

## Power play: Evaluating the U.S. position in the global electric vehicle transition

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This briefing evaluates the U.S. position in the emerging global light-duty electric vehicle industry. The briefing analyzes U.S. vehicle manufacturing plants and automaker commitments to transitioning to electric vehicle production and compares these developments with those happening globally.

### INTRODUCTION AND BACKGROUND

Global momentum to shift entirely to electric vehicles continues. National governments such as those of Canada, France, Germany, the Netherlands, Norway, Spain, and the United Kingdom, have announced their intention to transition to all electric vehicle sales in the 2025–2050 time frame.<sup>1</sup> To accelerate the transition to electric, governments are setting clear targets and implementing various regulatory, consumer, and industrial policies to overcome the barriers to widespread adoption.

The world's stock of electric passenger vehicles surpassed 10 million in 2020. Figure 1 shows global growth in electric vehicle sales from 2010 through 2020, which have increased from a few thousand in 2010 to more than 3.1 million in 2020.<sup>2</sup> Electric vehicles, including both battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), represented about 4.2% of all new passenger vehicles sold worldwide in 2020. Relative sales in the major regions are shown by the different colors in Figure 1, such that the two North American markets are shades of blue, the seven European markets are shades of green, and the three Asian markets are shades of red.

<sup>1</sup> Hongyang Cui, Dale Hall, Nic Lutsey, *Update on the global transition to electric vehicles through 2019* (Washington, DC: ICCT, 2020), <https://theicct.org/publications/update-global-ev-transition-2019>

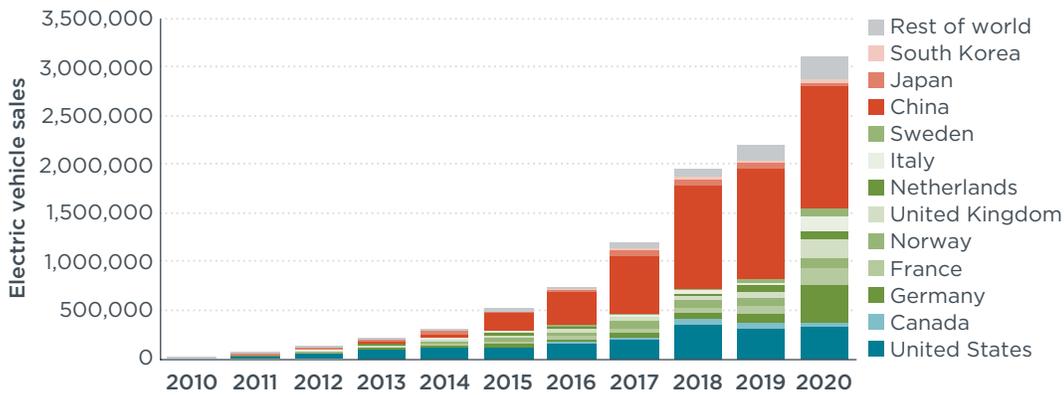
<sup>2</sup> Data obtained from EV-Volumes (EV Data Center, 2020), <http://www.ev-volumes.com/datacenter/>

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The 12 countries' markets shown together account for about 94% of all electric vehicle sales through 2020.

