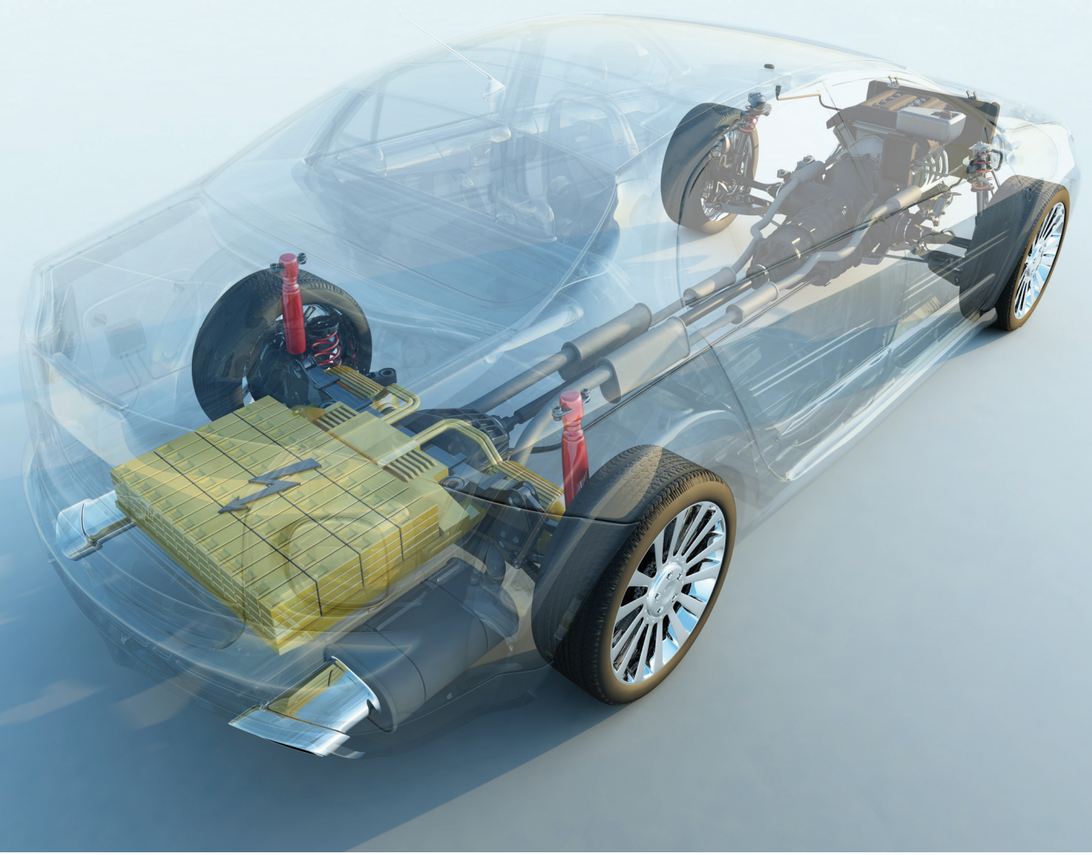
STAMPING JOURNAL

Electric Vehicle e-Book

IN THIS ISSUE:



All of them; all in on EVs

Automakers, governments ready for seismic shift

By *STAMPING Journal* Editor Kate Bachman

By now, if you are supplying to or working in the automotive industry in any developed nation in the world, you are aware that it is engaged in a seismic shift in its propulsion system from an internal combustion engine (ICE) to an electric motors and battery system. The industry is nearing the end of the ICE age, as it were.

The auto industry's shift to electrification is imminent. How imminent? Consider this:

Automakers Phase Out ICE. Virtually all legacy automakers have introduced electric vehicles, and most have pledged to covert to electrification, with varying end dates for gas- and diesel-fueled vehicles, according to the *New York Times*. Ford, Mercedes-Benz, General Motors, Volvo, BYD, and Jaguar Land Rover have pledged to phase out the sales of ICE vehicles by 2040 worldwide, and earlier in leading markets. Volkswagen has announced it will no longer manufacture ICE vehicles in Europe by 2035; Volvo expects its car lineup to be fully electric by 2030.

Countries, States Phase Out ICE. Governments around the world are driving the transition as a means of reducing carbon emissions to combat human-caused climate change. To date, 196 nations have made emissions reductions pledges in the Paris Climate Agreement. According to the United Nations, the Paris Climate Agreement is a legally binding international treaty. Its goal is to limit global warming to 1.5 degrees C, compared to pre-industrial levels.

Thirty countries, including India, the fourth-largest vehicle market, have joined a coalition to phase out sales of ICE vehicles by 2040. California, New York, and Washington state also signed the pledge that only zero-emissions vehicles would be sold there by 2035, the Times reported.

EV Sales Trend Up. The number of electric vehicles sold in the U.S. has tripled since January 2020, according to the White House. IDTechEx forecasts that there will be a total of 18.7 million units in electric vehicle fleets, including electric vans, trucks, and buses, on the road by 2032.

Investments Boom. Of the major automakers that did not formalize a phaseout pledge, most are investing heavily in electric vehicle technology. In the past two years, companies have invested nearly $85 billion in manufacturing of electric vehicles, batteries, and EV chargers in the U.S. Volkswagen, for example, professed to invest $100 billion to build six battery factories, install a global network of charging stations, and roll out more than 80 new electric models by 2025.

Battery Costs Dip. The cost of lithium-ion batteries has also declined roughly 80% since 2013, according to BloombergNEF. Motive battery costs has been the major factor in weighing down the cost of EVs.

Retailers, Corporations Pledge EV Purchases. Large retailers, leader corporations, and government agencies are demonstrating their commitments to countering climate change with large contracts and orders of EVs. DHL has set its goal of electrifying 60% of its last-mile fleet. Amazon, Best Buy, DHL, and Schindler Elevator are members of the Corporate Electric Vehicle Alliance, which comprises members pledging to buy EVs for their fleets. Collectively they own, lease, or operate nearly 1.3 million on-road vehicles in the U.S. Walmart has ordered 4,500 electric delivery vehicles from startup Canoo. Amazon has ordered 100,000 electric delivery vans from startup Rivian. Hertz formed an agreement with GM for 175,000 EVs, and with BP for the development of a national network of EV charging stations (Yes, you read that right, BP). The USPS plans to deploy more than 66,000 EVs by 2028. And in one of the most surprising announcements, the Saudi Arabian government has placed an order for 100,000 EVs from Lucid Motors.

Clearly, the momentum is shifting toward electrification and it is unlikely to reverse course. EV

2023 EVs—ranges, list prices

All Electric:
Auto industry's shift to electrification is imminent.

New and legacy automakers alike are on display at auto shows across the country. Attendees can view electric vehicle concepts, debuts, and production vehicles from nearly all automakers, including:

Legacy Automakers

	2023 Model	Range (Miles)	MSRP*
BMW	Gran Coupe i4 RWD/AWD40 i4 M50	301/270	$55,900/67,300
	iX xDrivd50/BMW iX M60	324/288	$84,100/108,900
Ford	F-150 Lightning Pro/XLT XR/Lariat XR	240/320/320	$46,974/80,974/85,974
	Mustang Mach-E Select/Premium XR, RWD/XR AWD	230/306/290	Select $45,995/ Premium 50,995/GT 63,995
	E-Transit	126	$49,575
GM	Chevy Bolt FWD	238	$26,500
	Chevrolet Silverado EV	400 on WT and RST	$39,900
	Chevy Equinox EV	300	$30,000
	Cadillac Lyriq RWD/ AWD	312	$61,795/63,795
GMC	Sierra EV	400	$50,000/$75,000 est.
	Hummer EV, EV 2, EV 2X, EV 3X [suv]	329	$86,245/96,245/106,245
HYUNDAI	IONIQ 5 RWD/AWD/XR RWD	220/266/303	$42,000/47,000/49,000
	KONA FWD SE/SEL/Ltd	258	$33,550/37,300/41,550
KIA	EV6/ KIA EV6 GT	310/206	$43,000 est./69,000 est.
	EV9	300	$50,000 est.
	Niro EV	253	$42,000 est.
NISSAN	Ariya Engage FWD/Venture+	216/304	$43,190/47,190
SUBARU	Solterra Prem AWD/Ltd AWD/Tour AWD	222/228/228	$46,220/49,720/53,220
TOYOTA	bZ4X XLE FWD/LTD AWD	252/222	$42,000/44,080
VOLKSWAGEN	ID.3 (Not for U.S. market) sedan	265	$39,000
	ID.4 [suv] Std RWD/Pro RWD/Pro AWD Pro S	208/275/255	$37,495/42,495/51,295

RWD—Rear wheel drive FWD—Front wheel drive AWD—All-wheel drive XR—Extended range battery
*MSRP—Mfr Sug Retail Price at the time of publication and is a best estimate.

Whippersnapper Startups

	2023 Model	Range (Miles)	MSRP
Aptera Solar Electric Vehicle		250-1,000 (16-40 miles per day)	$25,900/50,700
Canoo	Lifestyle Vehicle delivery/premium	250	$84,100/108,900
	Pickup Truck	200	$35,000/50,000
Faraday	Future FF 91	381	$180,000
Fisker	Ocean Sport	250	$37,499
	Ocean Ultra	340	$49,999
	Ocean Extreme	350	$68,999
	Ocean One	350	$68,999
Lucid Air	Sedan	516	$90,000 est.
Nio	ES8 STD/LR	233/311	$64,178/71,209
Rivian	R1S [SUV] Adventure [dual/quad]	260/320+	$78,000/91,075
	R1T [pickup truck]	314	$73,000
Tesla	Model 3 Compact Sedan RWD/XR/Perform	272/358	$43,990/53,990.
	Model X Mid-cross Base/Plaid AWD	335/351	$101,990/$119,990
	Model Y Compact Cross LR/Perform	303/330/500+	$53,490/$56,990
	Model S Mid-sedan	405	$95,000
	Cybertruck	500	$39,900

EVspeak

Battery swap: Exchange of a charged EV battery for an expired one

BEV: Battery electric vehicle

Body swap: Exchange of a new vehicle body for an older one onto a skateboard platform

Dual-motor; tri-motor; quad-motor: One motor at each axle; one motor in front, two motors on the back axle; one motor for each wheel.

