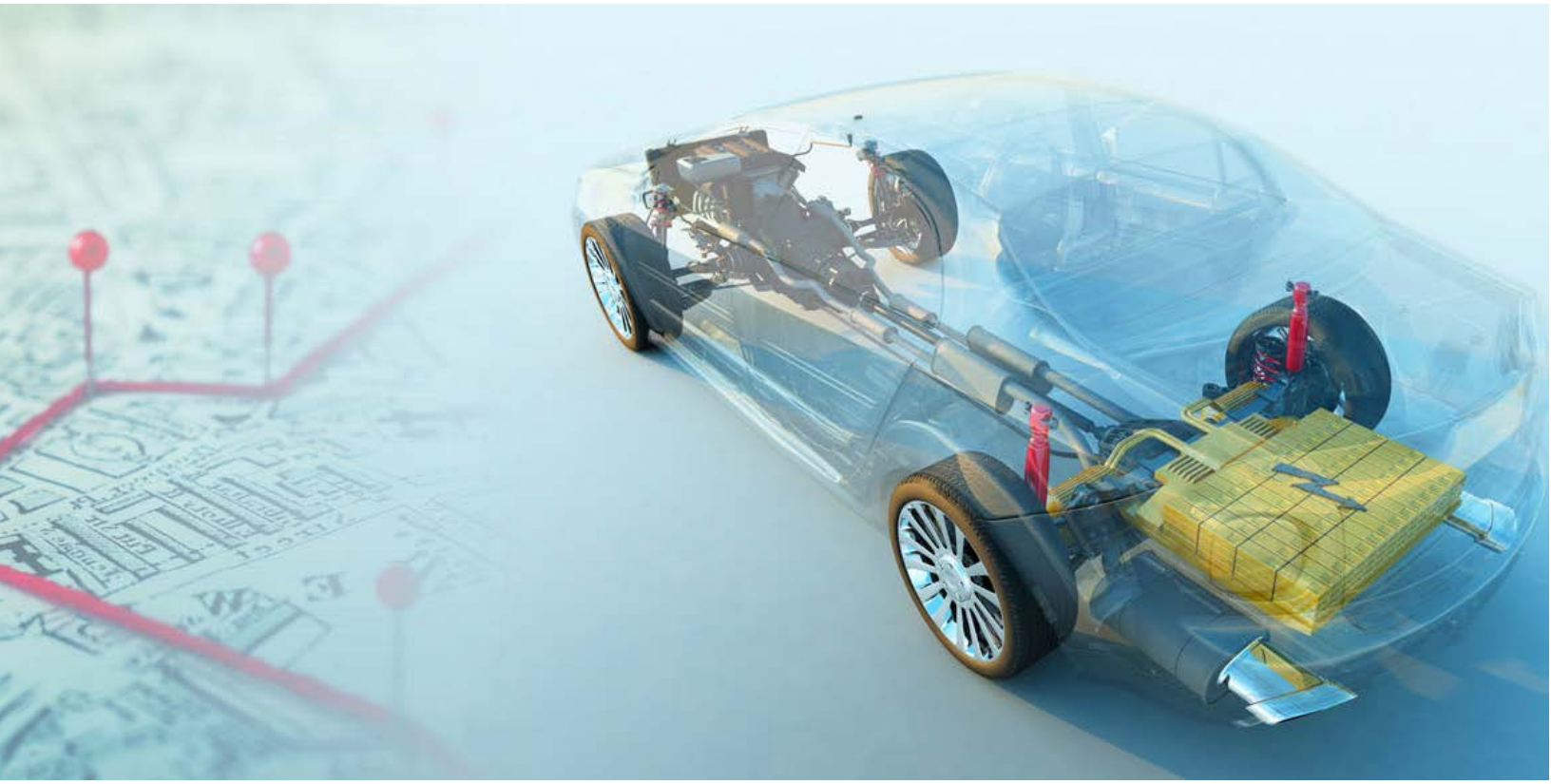


THE ELECTRIC FUTURE

By **Robert E. Calem**

What are some of the EV tricks that automakers are using to extend range?