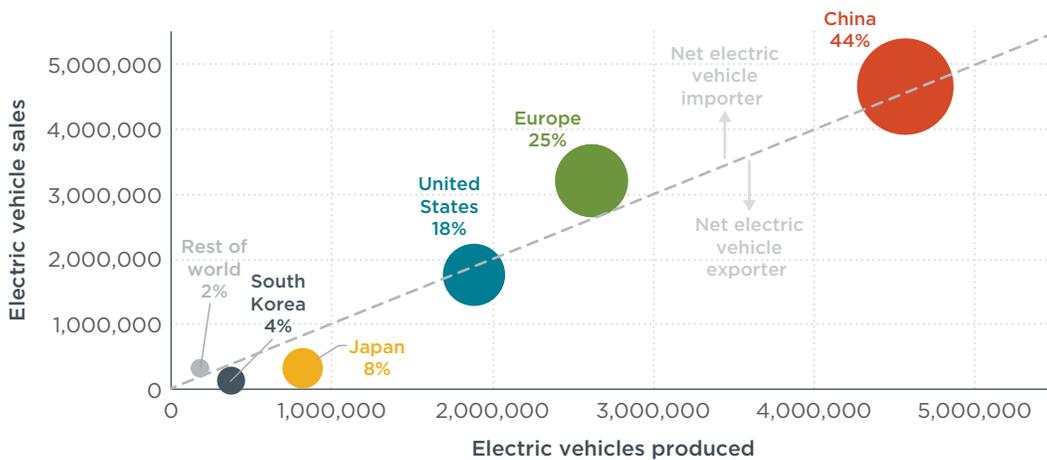


**Figure 1.** Global electric vehicle sales from 2010 through 2020 (based on EV-Volumes, 2021).

Governments' motivation to transition to electric vehicles is driven by the need for a stable climate, reduced fuel expenditures, reduced petroleum dependence, and clean air, especially for those disproportionately impacted by pollution. Equally motivating for many governments with considerable technology and manufacturing sectors is the opportunity to economically benefit from the emerging technology and its growing supply chain. Major economies such as China, Japan, Germany, the United States and others where there is substantial automobile manufacturing face the greatest industry risk if they lag in the transition to electric vehicles. Relatedly, the Biden administration's American Jobs Plan calls for \$52 billion in U.S. support with access to capital and tax credits for domestic manufacturing, including for the auto industry.<sup>3</sup> Countries that stake out a leadership position in the developing electric vehicle industry stand to gain from increased employment opportunities, expanded domestic vehicle sales, and expanded exports to other vehicle markets as the global electric vehicle transition continues.

Global electric vehicle sales and production trends provide an important introduction into the emerging industry dynamics. Figure 2 shows the cumulative electric vehicle sales (vertical axis) and production (horizontal axis) from 2010 through 2020 in China, Europe, the United States, Japan, and South Korea. These five regions account for about 97% of sales and 98% of production of electric vehicles. The diagonal dashed line represents equal sales and production, so markets that are above the line are net importers whereas those below the line are net exporters of electric vehicles. The circle sizes are proportional to the percentage of the approximately 10.5 million electric vehicles produced through 2020.

<sup>3</sup> The White House. "Fact sheet: The American Jobs Plan," (March 31, 2021), <https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/>



**Figure 2.** Cumulative electric vehicle sales and production from 2010 through 2020, in major regions (based on EV-Volumes, 2021).

Figure 2 puts U.S. electric vehicle sales and production into a broader global perspective. China is the largest electric vehicle producer and accounts for about 44% of electric vehicle production through 2020 with about 4.6 million in production and sales. Europe follows with 25% of global electric vehicle production, accounting for 2.6 million electric vehicles produced, and 3.2 million sold, making it a net importer. The United States represents about 18% of cumulative global electric vehicle production, down from 20% in 2017. In terms of annual production in 2020, the United States produced more than 450,000 electric vehicles, with Tesla accounting for about 85%, and annual electric vehicle exports exceeded 215,000, the most of any country. Also shown, Japan and South Korea have lower volume production and sales, and they are net electric vehicle exporters.

Electric vehicle sales and production dynamics have implications for where and when vehicle manufacturers make the transition to electric vehicle production. Most electric vehicles are manufactured in the same region in which they are sold. Of the 10 million cumulative electric vehicles sold through 2020, 80% of electric vehicle sales occurred in the region where they were manufactured. Based on automakers' inclination to locate manufacturing within the same region as their major markets, a clear way to attract electric vehicle production is to develop a market with increasing electric vehicle sales and supporting regulations, incentives, and charging infrastructure.<sup>4</sup> The global average electric vehicle share of new light-duty vehicles in 2020 was 4.2%. European sales greatly exceeded this with a 10% share, China somewhat exceeded with 6%, the United States lagged at 2.3%, South Korea lagged at 2.2%, and Japan lagged at 0.8%.