Integrated to structure: The battery pack is part of the body structure

HEV: Hybrid electric vehicle

Over-the-air (OTA) updates: The wireless delivery of new software, firmware, or other data

Range: The distance a vehicle can travel on a charge.

Skateboard: Platform-style chassis resembling a skateboard that carries a vehicle's battery and electric motors

MPGe: Miles per gallon of gas-equivalent

MPC: Miles per charge

Top hat: The upper-body structures that share a common platform

X-by-wire: The use of electrical systems to perform functions, such as braking and steering, that were traditionally done by mechanical linkages. Also called "drive-by-wire."

ZEV: Zero-emissions vehicle

6 ways government is involved in EV expansion

Consumer tax credits, manufacturing funding, requirements

Governments have long been involved in areas of national concern such as energy and transportation. That involvement has taken various forms, depending on the type of government. As a capitalist democracy, the U.S. government's involvement in supporting the shift to vehicle electrification has taken the forms of setting a goal, offering tax incentives to consumers, availing loans and grants to manufacturers, and assigning requirements for those financials.

1. Setting the Agenda, Goal

The current U.S. government, and the Biden Administration especially, has set what is probably the most ambitious goal yet to transition the country from fossil-fuel-burning vehicles to no- or low-emissions vehicles. President Biden set a goal for electric vehicles to make up half of all new vehicle sales in 2030. This seems to have taken the pressure off of the Environmental Protection Agency's (EPA) target for automakers to achieve 54.5 MPG by 2027.

"The President has united automakers and autoworkers around a bold goal for electric vehicles to make up 50% of all vehicles sold in the United States by 2030. His economic agenda, including robust new 'Made in America' policies, has spurred domestic manufacturing of EVs, EV chargers, and batteries," the White House said in a Sep. 14, 2022, press release.

"In 2021, all major automakers announced their shared aspiration to achieve sales of 40% to 50% of annual U.S. volumes of electric vehicles, including battery electric, fuel cell, and plug-in hybrid vehicles, by 2030 to move the nation closer to a zero-emissions future consistent with Paris climate goals."

No matter your perspective, it's hard to argue against the claim that President Biden has launched the most ambitious plan for the conversion to vehicle electrification yet. Since President Biden took office, companies have invested nearly $85 billion in manufacturing of EVs, batteries, and EV chargers in the U.S.

Several pieces of recently passed legislation are geared toward meeting those goals—the Bipartisan Infrastructure Law, Inflation Reduction Act of 2022, and Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act. They comprise tax credits for consumers and loans and grants for automakers, battery manufacturers, mining companies, and charging units producers.

2. Incentivizing Consumers With Tax Credits

The Inflation Reduction Act includes incentives for buyers of new and used EVs, extending them in some cases and limiting or ending them in others. This helps EV manufacturers by making the vehicle purchase more affordable.

Previously, a $7,500 tax credit expired after an automaker sold more than 200,000 EVs. General Motors (GM), Tesla, and Toyota had exceeded that ceiling. The Clean Vehicle Credit in the Inflation Reduction Act, which went into effect Jan. 1, 2023, removes that 200,000 limit, extending the eligibility for the tax credit through 2032 to all automakers' vehicles. So, as of Jan. 1, 2023, GM, Tesla, and Toyota vehicles are now eligible, as long as they meet other requirements.

For consumers to qualify for the full $7,500 tax credit, they and the vehicle must meet specific income, price, and country of origin manufacturing requirements:

Buyer Income Requirements. The buyer's adjusted gross income limit is $300,000 for joint/married filers; $225,000 for a head of household; and $150,000 for single tax filers.

Vehicle Requirements. The following must be true to qualify for the full $7,500 tax credit:

•The manufacturer's suggested retail price (MSRP) cannot exceed $55,000 if it is a passenger vehicle or $80,000 if it is an SUV, pickup truck, or van.

•The vehicle must be assembled in North America.

•In 2023, at least half of the battery components must be made in North America. (The percentage rises each subsequent year.)

•At least 40% of critical minerals extracted, processed, and recycled must be from North America or a U.S. free trade partner. (The percentage rises each subsequent year.)

These qualifiers have eliminated many vehicles that previously had been eligible for tax credits. { https://afdc.energy.gov/laws/electric-vehicles-for-tax-credit }The build location of a particular vehicle should be confirmed by referring to its vehicle identification number (VIN) using the VIN decoder { https://afdc.energy.gov/laws/electric-vehicles-for-tax-credit#vin-decoder} or an information label affixed to the vehicle.

3. Providing Funding for Vehicle Manufacturers

The Bipartisan Infrastructure Law, the CHIPS and Science Act, and the Inflation Reduction Act allocated more than $135 billion toward EV manufacturing. The law includes investments of more than $10 billion for clean transit and school buses.

The Inflation Reduction Act provides funding to help manufacturers retool existing facilities and build new manufacturing in the U.S.

Grants are available to manufacturers to make zero-emission, heavy-duty vehicles.

The U.S. Department of Energy (DOE) provides loans to support the manufacture of eligible vehicles and qualifying components under the Advanced Technology Vehicles Manufacturing Loan Program (ATVM), authorized by the Energy Independence and Security Act of 2007.

To date, the program has loaned $8 billion for projects that have supported the production of more than 4 million advanced technology vehicles, the DOE reports.

4. Investing in Battery Manufacturing, Processing

The Bipartisan Infrastructure Law invests more than $7 billion to ensure domestic manufacturers have the critical minerals and other components necessary to make batteries. Through ATVM, the DOE has announced a $2.5 billion loan in July 2022 to GM for battery manufacturing facilities in Ohio, Tennessee, and Michigan.

The federal government awarded $2.8 billion in grants in October to boost domestic manufacturing of EV batteries in 12 states. Altogether, 20 companies will receive grants for projects to extract and process lithium, graphite, and other battery materials. The funding is designed to help strengthen U.S. supply of critical minerals for the manufacture of batteries.

In November 2022, the DOE awarded $74 million from the Bipartisan Infrastructure Law for battery recycling and reuse projects. The 10 projects are intended to advance recycling and reuse of batteries for EVs and other purposes.

5. Financing Semiconductor Manufacturing

The CHIPS and Science Act is making critical investments in building domestic capacity for the semiconductors necessary for electric vehicles. The act provides $52.7 billion for American semiconductor research, development, manufacturing, and workforce development. This includes $39 billion in manufacturing incentives, $2 billion for the legacy chips used in automobiles and defense systems, $13.2 billion in R&D and workforce development, and $500 million to provide for international information communications technology security and semiconductor supply chain activities. It also provides a 25% investment tax credit for capital expenses for manufacturing of semiconductors and related equipment. These incentives are intended to secure domestic supply, create jobs, and catalyze more in private investment.

6. Funding Charging Network

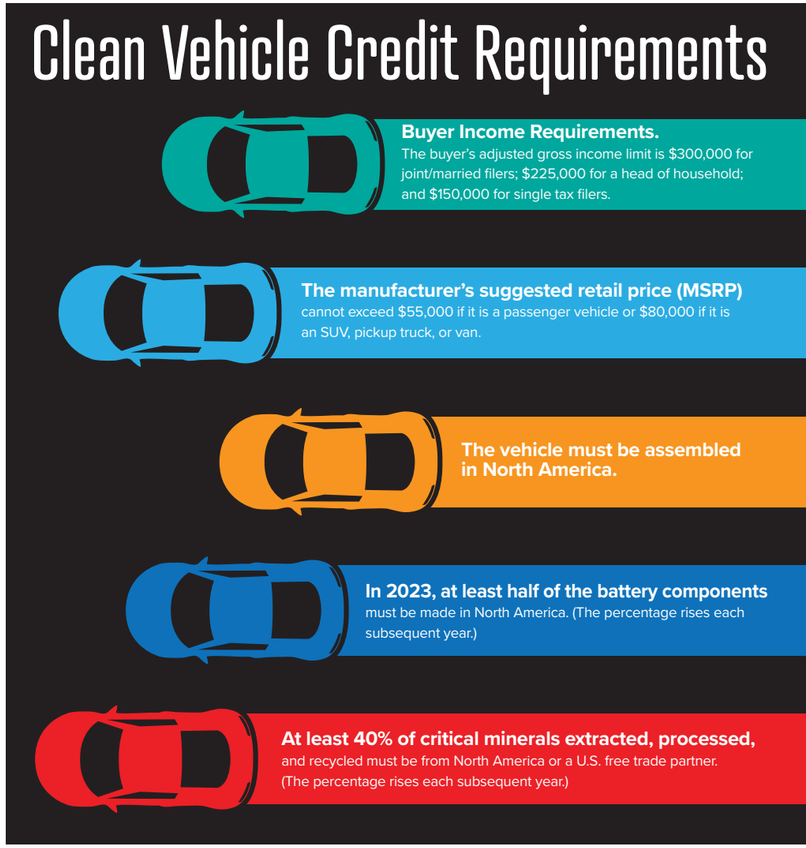
The Bipartisan Infrastructure Law invests $7.5 billion to build a national network of 500,000 EV charging stations to help make charging EVs predictable, reliable, and accessible.

The National Electric Vehicle Infrastructure Formula Program ($5 billion) provides funding to states to strategically deploy EV charging infrastructure and to establish an interconnected network to facilitate data collection, access, and reliability. The Discretionary Grant Program for Charging and Fueling Infrastructure ($2.5 billion) is a competitive grant program to strategically deploy publicly accessible electric vehicle charging infrastructure and other alternative fueling infrastructure along designated alternative fuel corridors.