As automakers transition to making only vehicles propelled by electricity and abandon the internal combustion engines (ICE) of yesteryear, consumers are experiencing range anxiety — the fear that an electric vehicle (EV) simply won't travel as far on a full battery as an ICE vehicle will on a tankful of fuel. And in many cases, they're correct. But the tide is turning.

Through engineering feats and technological advances, automakers are extracting far more range from EV drivetrains than ever before. Combined with an even greater variety of vehicles on offer, the result could be a sharp increase in consumer interest just when it's needed most.

MORE CHOICES COMING

From now to mid-decade, "the level of investment and the development of new models" that are pure battery-electric vehicles (BEVs) "is increasing significantly," says Masaichi Hasegawa, partner in the global automotive practice of consultancy Deloitte LLP, based in Los Angeles. That's good news for consumers in the form of more choices, which is a reversal from the past decade, he adds.

Yet he notes, *Deloitte's 2021 Global Automotive Consumer Study* conducted late last year reveals limited consumer interest in BEVs along with growing interest in ICE-powered vehicles.

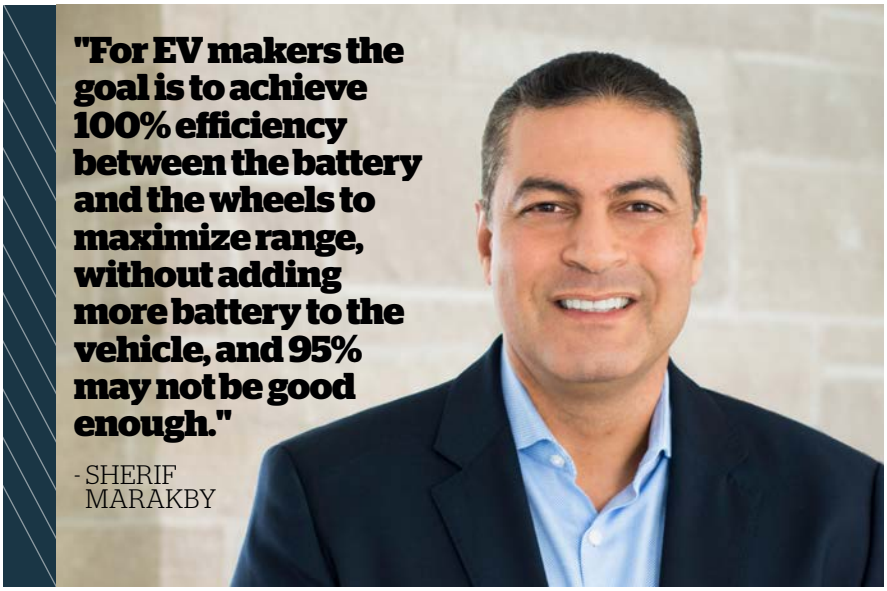
"Across major countries, this year for the first time," intention to buy an ICE-powered car next rose, marking "a reversal of the trend that we have been tracking for the last several years," Hasegawa says. ICE purchase intention steadily fell from 80% in Deloitte's 2018 study results to 71% in 2019 and 59% in 2020, then increased in this year's study to 74%.

The three factors restraining people from acquiring an EV are driving range, lack of charging infrastructure and price — in that order — says Ryan Robinson, lead researcher for the automotive sector at Deloitte, based in Toronto. However, 2021 begins manufacturers' concerted efforts to broaden their EV lineups to include models priced below $50,000, which is the most that U.S. consumers want to pay for an EV, Robinson says. And as for driving range technology is now able to easily satisfy consumers' requirements, even if consumers don't know that yet.

"I don't think anybody is expecting a smooth, orderly transition from ICE technology to electro-mobility. Historically that's not how these wholesale technological changes happen," Robinson says. "There are things happening that give us a good amount of comfort that the trajectory towards electro-mobility is solidifying," but the auto industry is "still working towards a place in the performance of the technology that allows consumers not to have to compromise — and that's a big thing, that's going to be another threshold moment for getting us to the next step of the penetration of EV technologies in the market," he adds.