Industry announcements and investments to increasingly deploy far more electric models ensure the growth in electric vehicle sales and production will continue in the years ahead. Major automaker announcements are summarized in Table 1, which includes the estimated value of investments, the number of electric models involved, and company goals for future electric vehicle sales and electric vehicle sales shares. We note that many emerging and start-up electric vehicle companies (e.g., Nio and Xpeng) have not specified such future capacity or production targets and are not

<sup>4</sup> Nic Lutsey, Mikhail Grant, Sandra Wappelhorst, and Huan Zhou, *Power play: How governments are spurring the electric vehicle industry* (Washington, DC: ICCT, 2018), <https://theicct.org/publications/global-electric-vehicle-industry>.

included. By linking the companies' electric production through 2020 and these announced targets, we estimate that electric vehicle production will increase from 3.2 million in 2020 to about 22 million in 2025 and about 35 million by 2030.

**Table 1.** Automaker electric vehicle model offerings and sales targets.

| Automaker group                   | Announced investment  | Electric models  | Annual global electric sales (approximate share of automaker overall production)   |
|-----------------------------------|---|--|--|
| <b>Volkswagen Group</b>           | <ul style="list-style-type: none"> <li>\$42 billion on BEVs by 2025</li> <li>\$60 billion battery procurement</li> </ul>  | <ul style="list-style-type: none"> <li>70 battery electric models by 2030</li> <li>Electric or hybrid version of all models by 2030</li> </ul>   | <ul style="list-style-type: none"> <li>4-5 million (40%) by 2030</li> </ul>  |
| <b>Nissan-Renault-Mitsubishi</b>  | <ul style="list-style-type: none"> <li>\$9.5 billion in China over 2018-2022</li> <li>\$1 billion in Thailand by 2020</li> </ul>  | <ul style="list-style-type: none"> <li>20 electric models by 2022 (China)</li> </ul>   | <ul style="list-style-type: none"> <li>3 million (30%) by 2022</li> </ul>  |
| <b>Toyota-Suzuki-Mazda-Subaru</b> | <ul style="list-style-type: none"> <li>\$2 billion over 2019-2023 in Indonesia for hybrid and electric vehicles</li> <li>\$1.2 billion Tianjin factory (Toyota with FAW)</li> </ul> | <ul style="list-style-type: none"> <li>All vehicles hybrid, battery, or fuel cell electric by 2025</li> </ul>  | <ul style="list-style-type: none"> <li>2-3 million (15%) by 2025</li> </ul>  |
| <b>Ford</b>                       | <ul style="list-style-type: none"> <li>\$30 billion by 2025</li> </ul>  | <ul style="list-style-type: none"> <li>16 all-electric models by 2022</li> <li>In Europe, all plug-in electric by mid-2026 and all electric by 2030</li> </ul>   | <ul style="list-style-type: none"> <li>2.3 million (40%) by 2030</li> <li>600,000 in Europe from 2023 through 2028 (up to 20%)</li> </ul>                |
| <b>Honda</b>                      | <ul style="list-style-type: none"> <li>\$430 million facility in China</li> <li>\$300 million for battery plants</li> </ul>   | <ul style="list-style-type: none"> <li>100% hybrid or electric sales in Europe by 2025</li> <li>20 electric models in China by 2025</li> <li>Two-thirds hybrid or electric sales globally by 2030</li> </ul> | <ul style="list-style-type: none"> <li>100% battery electric or fuel cell by 2040</li> <li>2 million (30%) by 2030</li> </ul>                            |