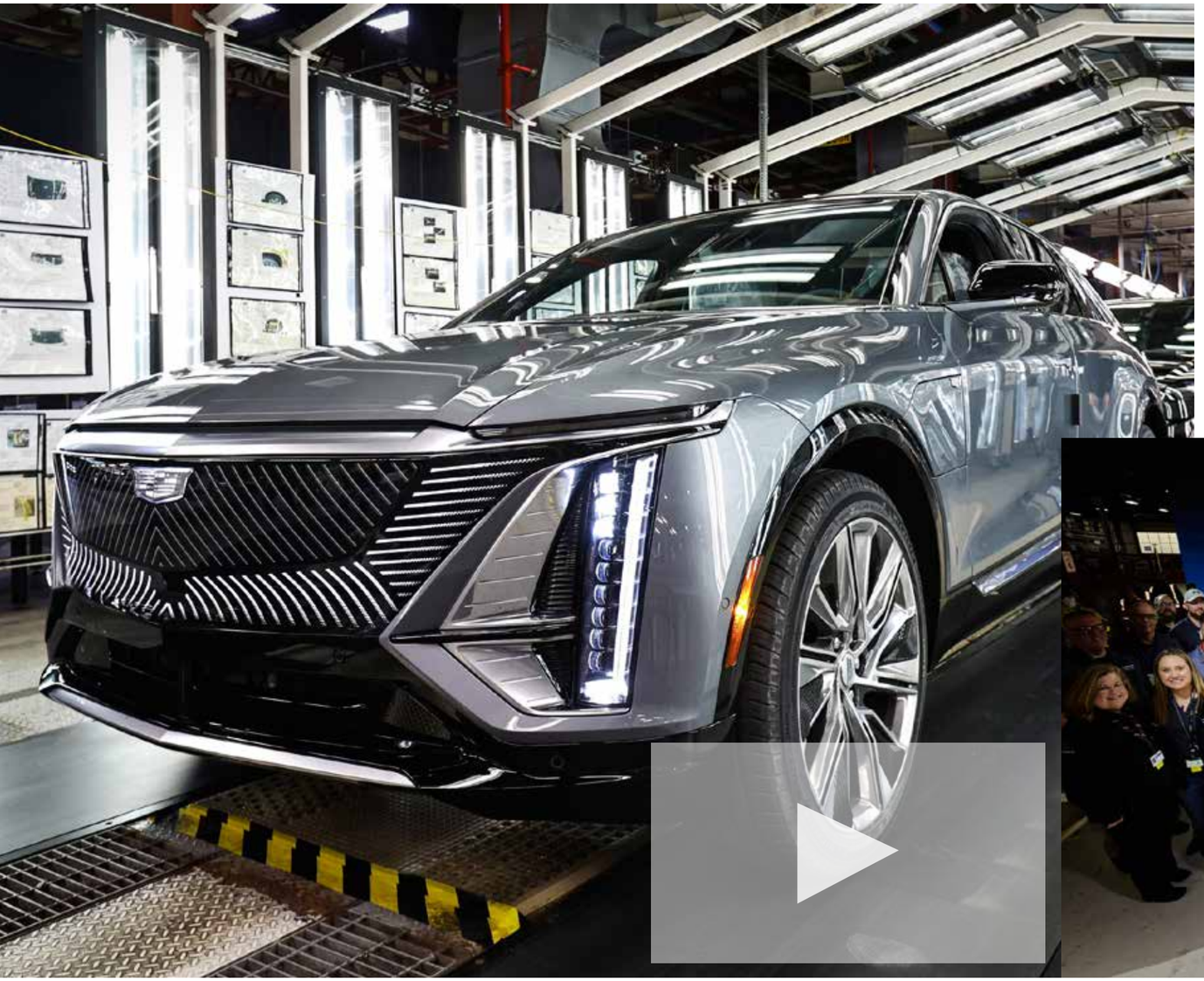
At least 50% of this funding must be used for a community grant program where priority is given to projects that expand access to EV charging and alternative fueling infrastructure within rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking spaces.

The law also makes the installation of EV charging infrastructure an eligible expense under the U.S. DOT Surface Transportation Block Grant formula program.

The U.S. DOT issued a proposal in August that would, if finalized, require federally funded EV chargers to be built in the U.S. starting in January 2023, and have more than 55% domestic content by January 2024. Build America Buy America standards are meant to send clear market signals, creating an incentive for firms to invest in America and create jobs. EV



Cadillac Lyriq: An opera for the drive



Iconic GM brand electrifies luxury

Few brands are so iconic, so enmeshed in consumer lexicon, that they have become inseparable from the qualities they embody. When something is referred to as "... the Cadillac of ...", it's understood to be the ultimate in luxury and performance. On March 21, 2022, Cadillac's first all-electric SUV, Lyriq, rolled off the production line in Spring Hill, Tenn., and is now in production. Some might call it the "Cadillac of Cadillacs."

The Lyriq is in high demand, according to Katie Minter, product and brand communications at Cadillac. The reserve orders were sold out in 10 minutes.

Produced Nine Months Early

Katie Minter

Remarkably, in the midst of the pandemic, worker shortages, material shortages, escalating material prices, and the war in Ukraine, the plant managed to accelerate its production to release the Lyriq nine months earlier than its original goal.

How?

"We committed to that accelerated timetable at the end of 2020. We were in the midst of the effects of the pandemic. We were aware of some of the shortages and we knew it was going to be a difficult task," Minter said. "But the engineering team, working with our purchasing and supply chain organization, found the right way to get the parts that we needed and to secure them so that we knew we could keep moving forward."

She attributed the achievement to the teams' good, advanced planning. "They prepared as best they could for the unknowns and protected what they could to make sure that these vehicles went into production in March as planned."

Customers: Loyalists, EV Enthusiasts, and Newcomers

Sometimes a brand is popular for a long time and appeals to a certain generation, and then its demand wanes as that generation ages. Cadillac seems to have reinvented itself, not only with its styling but with this electrification.

Lyriq customers who have bought the vehicle on reserve are a mix of Cadillac loyalists, electric vehicle buffs, and new customers, Minter relayed.

"There are loyal Cadillac customers in that pool, but also a significant number of conquest customers—customers coming from other manufacturers—as well. We have EV enthusiasts. And we are seeing that, for some of our customers, this is going to be their first electric vehicle. It's a really broad mix, to be honest," she said. "The really great thing about Lyriq is that it was designed to be just a great Cadillac vehicle and appeal to anyone who wants a luxury midsize SUV.
We're excited to know that we're bringing new people into the EV market, as well as new Cadillac customers, while still maintaining our current customer base."

Minter said there are at least three brand-specific "Cadillac" hallmarks in the Lyriq.

"One is just great design; the sleek exterior and interior design of the vehicle that is distinctly Cadillac, especially with our signature vertical lighting. And we've taken that a step further with our light choreography on the grill."

A second aspect is performance, Minter indicated. "Performance has been the core of Cadillac for a long time. And now that we're moving into electrification, that includes next-level performance features such as near-instant torque." Also, the battery lends itself to a low center of gravity and a 50-50 weight distribution, which is more common in performance vehicles.

A third hallmark is the advanced technology used in the vehicle, Minter said. Lyriq is equipped with Cadillac's Super Cruise, its hands-free driver assistance technology, and a 33-in. infotainment screen. "So, it offers a really great user experience," she explained

"We're really excited about bringing Lyriq to market and can't wait for the next chapter when we're able to talk about our future EVs as well."

The plant managed to accelerate its production to release the Lyriq nine months earlier than its original goal.

Ultium Battery Platform

The Lyriq is the first Cadillac and the first SUV with GM's Ultium platform, which includes the battery, the EV drive train, and electrical system.

Dan Flores, director, GM news relations, said, "All of our EVs, including the ones we've recently launched, like the Hummer EV pickup and Lyriq, will be based on our Ultium platform. This commonization helps from a manufacturing standpoint because it reduces manufacturing complexity and variation." The modularity enables the OEM to bring the vehicles to market quickly because a new battery architecture does not have to be developed for every single vehicle. For example, the Lyriq has a 12-module battery pack; the Hummer has double that—a 24-module battery pack. The platform can have 8, 10, 12, or 24 modules that will power everything from small SUVs to full-size pickup trucks. "We think that is a differentiator for General Motors that will help us achieve our vision of an all-electric future by 2030 for Cadillac," Flores said.

GM has stated that its goal is to have 1 million EVs in North America and 2 million EVs globally by the end of 2025. The goal is for the entire new GM fleet to be electric powered by the mid-2030s.

Production

While GM's EVs will comprise some differentiating componentry and assemblies, there will be a production continuum, Flores said.

"While there are now—and certainly will be in the future—different vehicle-specific components installed on the wide portfolio of new EVs, the way we fundamentally process vehicles through our assembly plants will not change," Flores continued. "Our EVs are going to continue to use sheet metal stampings of all kinds. I can't give you specifics, but there will be the need." Many will be stamped in-house at GM's metal stamping plants, and others will be sourced.

"Our assembly plants will still have a body shop where the body is welded together. They will still have a paint shop where the metal body is primed, painted, and clear-coated. And there will still be general assembly areas where all the content of a particular vehicle is installed, such as carpet, seats, IP, steering wheel, and so forth."

In terms of manufacturing the batteries, GM's joint venture with LG Energy Solution, called Ultium Cells LLC, includes four battery cell manufacturing facilities in the U.S., Flores said. Three locations have been announced so far—Warren, Ohio; Spring Hill, Tenn.; and Lansing, Mich.—and one more will be announced later this year.

The battery cells will be built in the Ultium battery cell plants and then shipped to the assembly plants. At the assembly plants, including Factory ZERO and Spring Hill, the cells will be built into battery packs which then will be installed in the EVs. "For competitive reasons, we are not publicly disclosing volumes, but the cell volume will certainly support our planned EV output. We plan to have the manufacturing capacity to build 1 million EVs by mid-decade," Flores said.