BEYOND BIGGER BATTERIES

EVs have been available for decades, but big leaps in driving range occurred in the last one. The original Nissan Leaf, which debuted in 2010 as a model year 2011 vehicle, traveled 73 miles on a full battery charge. Meanwhile, startup Lucid Motors' coming Air car is expected to go more than 500 miles at full capacity. Why the boost? Automakers and their suppliers credit lots of different advances.



"From the battery all the way to the wheels, there are many components and systems," says Sherif Marakby, executive vice president of research and development at Magna International, an automotive technology supplier based in Troy, MI. "Any percent reduction" of energy efficiency among them "takes away from that electric range and there's always tradeoffs." He says for example adding rare earth metals to an electric motor increases efficiency and range while inflating complexity and costs "but could be cheaper than adding more battery" capacity. Inverters, which move the electricity from the battery to drive the motor, can also lose or gain efficiency and range. So, for EV makers the goal is to achieve 100% efficiency between the battery and the wheels to maximize range, without adding more battery to the vehicle, and 95% may not be good enough," he declares.

But other factors such as lightweight structural materials, advanced driver assistance systems (ADAS) and a vehicle's computing architecture contribute to range extension, too, Marakby explains. In an EV, he says, weight reduction strategies can include the use of composite materials for battery trays instead of pure metal, which is a Magna specialty. Moreover, ADAS is actually a big energy user when sensing and computing is considered, so Magna offers automakers a single electronic control unit (ECU) that integrates all ADAS sensing functions in one place rather than via a distributed architecture.

Magna's EtelligentReach

Eric Bach

The Lucid Air

In March, Magna debuted EtelligentReach, an all-electric all-wheel-drive powertrain that incorporates hardware and software innovations for increased range as well as better driving dynamics. Among the hardware updates are a silicon carbide inverter with greater power density and a new "decoupling" function called Decoupling+ that engages or disengages a separate e-drive motor for the front wheels, resulting in a higher load and greater operating efficiency for the remaining rear-drive motor. Decoupling+ is a world's first development for EVs that is expected to be on the market in mid-2022.

EtelligentReach's new inverter and combination of front and rear e-drive systems together with improved operating software will contribute to a 20% increase in electric driving range compared with a typical EV on the road today, Magna says. Besides supplying automakers with technology, Magna also builds entire vehicles. It is the contract manufacturer for Fisker Automotive's forthcoming Ocean BEV SUV.

For all cars, the measure of efficiency is described as miles traveled per energy consumed. There are four key contributors to efficiency loss or gain, says Eric Bach, senior vice president of product and chief engineer at Lucid, based in Newark, CA. Those are aerodynamics, rolling resistance and other elements of friction, the vehicle's powertrain, and consumption by all auxiliary units that the vehicle needs to run — and optimizing all of them extracts more range out of an energy unit. The **Lucid Air** touts a 113 Kilowatt-hour (kWh) battery pack, which Bach believes to be the largest in any electric car, "but that's not necessarily what makes our car efficient," he says. Sizing up the battery is merely equivalent to having a larger gasoline tank. "Then, efficiency kicks in and takes you to the total available range." He says, "We have designed the Lucid Air with all of these areas of efficiency in mind."

"If everybody reduces the amount of energy needed for traveling further distances, the planet wins after all."

- ERIC BACH

In terms of aerodynamics, the Air's styling achieves a drag co-efficient (CD) of 0.21, which is better than the 0.23 CD of the Tesla Model S, Bach says. Yet, because Lucid's mission is to "inspire the adoption of sustainable transportation," the company welcomes competition and "wants to inspire others to think about the same topics, because then if everybody reduces the amount of energy needed for traveling further distances, the planet wins after all," he says.