| <b>Chongqing Changan</b>          | <ul style="list-style-type: none"> <li>\$15 billion by 2025</li> </ul>  | <ul style="list-style-type: none"> <li>21 electric models by 2025</li> <li>12 plug-in hybrid models by 2025</li> </ul>   | <ul style="list-style-type: none"> <li>1.7 million (100%) by 2025</li> </ul>   |
| <b>Mercedes</b>                   | <ul style="list-style-type: none"> <li>\$13 billion manufacturing plant</li> <li>\$1.2 billion battery manufacturing</li> <li>\$22 billion battery procurement</li> </ul>           | <ul style="list-style-type: none"> <li>10 electric models by 2022</li> <li>25 plug-in hybrid models by 2025</li> </ul>   | <ul style="list-style-type: none"> <li>1.5 million (50%) by 2030</li> </ul>  |
| <b>Geely</b>                      | <ul style="list-style-type: none"> <li>\$3.3 billion</li> </ul>   | <ul style="list-style-type: none"> <li>All models hybrid or electric by 2019 (Volvo)</li> </ul>  | <ul style="list-style-type: none"> <li>780,000 (100%) BEV by 2030 (Volvo)</li> </ul>   |
| <b>Tesla</b>                      | <ul style="list-style-type: none"> <li>\$5 billion factory in Shanghai</li> <li>\$4.4 billion factory in Berlin</li> <li>\$1 billion factory in Texas</li> </ul>                    | <ul style="list-style-type: none"> <li>Six all-electric models</li> </ul>  | <ul style="list-style-type: none"> <li>1 million (100%) by 2022</li> <li>20 million (100%) by 2030</li> </ul>  |
| <b>Hyundai</b>                    | <ul style="list-style-type: none"> <li>\$16 billion through 2025</li> </ul>   | <ul style="list-style-type: none"> <li>23 BEV, 6 PHEV, 2 fuel cell electric vehicles (FCEV) by 2025 (Hyundai Motor Group)</li> </ul>   | <ul style="list-style-type: none"> <li>600,000 (13%) by 2025</li> </ul>  |
| <b>Kia</b>                        | <ul style="list-style-type: none"> <li>\$25 billion through 2025</li> </ul>   | <ul style="list-style-type: none"> <li>11 electric vehicles by 2026</li> </ul>   | <ul style="list-style-type: none"> <li>500,000 (17%) by 2026</li> <li>880,000 (27%) by 2030</li> </ul>   |
| <b>BMW</b>                        | <ul style="list-style-type: none"> <li>\$11 billion battery procurement from 2020-2031</li> </ul>   | <ul style="list-style-type: none"> <li>13 electric models by 2025</li> <li>12 plug-in hybrid models by 2025</li> </ul>   | <ul style="list-style-type: none"> <li>900,000 (30%) by 2030</li> </ul>  |
| <b>General Motors</b>             | <ul style="list-style-type: none"> <li>\$35 billion for electric and autonomous vehicles from 2020 through 2025</li> </ul>  | <ul style="list-style-type: none"> <li>30 new electric models globally by 2025, with 20 available in North America</li> </ul>  | <ul style="list-style-type: none"> <li>100% electric by 2035</li> <li>1 million by 2025 (15%)</li> </ul>   |
| <b>Fiat Chrysler*</b>             | <ul style="list-style-type: none"> <li>\$10.5 billion to develop hybrid and electric vehicles through 2022</li> </ul>   | <ul style="list-style-type: none"> <li>30 nameplates will have hybrid or electric options by 2022</li> </ul>   | <ul style="list-style-type: none"> <li>75,000 (3%) by 2022 in China and North America combined</li> </ul>  |