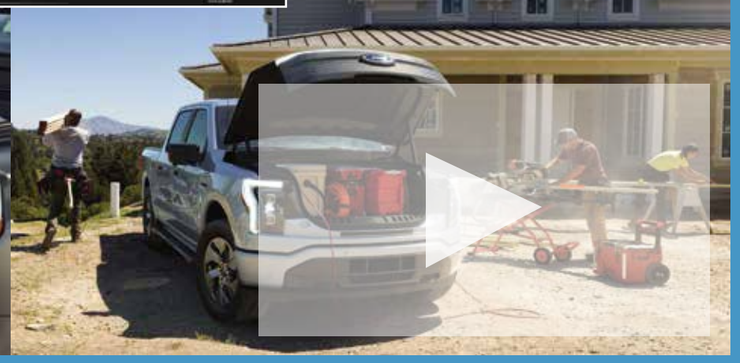
Flores projected that the transition to EVs will take many years. "To clarify, while we certainly have begun our transition to an all-electric future, we will continue building gas-engine-powered vehicles for years to come."

North American Raw Materials Supply Chain

In addition to strategically adding battery cell and EV assembly capacity to ensure continuous production, GM is working to build a new supply chain via strategic supplier agreements for batteries and EV components, Flores said. That supply chain is intended to be scalable, resilient, sustainable, and more focused on North American. These strategic supplier agreements include:

- MP Materials to scale rare-earth magnet sourcing and production in the U.S.
- VAC to build a new magnet factory in the U.S. to support EV growth.
- POSCO to build a new North American plant to process cathode-active material.
- GE Renewable Energy to serve as a source of rare-earth and other materials.
- Wolfspeed to develop and provide silicon carbide power device solutions.
- Controlled Thermal Resources to develop a source of U.S.-based lithium through a closed-loop process with lower carbon emissions than traditional processes. EV

Ford frunks and other "unks"



First, Ford sunsetted several of its less popular makes, retaining only its standouts. Then, one by one, it has begun electrifying them. The Mustang Mach-E. The F-150 EV. The E-Transit. More to come ...

Re-engineering and transforming a legacy gas vehicle into an electric vehicle opened opportunities for new capacity and features, like a frunk, an ice chest, and a power source for work tools. Who woulda thunk? An interview with Ford's just-retired Eric Frevik reveals some behind-the-scenes

Stand Out as EV or No?

EV makers tend to fall into one of two groups: those that want the vehicle to really stand out as a different kind of vehicle—to scream "EV!"—or those that want consumers to view it as just another one of its fleet.

Design. Right from the exterior, the Ford F-150 Lightning is designed to project "electric," according to Eric Frevik, the recently retired Ford Motor Co. chief engineer, global stamping engineering, vehicle manufacturing engineering. "From a studio design perspective, they [Ford designers] wanted it to look unique," Frevik noted. "When you look at the Lightning, you know it's electric. It looks different. It's got more lighting on it, unique contours ... it stands out."

The cab is essentially the same, but with a different-looking box and front end, and that required new tooling, Frevik said. "It used to be that when we tooled an F-150, we had the same front end and then three different cab styles and three different box lengths. Now, in addition, we have a hood, fender, box outers, and tailgate that are unique to the Lightning. So that means more dies, more stampings, more complexity for the plant."

Eric Frevik

How Has Electrification Altered the Vehicle Architecture?

Space. The new propulsion system eliminates the large engine, exhaust, transmission, and radiator, freeing up a massive amount of space. Automakers have taken different approaches to dealing with this recovered space in their designs.

Ford converted the space vacated by the engine and transmission to a sealed, watertight, lockable frunk in the F-150 Lightning and Mustang Mach-E. It offers extra storage space for items that you might not want to leave exposed in the bed or take up space in the cab. And it is huge—14 ft.^{3}. It holds two golf bags.

Frevik said that the space became available because the design started with an existing package. The inner and outer hood is very similar in design to internal combustion engine (ICE) vehicle hoods, he said. What is unusual in the Lightning is that the frunk has a seal and an uninterrupted seal surface all around the periphery.

"The sealed front cavity is a little unique for stamping because typically, you don't have that in the front like you do for a deck or lift gate. In an ICE vehicle, there are some seals in the front to manage airflow and for compression so the hood doesn't flutter when it's on the highway, but that's all," Frevik said.

Another unique aspect of the Lightning is that the entire grill piece is attached to—and lifts up with—the hood. That is designed to make loading and unloading easier, Frevik said. The seal goes through that also. “That seal surface has a tolerance that we have to make dimensionally correct so that when it closes, it compresses the seal and keeps water out. The grill part that hangs on the front hood is quite heavy. Additional reinforcements are required inside the hood to stiffen it so it doesn’t deflect with the closure.”

Frevik pointed to the fact that the stiffeners, reinforcements that run along the fender toward the hood, and several other reinforcements are sourced stampings.

Frevik commented that the removal of the engine has affected vehicle design in other ways, too. “A lot of package space had to be maintained for the engine. Now that it’s gone, it’s not a constraint anymore.” By moving the front wheels forward, the windshield and the occupant space could be moved forward also to make the interior bigger.

The space is still constrained by the position of the wheels to some degree, Frevik relayed. The occupants are situated between the wheels, which makes the most sense for passengers. The center of gravity should be in the center of the vehicle. But the distance between the windshield and the front of the vehicle had been determined by the space required to fit the engine. “And I think that’s where there will be design changes in the future. The length of the hood is in play now. Even the angle of the windshield could change.”

Frevik conjectured that OEMs will take advantage of the elimination of that space constraint to continue to make their vehicles different from ICE vehicles. How far they will go depends on market research. “Will people think it’s too radical? Will they say, ‘It doesn’t look like a car anymore?’

“Our Mustang has had a very long hood and a short deck since day No. 1. Even the different variations have always looked like that. That’s the typical Mustang DNA. A lot of that had to do with putting a giant performance engine in it. Not every Mustang had a V8 in it but there were versions of the Mustang engine that went up to 428 in.[3].”

So when a vehicle like a Mustang goes electric, what do you do with that design? You make it look the same. “It’s an SUV silhouette, but obviously it has a Mustang DNA,” Frevik said. “It’s been very well received.”

Utilitarian Features. One of the more interesting aspects of some EVs is that they can act as an electric power source, completely upending the one-way energy flow concept. Though ICE vehicles are only energy consumers, EVs can be both consumers and providers.

The F-150 frunk is equipped with four 120-V power outlets, providing up to 2.4 kW—enough to run a jackhammer and concrete mixer simultaneously, according to the company. Ceiling lights make it an illuminated workstation.

Other new features make the truck even more utilitarian. For example, a storage area under the frunk has a drain that allows it to be hosed out for cleaning or to double as a cooler.

Port Location. The port location is one design area that may be in flux. “We’re all over the map,” Frevik said. “The charging port on the Mach-E is located in the fender. It looks like the fuel filler. On the Transit, it’s in the front grill.” A possible flaw in that location is that a front-end collision could render the vehicle unchargeable.

The F-150 port also is in the fender, but it’s hidden behind one of the Ford logo badges. The badge flips open and the charging port is located underneath. “Part of it makes up the margins for the door. I think that’s good execution. I hope that’s how it continues.”

The EV’s charging port location matchup with a charging station is in play too, especially for trucks towing campers. Charging stations are positioned close together for charging from the front or back rather than the side of the vehicle, which makes it difficult to charge a truck that is towing a camper or trailer. The truck might take over two spots or the driver might have to disconnect their camper to pull in and charge.

“Those things will probably change over time. I think we’ll see drive-through charging stations in rest areas on the interstate. Things like that will make charging more convenient,” Frevik said.

The length of the hood is in play now.

“I think we’re going to see a variety of different charge port locations and charging station positions before it settles down to a standard,” Frevik added.

The Weight Equation

Although the elimination of the engine, transmission, and exhaust system in an EV removes a substantial amount of weight, it does not offset the weight of the batteries in most cases, automakers said.

As a result, a great deal of EV design and manufacture concentrate on lightweighting and weight distribution.

Weight Distribution. Weight is more centrally distributed in EVs than ICE vehicles because the heavy engine is gone from the front and the battery pack is in the center and bottom of the vehicle, locating it at the center of gravity.

“That’s one of the advantages of an electric vehicle. You get better weight distribution. It’s close to 50-50, which you didn’t have with an engine up under the hood,” Frevik said.

What’s Stamped?

Frevik said that he doesn’t anticipate a major change in the process Ford uses to form parts. “It would take quite some other technology to get away from stamping. Stampings are cost-effective,” Frevik said.

Frevik projected that legacy automakers like Ford will continue to manufacture the largest metal components in their plants. “The upper-body components in an EV are pretty much the same as they are in ICE vehicles. We stamp the fenders, doors, body sides, roof, floor pan, dash panel … parts that are difficult to ship because they’re large. The floor pan, additional stampings for the battery tray, cover, and protective skid plate underneath … it appears that those are gravitating towards metal stampings. Stampings are cheap and efficient.” The Mach-E lift gate is plastic; that’s purchased, he added.

In addition to the Mach-E and F-150 Lightning, Ford has electrified a delivery vehicle, called Transit. The team made some engineering changes for electrification, such as hole locations, but didn’t need to make any unique stampings for that vehicle, Frevik said. “They’re pretty flat and boxy, so it’s not anything real difficult. It’s all steel. Nothing aluminum. And we make a lot of stampings for that vehicle. We have one press dedicated to the Transit and we’re running that 24/7.”

The only electrical stampings that are unique to EVs are the ones related to the battery enclosure, Frevik added. “Anything involved with the battery enclosure looks like new business for us.”

Battery Construction. Because the batteries are located in the vehicle underbody, they need to be protected, Frevik said. Battery enclosures house the high-voltage batteries, electrical components, sensors, and connectors, and protect critical components from potential

impact, heat, and water while contributing to the structural aspects of a vehicle's frame.

"All the battery guts are in there, the anodes and cathodes. If you drive over something and scrape the bottom, you don't want to pierce the battery." There are three main stamped components in the battery pack: the tub; the cover, which is screwed on; and the protective shield underneath.

In addition, up to seven cross members and reinforcements could potentially be stamped with progressive dies or hot stamped. "Those are parts we would purchase from suppliers if we don't have capacity to make them in-house. All of those parts are all good-sized stampings."

The F-150 is a body-on-frame vehicle. That battery pack for the Lightning fits inside the frame, which provides additional protection for the battery, Frevik said.

Ford converted the space vacated by the engine and transmission to a sealed, watertight, lockable frunk in the F-150 Lightning and Mustang Mach-E.