Tires are a major source of friction between the vehicle and the road surface, and the science that goes in to optimizing them for rolling resistance, vehicle dynamics and safety is often under-estimated by people, Bach says. Other friction losses can occur through electromagnetic fields, and to counter this Lucid has developed an electric motor with specially placed permanent magnets, he explains.

Also in Lucid's powertrain, the company's proprietary battery pack is engineered to minimize energy lost to heat, letting more flow to the vehicle's inverter and motor system, which itself is ultra-compact and efficient. The result, Bach says, is the addition of tens more horsepower without additional energy consumption.

It all boils down to "a complexity of interactions" and "you trade off all of them for a system level goal, a system level approach, and that's how we've done it," Bach asserts.

With an EV versus an ICE vehicle, the economics of energy shifts to the automaker from the consumer, as the biggest cost driver for the vehicle becomes its battery and consumers don't absorb the expense of filling a gas tank, proclaims Matthew Renna, vice president of e-mobility and innovation at Volkswagen of America, based in Herndon, VA. Further, the upfront cost of that battery is considerably high, Renna says. Thus, for automakers, the calculations around making an EV "changes from dollars of material cost per miles per gallon into dollars of material cost per miles of range. It puts a huge amount of emphasis on range efficiency and ups the value to the [automaker] for that efficiency," he says.

Volkswagen's ID.4 BEV SUV

In that context, Renna adds, there are three main avenues to extracting maximum range from an EV: the battery technology, the drive units — including motors, gearboxes, inverters and cooling systems — and the in-cabin HVAC systems. Regarding the last, he notes that EVs don't have engines that generate heat to warm a vehicle's interior, so there's a greater emphasis needed on energy efficient climate controls as well as how climate is managed within the cabin, using components such as "isolation layers" and glass.

But, without taking "a firm stance in one direction or the other," Renna points out, "there's a broad debate around whether electric vehicles will continue to increase in range — in other words, keep large batteries in cars and push the limits of actual range — or do we take the other stance, which is keep the range and use the efficiency improvements to reduce costs and therefore price to customers." VW and other automakers have built modularity into battery packs to give flexibility to do both, he says.

VW's new **ID.4** BEV SUV arrived at dealerships in March. It offers an EPA-estimated range of 250 miles on a full charge, the automaker says.

When the original Nissan Leaf came to market over 10 years ago, the top priority was battery safety, so the automaker was conservative on capacity and kept range to below 100 miles, says Jonathan Ratliff, senior manager for zero emissions development at Nissan North America in Farmington Hills, MI. Then the energy density of available batteries increased, boosting range. Now, Ratliff says, customer expectations are rising. And because motors are both capable and lightweight, he adds, vehicle aerodynamics has become an increasingly important factor in EV design. In fact, he says, aerodynamics and associated friction from wind resistance accounts for 65% of energy consumption at highway speeds.

"Every little piece of energy in an EV is precious," says Jerome Gregeois, senior manager for powertrain and electrification at the Hyundai Kia America Technical Center in Chino Hills, CA. "Anything you can save brings you a few miles."

Hyundai's **2022 Ioniq 5** BEV SUV coming to the U.S. this fall will have an AWD powertrain with a disconnection system for the front wheels motor (akin to Magna's EtelligentReach). When disengaged when not needed, it will yield perhaps a 4% range gain, or 12 miles on every 300 miles of base range capacity, Gregeois says. "If you have three or four of those" efficiency gains through innovations, he posits, soon enough "you get close to fifty miles of range, which is putting you almost in a different bracket."

The Ioniq 5 vehicle also will have a solar panel roof that provides a little over 200 watt of power and can add power to the vehicle's main battery. It is expected to add at least 1000 miles of range per year in sunny climates, Gregeois says.

In the future, there'll be a compromise to figure out between range and charging speed, and "we'll have to see what the market likes the best," Gregeois concludes. "What we'll observe in the next few years is where will the consumer settle and be satisfied." ■

Hyundai's 2022 Ioniq 5 BEV SUV