| <b>Jaguar Land Rover</b>          | <ul style="list-style-type: none"> <li>\$18 billion over 2019-2022</li> </ul>   | <ul style="list-style-type: none"> <li>All Jaguar models battery electric by 2025</li> <li>Offer battery electric for all models by 2030</li> </ul>  | <ul style="list-style-type: none"> <li>180,000 (100%) Jaguar battery electric by 2030</li> <li>225,000 (60%) Land Rover zero emission by 2030</li> </ul> |
| <b>BAIC</b>                       | <ul style="list-style-type: none"> <li>\$1.5 billion by 2022</li> <li>\$1.9 billion (with Daimler)</li> </ul>   | <ul style="list-style-type: none"> <li>All electric models by 2025</li> </ul>  | <ul style="list-style-type: none"> <li>1.3 million (100%) by 2025</li> </ul>   |
| <b>Great Wall</b>                 | <ul style="list-style-type: none"> <li>Up to \$8 billion through 2030</li> </ul>  | <ul style="list-style-type: none"> <li>12 electric models by 2023</li> </ul>   | <ul style="list-style-type: none"> <li>700,000 (30%) by 2025</li> </ul>  |
| <b>Rivian</b>                     | <ul style="list-style-type: none"> <li>\$750 million in Illinois plant</li> </ul>   | <ul style="list-style-type: none"> <li>Six all-electric models by 2025</li> </ul>  | <ul style="list-style-type: none"> <li>Up to 400,000 (100%) by 2025</li> </ul>   |
| <b>Lucid Motors</b>               | <ul style="list-style-type: none"> <li>\$700 million in Arizona plant</li> </ul>  | <ul style="list-style-type: none"> <li>Plan first model launch in 2021</li> </ul>  | <ul style="list-style-type: none"> <li>Up to 380,000 (100%) by 2025</li> </ul>   |
| <b>Smart</b>                      | <ul style="list-style-type: none"> <li>\$780 million for an electric Smart</li> </ul>   | <ul style="list-style-type: none"> <li>Only all-electric options from 2020 in Europe</li> </ul>  | <ul style="list-style-type: none"> <li>100,000 (100%)</li> </ul>   |
| <b>PSA Group*</b>                 | <ul style="list-style-type: none"> <li>\$250 million in electric motors</li> <li>\$90 million in transmissions</li> </ul>   | <ul style="list-style-type: none"> <li>Hybrid or electric options of all models by 2025</li> </ul>   | <ul style="list-style-type: none"> <li>(not available)</li> </ul>  |
| <b>SAIC</b>                       | <ul style="list-style-type: none"> <li>\$820 million for high-end electric vehicles</li> </ul>  | <ul style="list-style-type: none"> <li>100 electric models by 2025 with its partners GM and VW Group</li> </ul>  | <ul style="list-style-type: none"> <li>(not available)</li> </ul>  |
| <b>BYD</b>                        | <ul style="list-style-type: none"> <li>\$3 billion on battery factories by 2020</li> <li>\$1.5 billion Changzhou NEV factory</li> </ul>   | <ul style="list-style-type: none"> <li>(not available)</li> </ul>  | <ul style="list-style-type: none"> <li>(not available)</li> </ul>  |
| <b>Dongfeng Motor</b>             | <ul style="list-style-type: none"> <li>(not available)</li> </ul>   | <ul style="list-style-type: none"> <li>20 electrified models by 2022 with its partners Nissan, Venucia, and Infiniti</li> </ul>  | <ul style="list-style-type: none"> <li>(not available)</li> </ul>  |