Frevik said that although battery electric vehicles still are more expensive to manufacture than an ICE vehicle, costs are projected to come down. "As batteries store more energy and cost less to produce, it's going to go that way. Eventually, it'll come to a point where the battery is less expensive and a battery electric vehicle is more profitable to build," he predicted.

Currently, Tier 1 supplier Magna supplies the battery enclosures for the F-150 Lightning, as it stated in a press release. Frevik speculated that although Ford is sourcing batteries and battery packs currently then assembling them into the vehicle, their manufacture is primed to move in-house as well eventually, in an effort to reduce battery costs. "When it comes to making the batteries, I believe Ford and other traditional OEMs are moving toward vertical integration and will be building the batteries in-house. The battery is one of the most expensive components of an electric vehicle," he expounded. "We're trying to drive the cost down."

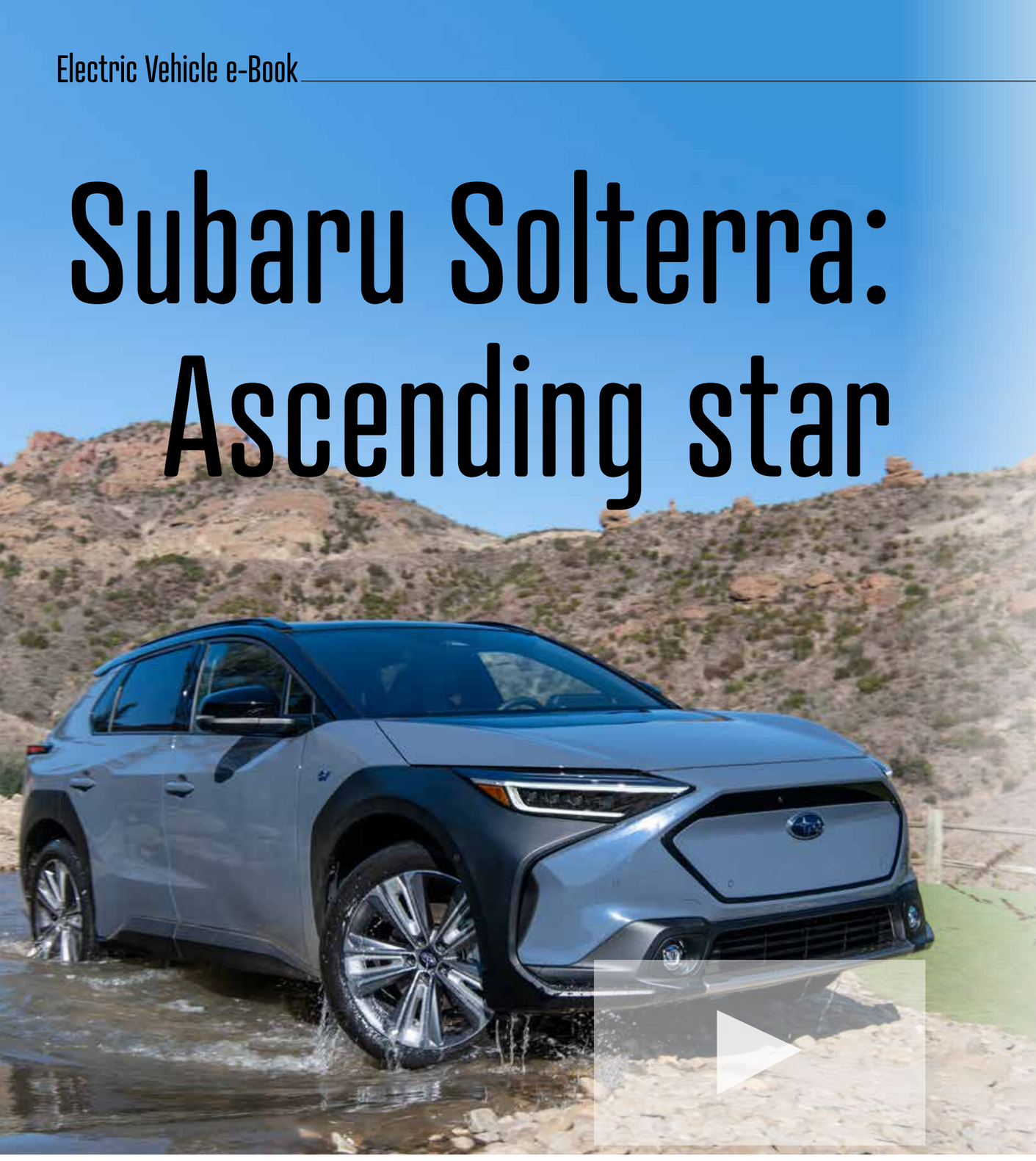
Another reason automakers are likely to manufacture the battery enclosures in-house is simply because of their size, Frevik predicted. "The battery is pretty large. When you think about the F-150 Lightning, the battery's got to move a lot of weight; it's got to have a good-sized battery. And there's some structure to it. So the battery enclosures are very large. Potentially, they're bad shippers."

He added that the main transitions that may occur are in the steel/aluminum makeup. Ford runs feasibility studies on both steel and aluminum stampings for the enclosure. "We have some all-aluminum vehicles, and we have some vehicles that are almost all steel, except for maybe an aluminum hood."

Motors. Frevik projects that OEMs will manufacture the motors in-house also. "Rather than closing all the engine plants and transmission plants, OEMs are going to gravitate towards making the batteries and motors in their power train divisions ... motors and batteries versus engines and transmissions."

"Anything could change," he added. EV

Subaru Solterra: Ascending star



Meeting the Subaru mindset

While some legacy automakers surprised consumers by coming out with electric vehicles in 2022, others surprised their loyal customers by not doing so. Subaru has successfully established itself as a friend of the environment, fostering expectations for an EV. Enter the 2023 Solterra. The name combines the Latin words for sun and earth.

Subaru Car Line Planning Manager Garrick Goh pointed to the heightened consumer demand for EV, especially among the automaker's loyal customer base, "Subaru customers tend to be highly educated. They consider themselves global citizens. They are very concerned about the planet. They believe climate change is real and they want to do something about it. So an EV totally fits with that mindset." He added, "And for us to come up with an EV that lets them do Subaru things—that's even better."

Cyber Vehicle or Just Part of the Brand?

Goh said that Subaru's approach for the Solterra was for it to blend in with the company's brand identity.

"We did not want it to be a commuter car just because it's an EV. We did not want it to be some kind of weird space pod urban car. It had to be an SUV that you can use every day.

"That means it has to have good ground clearance. It clears the ground by 8.3 in. That means it has to have a superior all-wheel-drive system. It needs to be able to handle very well in all weather, off-road, and do other 'Subaru things' like support bikes on the roof trailer, have a trailer hitch … house muddy dogs in the back."

How Has Electrification Affected the Vehicle Architecture?

Garrick Goh

Unlike some other legacy automakers, instead of converting an existing platform to an EV, Subaru chose to design a completely original platform. "Making an EV offers a lot of possibilities for us," Goh relayed. The automaker built the chassis as a skateboard-style platform with all the batteries at the bottom. This resulted in a flat floor.

Space. The new propulsion system eliminates the large engine, exhaust, radiator, and transmission, freeing up a massive amount of space. Automakers have taken different approaches to dealing with this space in their designs.

Rather than design the Solterra with a frunk, the company shortened the front area and enlarged the interior space.

"Instead of hanging a gasoline engine out in front of the front wheels, the motor is in line with the wheels. We took advantage of the EV skateboard

platform to stretch the wheel base. That opens up so much more space in the cabin. We've got more room in the back seat, too, compared to some of our other vehicles.

"We do not have a frunk in the Solterra. If you park it alongside another EV that has a frunk and line up the front wheels, the other EV will tend to be at least 2 ft. longer. We felt that a frunk was an inefficient way to use space. Yeah, it's nice to have a frunk, but is it better if you have to have a car that's 2 ft. longer? We don't think so."

Goh said the altered architecture allowed company designers to get more playful with the styling. The cabin does not look like a traditional ICE vehicle's. "Even the digital gauge instrument cluster is on a floating, freestanding platform, with the big 12.3-in. touchscreen in the center," Goh said.

Because there is no transmission between the driver and front passenger seat, that whole area now is storage. "So you can put your muddy boots, shoes, purse, whatnot in there," he added.

Features. The new propulsion system has forced automakers to take a new approach to the anatomy of the vehicle. In many ways, it has freed them up to design the vehicle differently to include features they couldn't before and to improve the user experience.

Goh said that because the Solterra was "built from the ground up," its design was based on customer preferences.

"Customers wanted something modern. They absolutely wanted something safe. All of them specifically said, 'We do not want to be seen driving something that looks like a science experiment.' So, we gave the Solterra a modern design, but not something that says, 'Hey, look, I'm driving an EV.' Our customers are not into prestige. They're not into status. They are just confident in knowing that they bought a really good vehicle, and they don't feel the need to shout it to everybody."

Goh cited Solterra's off-road performance as a benefit. "It seems that most of our competitors' focus is on on-road performance; we are taking this Subaru off-road." Because it doesn't have long overhangs in the front and the rear, drivers are able to drive over certain kinds of obstacles more easily, Goh reported. "We'll have best-in-class ground clearance. And of course, it has symmetrical all-wheel drive, which is not just a marketing ploy. Even though it is a completely different system than our gas cars, it still has to pass all of our internal standards for all-wheel drive.

"The instant torque from the electric motors makes off-road driving a more relaxing experience because you can just creep right up to whatever rock you're trying to drive over and crawl right over it.

"Because the electric motors and associated hardware are physically smaller, that lets us have a lower tow height and a lower hood line for better outward visibility," Goh said.

Manufacturing Challenges

Manufacturing an EV did present challenges for Subaru, Goh said, in terms of its safety goals and balancing weight.

Meeting Safety Standards. Safety has been a brand earmark for Subaru and so is a huge priority, Goh said. "We are aiming for a five-star rating from NHTSA and Top Safety Pick from IIHS for this vehicle." Designing for safety in an EV differs from designing safety for a gas-fueled vehicle because of the altered architecture.

