in two minutes. If BYD's and Zeekr's power specs are accurate, they have already exceeded this standard. At the same time, this new high-water mark might not be the endpoint for innovation.

By focusing on silicon-dominated anode technology, StoreDot believes there could still be scope to surpass this performance and enhance the commercial scalability of batteries. Indeed, battery and E/E architecture advancements will be vital, as it's unclear how many BEVs can actually support megawatt charging today.

It also remains to be seen whether customers who were on the fence about BEVs would be swayed even further by incremental speed gains at this point. After all, practically none currently expect BEV charging to take less than ten minutes, according to Deloitte, let alone five minutes.

Either way, it seems Tesla's idea of a drive-in restaurant for customers waiting to recharge could soon become redundant. Moreover, it may demonstrate that the world's foremost BEV pioneer has lost a fatal degree of momentum, and its crown may imminently pass to fast-ascending competitors in China.