Note: Estimates based on public company announcements. \* Fiat Chrysler and PSA group electric vehicle announcements preceded their merger announcement in January 2021.

Since December 2020, many companies including Ford, General Motors, Tesla, and Volkswagen have increased their investments in electric vehicle production.<sup>5</sup> The announcements shown in Table 1 total about \$345 billion in global investments through 2030, which increases the \$275 billion estimate from December 2020 by about 20%.<sup>6</sup> Including all the necessary associated battery procurement that has not been announced, and therefore is not included in Table 1, would make the overall investment much higher. In addition, many details of the companies' strategic plans are not fully disclosed; therefore, the actual and comprehensive investments are likely greater.

With several hundred billion dollars in electric vehicle investments slated to be made before 2030, key questions remain about the specific regions and manufacturing facilities that automakers will invest in. This briefing assesses such industry actions in the United States, focusing on major U.S. brands, and puts them in the context of global developments. Our assessment includes a detailed analysis of global electric and combustion light-duty vehicle production, automaker electric vehicle commitments in the United States and globally, and light-duty vehicle assembly facilities in the United States. Examples of automaker announcements for electric vehicle supply and assembly plant investments for U.S. and non-U.S. markets are also provided. In doing so, this work introduces several policy questions related to the industrial opportunity for the United States to strengthen its position in global light-duty vehicle manufacturing.

## GLOBAL ELECTRIC VEHICLE MANUFACTURING DEVELOPMENTS

This section assesses the global automaker electric vehicle manufacturing developments as of June 2021. Industry announcements about electric vehicle production are put in context of the overall estimates of 2025 light-duty vehicle production in the United States and globally for major automakers in the U.S. market. We incorporate future industry electric vehicle manufacturing investments and put them in the context of estimated overall automaker production volume by 2025, generally assuming an annual future vehicle growth rate of 1% and production at 75% of the reported assembly plant capacity. Ultimately, the research summarizes the automaker electric vehicle actions as they relate to each light-duty vehicle assembly plant in the United States.

To catalogue the assembly plant information for this analysis, several data sources were combined. The first step was to develop a comprehensive database of all the major vehicle assembly plants, or announced near-term plants, for manufacturing light-duty electric vehicles. This was based on a variety of industry announcements

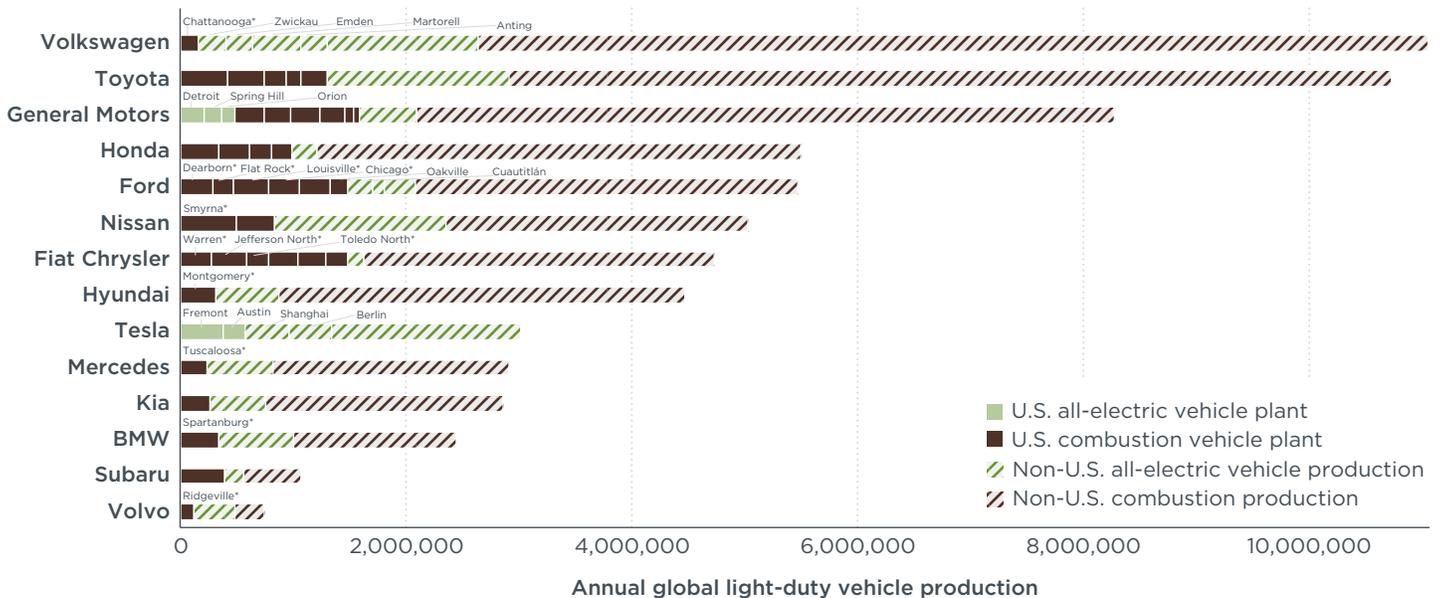
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5 General Motors' most recent announcement indicates forthcoming electric vehicle, battery, fuel cell, and autonomous investments. The relative investments by technology and region are not available, and the company says more details will be announced in the future. "GM will boost EV and AV investments to \$35 billion through 2025," GM Corporate Newsroom, accessed June 16, 2021, <https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2021/jun/0616-gm.html>