"When you are in a front collision in a gas-fueled car, you've got the engine, transmission, and everything in that engine compartment to help absorb some of the impact. But in an EV, you've got a heavy battery pack in the middle and a motor right in front of it—that's it."

To compensate for the absence of the engine and the distance in the front for encroachment in a crash, Subaru built in additional high-strength steel (HSS) structural components around the front and back of the vehicle to dissipate the crash energy, Goh said. To protect the occupants and the battery on side impact, a lot of HSS is used along the side of the vehicle for reinforcement.

Balancing Weight Equation. Although the elimination of the engine, transmission, and exhaust system in an EV removes a substantial amount of weight, it does not offset the weight of the batteries in most cases.

Like most other EV, the weighty battery has made a dent in efforts to reduce overall vehicle weight. The Solterra's weight is between 4,365 and 4,505 lbs., with a 222 to 228 miles-per-charge range, depending on trim level.

"It is still noticeably heavier [than an ICE SUV], even though we are lightweighting as much of the car as we can. The batteries are really heavy," Goh said. He noted that even though the EV powertrain is heavier, the weight is in a good position. "It's toward the center of the car and down very low. As a result, there is very little body roll. If the driver throws the vehicle around hard, it doesn't lean because of the low center of gravity."

Weight Distribution. As a result, Subaru has increased the advanced high-strength steel (AHSS) and HSS significantly in its Solterra to offset the battery weight to lightweight the vehicle, Goh said.

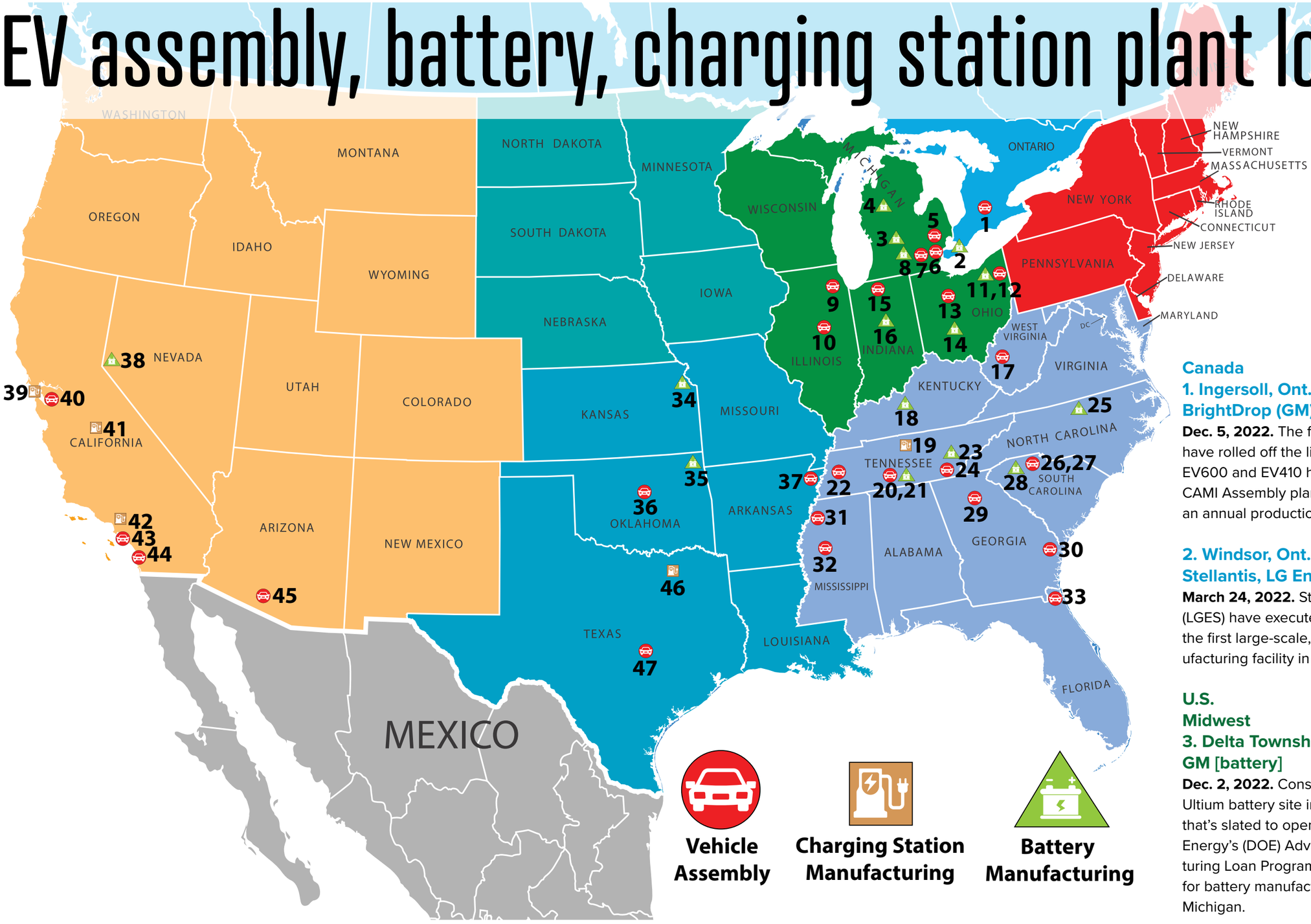
With the weight more centrally distributed than in ICE vehicles because the heavy engine is gone from the front and the battery pack is located in the middle and bottom of the vehicle, Subaru developed an AHSS ring structure that envelopes the front motor to help absorb some of that front crash impact load and transfer it into the center of the vehicle.

The steel types used in the vehicle are:

1180: 26%
980: 13%
590: 22%
440: 4%
270: 35%

"So the makeup of HSS in the Solterra is noticeably higher than it is on some of our other vehicles—not just because of safety, but because of weight distribution." Goh said. EV

EV assembly, battery, charging station plant locations



Canada

1. Ingersoll, Ont.

BrightDrop (GM) [vehicle assembly]

Dec. 5, 2022. The first BrightDrop electric delivery vans have rolled off the line. Production of the BrightDrop EV600 and EV410 has begun at the General Motors (GM) CAMI Assembly plant in southern Ontario. GM is targeting an annual production output of around 50,000 units.

2. Windsor, Ont.

Stellantis, LG Energy [battery]

March 24, 2022. Stellantis N.V. and LG Energy Solution (LGES) have executed definitive agreements to establish the first large-scale, domestic electric vehicle battery manufacturing facility in Canada.

U.S.

Midwest

3. Delta Township, Mich.

GM [battery]

Dec. 2, 2022. Construction has started on a third GM Ultium battery site in Delta Township near Lansing, Mich., that's slated to open in late 2024. The U.S. Department of Energy's (DOE) Advanced Technology Vehicles Manufacturing Loan Program is providing a $2.5 billion loan to GM for battery manufacturing facilities in Tennessee, Ohio, and Michigan.

4. Big Rapids, Mich.
Gotion, Ford [battery]

Oct. 5, 2022. Gotion High Tech Co. was awarded $175 million in grants from the state of Michigan and a zoning designation estimated to be valued at $540 million, according to the Michigan Economic Development Corp. The company has proposed investing $2.4 billion in a plant in Big Rapids, Mich., to build battery anodes and cathodes and employ as many as 2,350 people.

5. Detroit-Hamtramck, Mich.
GM [vehicle assembly]

Nov. 17, 2021. GM celebrated the grand opening of Factory Zero, its first fully dedicated EV assembly plant, which the company described as a milestone in its all-electric future. President Biden attended the grand opening.

6. Detroit
Daimler Trucks NA [vehicle assembly]

Feb. 8, 2021. Daimler Trucks North America (DTNA) announced a $20 million investment in its Detroit manufacturing facility, which will produce its proprietary Detroit ePowertrain to power the upcoming Freightliner eCascadia and Freightliner eM2. The Detroit plant will serve as the North American source of Detroit ePowertrain components. DTNA, headquartered in Portland, Ore., is the leading heavy-duty truck manufacturer in North America.

7. Dearborn, Mich.
Ford [vehicle assembly]

April 26, 2022. Ford Motor Co. began full production of its F-150 Lightning electric pickup truck at the Rouge Electric Vehicle Center. The automaker plans to produce an annual run rate of 150,000 units in 2023 to meet what it describes as “soaring demand.”

8. Van Buren Township, Mich.
Our Next Energy [battery]

June 14, 2022. Our Next Energy (ONE) has signed an agreement with BMW Group to integrate its Gemini Dual-Chemistry battery technology into the BMW iX all-electric sports activity vehicle. ONE is investing $1.6 billion to convert a building in Van Buren Township, Mich., into an EV battery cell plant.

9. Joliet, Ill.
Lion Electric [vehicle assembly]

Nov. 2, 2022. Canada-based Lion Electric, a leading manufacturer of all-electric medium- and heavy-duty vehicles, produced its first zero-emission LionC school bus in its Joliet, Ill., factory. The Joliet facility is expected to have a production capacity of up to 20,000 all-electric buses and trucks.

10. Normal, Ill.
Rivian [vehicle assembly]

Nov. 7, 2022. Automaker startup Rivian won a coveted 100,000 electric Amazon delivery vans order. It produces them in addition to its all-electric R1T pickup truck and R1S SUV at its Normal, Ill., plant. Since first rolling out in July, Amazon’s zero-emissions vehicles have delivered more than 5 million packages to customers in the U.S., Amazon reported. The plant is equipped to produce up to 150,000 EVs annually. Supply chain disruptions knee-capped production output to 25,000 this year, however. The automaker also is scaling its capacity at the plant with a 623,000-sq.-ft. expansion, which will bring the total footprint of the Normal, Ill., plant to approximately 4 million sq. ft. with further plans to extend warehouse, storage, and production capacity on-site. The company plans to add 800 to 1,000 employees.

11. Lordstown, Ohio
GM [battery]

Dec. 9, 2022. GM’s Ultium battery plant voted overwhelmingly to unionize with United Auto Workers (UAW). Ultium is GM’s battery joint venture with LG Energy. The Lordstown/Warren plant in Ohio is already up and running, though, and producing batteries for GM’s Hummer EV, Equinox, Blazer, Silverado, and Cadillac Lyriq. GM’s other current EV, the Chevy Bolt—named Electrek’s EV of the year—does not use Ultium cells because it came out before Ultium was developed.

12. Lordstown, Ohio
Lordstown Motors [vehicle assembly]

Nov. 7, 2022. Lordstown Motors, Lordstown, Ohio., entered into a strategic partnership with Taiwan-based Hon Hai Technology Group (Foxconn). Foxconn plans to invest up to $170 million in Lordstown Motors. The two companies plan to pursue the first joint EV program in production of the Endurance pickup truck, which began production on Sept. 29, 2022.

13. Marysville, Ohio
Honda [vehicle assembly]

Oct. 12, 2022. Honda announced that it will start making EVs by retooling three of its Ohio plants, including the Marysville Auto Plant, where it began building cars in America 40 years ago. The automaker has committed to investing $700 million to producing EVs, beginning in 2024 with the Honda Prologue and Acura ZDX electric SUVs it is co-developing with GM.

14. Fayette County, Ohio
Honda [battery]

Oct. 12, 2022. Honda plans to make the batteries that will be used exclusively for EVs built in its Honda auto plants. It is expected to create 2,200 new jobs.

15. Mishawaka, Ind.
Mullen [vehicle assembly]

Dec. 1, 2022. Mullen announced the acquisition of Electric Last Mile Solutions (ELMS) assets, including the factory in Mishawaka, Ind. Previously, the 650,000-sq.-ft. Mishawaka plant produced GM’s Hummer H2 and the Mercedes-Benz R-Class vehicle. It will produce the Mullen FIVE SUV and the Bollinger B1 and B2 platforms.

16. Kokomo, Ind.
Samsung SDI, Stellantis [battery]

May 24, 2022. Samsung SDI and Stellantis are investing $2.5 billion in a joint venture to build a motive battery production plant in Kokomo, Ind., to meet Stellantis’ electrification strategic plan. The plant’s target production date is 2025 with an annual production capacity of 23 GWh, with intentions to increase to 33 GWh hours. Stellantis currently has a transmission and engine plant in Kokomo.

Southeast

17. South Charleston, W. Va.
Green Power Motor Co. [vehicle assembly]

Feb. 14, 2022. GreenPower Motor Co. Inc. has announced plans to open a manufacturing facility in South Charleston, W.Va., for producing zero-emission, all-electric school buses. It calls the vehicle the BEAST, which stands for battery electric automotive school transportation. It has been designed from the ground up to be battery electric.

18. Glendale, Ky.
Ford [battery]

Sept. 28, 2021. Ford Motor Co., with its partner SK Innovation, announced plans to invest $5.8 billion in a dedicated manufacturing complex called BlueOval SK Battery Park in Glendale, Ky., creating 5,000 jobs. Twin battery plants on the site are intended to supply Ford North American assembly plants with locally assembled batteries for powering next-generation electric Ford and Lincoln vehicles.

19. Lebanon, Tenn.
Tritium DCFC [charging station]

Oct. 25, 2022. Tritium DCFC Ltd., a provider of DC fast chargers for EVs, has announced a partnership with EV supply equipment manufacturer DC-America. DC-America is now offering its charging station infrastructure equipped with Tritium’s 150-kW fast chargers. The resulting EV charging system is expected to be compliant with federal Buy America standards and eligible for National Electric Vehicle Infrastructure Formula Program funding.

20. Spring Hill, Tenn.
GM [vehicle assembly]

April 21, 2022. GM began production of the 2023 Cadillac Lyriq—the brand’s first all-electric vehicle—at its Spring Hill, Tenn., assembly plant. The automaker

launched the Lyriq nine months ahead of schedule. It is equipped with GM's Ultium battery powertrain.

21. Spring Hill, Tenn.
GM [battery]

Dec. 2, 2022. GM announced that it and partner LG Energy Solutions are investing $275 million at their Tennessee Ultium Cells LLC joint-venture battery plant to increase cell production there when it opens in late 2023. Expanding the Spring Hill operation will increase Ultium's battery cell output by more than 40% at the plant. The additional investment is on top of the $2.3 billion initial investment GM and LG announced in 2021. The expansion will add 400 jobs to the 1,300 previously anticipated for the plant.

22. Stanton, Tenn.]
Ford Motor Co. [vehicle assembly]

Sept. 28, 2021. Ford Motor Co., with its partner SK Innovation, announced plans to invest $5.6 billion in a mega campus called BlueOval City in Stanton, Tenn. The next generation of electric F-Series trucks and the batteries for future EVs are to be produced at the 6-sq.-mile complex, creating approximately 6,000 jobs.

23. Etowah, Tenn.
Piedmont Lithium [battery]

September 2022. Piedmont Lithium announced a $582 million investment to establish a lithium hydroxide processing, refining, and manufacturing facility in southeast Tennessee. With proximity to lithium and byproducts markets, the integrated project will consist of a proposed mine, spodumene concentrator, and lithium hydroxide conversion plant. It is expected to produce 30,000 mt of lithium hydroxide per year when fully operational in 2026.

24. Chattanooga, Tenn.
Volkswagen [vehicle assembly]

July 26, 2022, Volkswagen shifted the manufacturing of its 2023 ID.4 EV from Germany to its Chattanooga, Tenn. Assembly Plant. The Volkswagen ID.4 and ID.5 are battery electric, compact crossover SUVs based on its MEB platform.

25. Greensboro-Randolph, N.C.
Toyota [battery]

Aug. 31, 2022. Toyota Motor North America said that it was more than doubling its investment in a battery plant in North Carolina as part of a broader effort to catch up to rivals in fielding EVs. The automaker said it would invest an additional $2.5 billion in the plant, which is to be built near Greensboro, an expansion that would create an additional 350 jobs. It now expects to spend a total of $3.8 billion on the factory and to employ 2,100 people.

26. Spartanburg, S.C.
OshKosh Defense [vehicle assembly]

July 20, 2022. Upon urging by the White House and environmentalists, the U.S. Postal Service will order four times more zero-emission battery electric vehicles (BEV) than originally planned as part of the Next Generation Delivery Vehicles fleet to be produced in Spartanburg, S.C., starting in 2023 by Oshkosh Defense. USPS will make 40% of its new trucks electric, up from 10%. The wholly owned subsidiary of Oshkosh Corp., Oshkosh, Wis., opened a dedicated facility in Spartanburg, S.C., to build USPS EVs. The company expects to hire more than 1,000.

27. Spartanburg, S.C.
BMW [vehicle assembly]

Oct. 19, 2022. BMW Group announced it will invest $1.7 billion to build EVs in U.S. in Spartanburg, S.C. and will spend $700 million on a new high-voltage battery assembly facility in nearby Woodruff, South Carolina, and create at least 300 jobs. BMW employs 11,000 people at the 7 million sq.-ft. campus. This is the latest announcement from a major automaker about plans
to ramp up U.S. EV production.

28. Greer, S.C.
Proterra [battery]

Dec. 14, 2021. Proterra, a manufacturer of electric transit vehicles and components based in California, has announced plans to build a factory in Greer, S.C., to produce its EV battery systems for delivery and work trucks, industrial equipment, and buses. The company plans to begin production in second half of 2022. Proterra committed to a minimum investment of at least $76 million and expects to create more than 200 new jobs.

29. Rutledge, Ga.
Rivian [vehicle assembly]

Nov. 10, 2022. Rivian will delay production of a new crossover at its second manufacturing plant, being built in Rutledge, Ga., near Atlanta, until 2026. The company announced its intentions to build a second plant in early 2022. A $1.5 billion state subsidy was part of the deal. The company has encountered legal resistance by neighboring property owners.

30. Savannah, Ga.
Hyundai [vehicle assembly] [battery]

May 22, 2022. Hyundai announced a $5.5 billion investment to build facilities dedicated to manufacturing EVs and batteries in Savannah, Ga., marking Hyundai's first EV-only plant in the U.S. (via CNBC). The South Korean automaker will spend $5.5 billion on the new facilities and will receive an additional $1 billion investment from its suppliers.

31. Tunica, Miss.
Mullen Technologies [vehicle assembly]

March 21, 2021. Mullen Technologies Inc., an emerging EV manufacturer based in California, is merging with Net Element Inc. in a stock-for-stock reverse merger, with plans to deliver EV out of Tunica, Miss., near Memphis, Tenn. The 120,000-sq.-ft. facility sits on 100 acres and will employ approximately 50 people in the first year, with plans to employ 200 employees in three years.

32. Canton, Miss.
Nissan [vehicle assembly]

March 10, 2022. Nissan announced plans to build two new, all-electric models at its Mississippi assembly plant. The automaker is transforming its Canton Vehicle Assembly Plant in Mississippi with the latest in EV manufacturing technology to support production of two all-new, all-electric vehicles.

33. Jacksonville, Fla.
Cenntro Automotive [vehicle assembly]

Jan. 26, 2022. Cenntro Automotive, a manufacturer of electric commercial vehicles, has selected Jacksonville, Fla., for its first U.S.-based manufacturing facility.

Central

34. De Soto, Kan.
Panasonic [battery]

July 13, 2022. Panasonic announced it will build a $4 billion plant in De Soto, Kan., that will create 4,000 jobs. The Kansas plant is expected to produce Tesla-designed next-generation 4680 cells and supply the carmaker's

factory in Texas. Kansas Governor Laura Kelly approved a package of incentives worth as much as $1 billion in early 2022.

35. Pryor, Okla.
Canoo [battery]

Nov. 2, 2022. EV startup Canoo announced its plans to build a battery manufacturing facility in Pryor, Okla., with a capacity of 3,200 MWh.

36. Oklahoma City
Canoo [vehicle assembly]

Nov. 9, 2022. E-mobility company Canoo plans to acquire a vehicle manufacturing facility in Oklahoma City to produce Canoo's LDV and LV vehicles for delivery to customers in 2023. The company won a contract from WalMart to produce its delivery vehicles.

37. Osceola, Ark.
Environtech [vehicle assembly]

March 21, 2022. Envirotech, a manufacturer of electric transit and commercial vehicles, has announced it will build an $80 million manufacturing facility in Osceola, Ark., creating more than 800 jobs.

West/Southwest

38. Sparks, Nev.
Panasonic / Tesla [battery]

Oct. 3, 2022. Tesla, partnering with Panasonic, will expand its Gigafactory 1 after years of being at 30% of its final expected size. Tesla Gigafactory Nevada was the first major step in Tesla's effort to secure battery cell supply for its ambitious growth. Panasonic has unveiled its 4680 battery, a prototype designed for use in Tesla EVs. Telsa manufactures batteries, electric motors, and powertrains at the site.

39. San Francisco
Ford/ Electriphi [charging station]

June 18, 2021. Ford has announced it is acquiring Electriphi, a California-based provider of charging management and fleet monitoring software for EVs.

40. Freemont, Calif.
Tesla [vehicle assembly]

June 11, 2022. Tesla's first factory in Fremont, Calif., produces its Model S, Model 3, Model X, and Model Y. Tesla now produces more cars at the Fremont factory than when it was operated by GM and Toyota, according to Tesla. To date, Tesla produces more EVs than any other automaker. From all of its sites, it has the capacity to manufacture more than a million vehicles every year, the company says.

41. Fresno, Calif.
Infinity Energy
[charging station]

Dec. 1, 2021. Solar energy firm Infinity Energy has announced plans to build a facility in Fresno, Calif., to produce solar-powered charging stations for EVs. The company, which provides solar power systems to homeowners and commercial facilities, received a tax credit from the state of California for $2.5 million to support the construction of an $11 million facility that will manufacture solar-powered electric car charging stations.

42. Los Angeles
EVgo [charging station]

March 17, 2022. Los Angeles-based EVgo Inc., a public fast-charging network for EVs powered by 100% renewable electricity, has expanded its EVgo Advantage program and formed a partnership with Save Mart Companies.

43. Gardena, Calif.
Faraday Future [vehicle assembly]

Nov. 22, 2022. Faraday Future warns it may not be able to deliver its luxury EV. The EV startup has raised a going concern warning, per regulatory filings. The company said it has substantial doubt as to whether it would be able to continue operating over the next year, adding that it is uncertain when it will dispatch first deliveries of its FF 91 luxury EVs.

44. Carlsbad, Calif.
Aptera Motors [vehicle assembly]

Nov 22, 2022. Aptera Motors is an American high-efficiency startup car company. It produces the world's first solar EV that requires no charging for most daily use. The company reports that its vehicles have up to 1,000 miles of range and best-in-class aerodynamics. CNBC speculated that solar vehicles might be the next generation of EVs.

45. Casa Grande, Ariz.
Lucid Motors [vehicle assembly]

Aug. 25, 2022. According to recent reports, Lucid's Casa Grande, Ariz., site will expand to about three times its current size to 2,000 acres. The automaker produces the Lucid Air and recently released the Lucid Air Grand Touring Performance, a dual-motor EV with 1,050 HP and an estimated driving range of 446 miles.

46. Plano, Texas
SK Signet [charging station]

Dec. 2, 2022. SK Signet, a manufacturer of EV charging systems, has announced plans to open its first U.S. manufacturing facility for EV fast chargers in Plano, Texas, creating up to 183 jobs by 2026. The 136,200-sq.-ft. facility is expected to be operating at full capacity by July 2023, producing more than 10,000 fast chargers per year.

47. Austin, Texas
Tesla [vehicle assembly]

March 11, 2022. Reuters has reported that Tesla has raised prices on its U.S. Model Y SUV and Model 3 Long Range sedan by $1,000 each amid surging raw material costs, made worse by Russia's invasion of Ukraine. Tesla still commands over 60% of the market share in the U.S. and many developed countries. Gigafactory Texas, the company's new global headquarters in Austin, produces the Model Y and is the future home of its Cybertruck.

Mexico

48. Cuautitlán, Mexico
Ford [vehicle assembly]

Dec. 1, 2022. Ford will triple production of its electric Mustang Mach-E model. As of January 2023, production will increase from 70,000 units to 270,000 units per year. Unlike the ICE Mustang models, the Mach-E is not assembled in the U.S. Rather, the final assembly of the Ford Mach-E is at Ford's plant in Cuautitlán, Mexico for the North American market, as well as for 37 global markets. Sales of the Mach-E have made Ford the second-best-selling electric car brand in the U.S.

49. Ramos Arizpe, Mexico
Magna [battery]

April 20, 2022. LG Magna e-Powertrain, a joint venture between LG Electronics and Magna Intl. Inc., has started construction of its new plant in Ramos Arizpe, Mexico.

Quotes of Interest

"It's not like you can stop assembling ICE vehicles one day and start assembling BEVs the next day. It's a transition, not a switch."—*Reinhard Fischer, Volkswagen*

"The scale we can get supplying one component over eight vehicles is probably on par with—or larger than— what an OEM could get across their own volumes."
—Sandy Stojkovski, Vitesco

"We've got to build the supply chain. Recent legislation is trying to help us do that, but still, 80% of all the lithium-ion battery materials in the world are processed in China, and 60% of them are mined there."
—John Warner, American Battery Solutions

"The supplier selection is not a blind bid situation anymore, where the lowest price wins. It's 'Where is the value-add?' 'Do they provide an advantage all the way through?'"—*Tim Grewe, General Motors*

"One of our 100-kWh battery packs is over 800 lbs., so serious structural support has to be engineered in." –*Harry Husted, BorgWarner*

"Early adopters of electric vehicles … they're not going back. We're way past the tipping point."—*Bob Kruse, Faraday Future*

"The differences [between ICE vehicles and EVs] drive a lot of the questions: 'Make or buy? What do we build in-house? What do we outsource?'"
—Reinhard Fischer, Volkswagen

"A lot of material choices for the battery tray and the chassis—steel, aluminum, composites—come down to what are you are a master in. The Bolt EV has eight different kinds of steel in the battery tray. I think we'll stay with steel for a long, long time."
–Tim Grewe, General Motors

"BorgWarner has long been an engine-based, transmission-based, propulsion system manufacturer. With our 'Charging Forward' initiative a year ago, we declared that we're all in on EVs."
—Harry Husted, BorgWarner

"Typically, at the end of life of an EV, you still have 80% or so of battery life left. So, the battery can have a life after personal transportation."—*Bob Kruse, Faraday Future*

"And so, this insourcing/outsourcing, control/competition pendulum … I think we've seen this movie before."
—Sandy Stojkovski, Vitesco

On-ramping the EV ecosystem

Supplying the EV infrastructure may temper heightened competition

A perspective from FMA President Ed Youdell

With every drive I take these days, I see increasingly more electric vehicles in the lanes near me on the highway or dotting the parking lots and streets around my hometown. According to electric vehicle tracker Electrek, 2022 was the biggest year on record for EV sales, and more than 200,000 EVs were sold in the third quarter. The U.S. EV market share has exceeded 6%, which is real progress towards the current administration's goal for EVs to make up half of all U.S. vehicle sales by 2030.

The U.S. Environmental Protection Agency and the U.S. Department of Transportation (DOT) have added teeth to the goal by reinstating efficiency standards for vehicles, which require new cars to produce 10% fewer greenhouse gas emissions, starting in 2023. Further reductions of 5% a year will be required until 2026.

Facing Headwinds Head On …

The headwind in the face of EVs reaching such lofty adoption rates is the need to have the corresponding infrastructure of charging stations and ports to supply the power to the coming wave of EVs.

The U.S. DOT has approved all states for EV charging stations, and plans are to build these units across 75,000 miles of highway from coast to coast. According to the U.S. Department of Energy, the country currently has about 47,000 EV charging stations providing more than 120,000 charging ports.

A recent report by www.cheaper-quotes.com, a car insurance comparison website, projected 35 million EVs will reach the road in 2030. Subsequently, the U.S. will need to build and install 1.5 million new charging ports to supply these vehicles with power. This means about 478 charging stations will need to be built every day for the next eight years.

The current universe of manufacturers making EV charging stations is around 300 globally, with nearly 100 in North America, according to Reuters. And according to PitchBook, investors have ponied up more than $2 billion for startups. Some companies, such as EVgo, Nuvve, ChargePoint, and Volta Charging, have decided to go public through SPAC-backed reverse mergers. Corporate money also is in the game. Toyota Motor Corp., Daimler AG, Shell, Chevron, Qualcomm, and eBay all have made startup investment plays.

… With Metal Stampings, Fabrications

Stampers and metal fabricators seem to me to be the ideal supply chain partners to build the needed

enclosures and components that comprise a charging station. The Infrastructure Investment and Jobs Act that Congress passed in 2021 allocates $7.5 billion for charging station infrastructure, split between $5 billion for states to roll out charging stations and $2.5 billion in competitive grants for specific community-based programs. Finding a charging station OEM that you can partner with is a challenge to consider as an opportunity ahead.

Inherent to EV architecture is the fact that it takes fewer vehicle components to build the car. There likely will be more competition to build those components. I would expect it to intensify as suppliers ramp up their efforts to identify and capture opportunities to increase their offerings to this new sector.

Still, the EV market is expanding. That does not mean finding the supply chain opportunities will be easy. As the old saying goes, “If it were easy, anyone could do it.” It will take the usual ingredients like creativity and hustle to capture the work, but those who are prepared and have the necessary secret sauce when the opportunity comes will be successful.

Metal stamping and fabricating manufacturers have an opportunity to shape the daily interaction that millions of consumers will have with these charging stations and other critical elements while connecting their commutes. Policymakers should know the reliability and innovation that our industry is uniquely positioned to contribute.

It is in your best interest to stand ready when the moment arrives and to ask leaders across the country to prioritize on keeping the opportunities here for American businesses. EV

www.fmamfg.org

The headwind in the face of EVs reaching such lofty adoption rates is the need to have the corresponding infrastructure of charging stations and ports to supply the power to the coming wave of EVs.