6 The table updates information from Peter Slowik, Nic Lutsey, and Chih-Wei Hsu, *How technology, recycling, and policy can mitigate supply risks to the long-term transition to zero-emission vehicles*, (Washington, DC: ICCT, 2020), <https://theicct.org/publications/mitigating-zev-supply-risks-dec2020>; Nic Lutsey, "The future is electric, but why's it taking so long?" *ICCT Staff Blog*, September 6, 2018, <https://theicct.org/blog/staff/future-is-electric-but-why-so-long>; Lutsey, Grant, Wappelhorst, and Zhou, *Power play: How governments are spurring the electric vehicle industry*; Paul Lienert and Christine Chan, "A Reuters analysis of 29 global automakers found that they are investing at least \$300 billion in electric vehicles, with more than 45 percent of that earmarked for China." Reuters, January 10, 2019, <https://graphics.reuters.com/AUTOS-INVESTMENT-ELECTRIC/010081ZB3HD/index.html>

(see Table 1) and corroborated with external sources about electric vehicle model specifications and assembly locations. To put this global electric vehicle manufacturing in context, the electric vehicle announcements were compared with overall vehicle production statistics.<sup>7</sup> A more detailed database was constructed including each of the major light-duty vehicle assembly plants in the United States, along with a detailed cataloging of the extent to which each plant has begun manufacturing electric vehicles or its automaker has made announcements related to its transition to electric.

Figure 3 shows the estimated 2025 global light-duty vehicle production for 14 major automakers that have at least one U.S. assembly plant. Companies are ordered from top to bottom based on highest expected 2025 production volume and range from about 11 million vehicles (Volkswagen Group) to about 750,000 vehicles (Volvo). Plants slated for all-electric vehicle production are shown in green, whereas plants with combustion vehicle production are shown in brown. The solid bars represent U.S. production, and the hatched bars represent production outside of the United States. Known electric vehicle assembly plants are labeled, and U.S. plants with relatively limited announced electric vehicle assembly, which is to say unclear future production or typically less than 15% of that plant's annual production as of 2020, are labeled with an asterisk.



**Figure 3.** Estimated global light-duty vehicle production through 2025, by automaker.

The combined light-duty vehicle production in 2025 for the 14 automakers listed in Figure 3 is approximately 68 million units. About 16% of these manufacturers' production is in the United States. Overall, electric vehicles represent about 20% of the light-duty vehicle production shown. Of the companies shown, Tesla and Volkswagen stand out with the greatest expected electric vehicle production at about 3 million vehicles each. As a portion of automakers' 2025 light-duty vehicle production, estimated electric vehicle production ranges from 5% for Honda, to 50% for Volvo, and up to 100% for Tesla. Nissan's global sales shown in Figure 3 exclude those of

<sup>7</sup> Sales data and plant production capacity are from Marklines. (2020), [https://www.marklines.com/portal\\_top\\_en.html](https://www.marklines.com/portal_top_en.html)

its broader alliance with Renault and Mitsubishi, and Volvo's global sales exclude those from the broader Geely group. Other automakers not shown with more than one million annual global sales include PSA (which is merging with Fiat-Chrysler as Stellantis), Suzuki, Changan, Mazda, Great Wall, SAIC, and Dongfeng.

Based on industry announcements, electric vehicle production is expected to remain greater outside of the United States. The announced U.S. electric vehicle assembly amounts to about 2.3 million electric vehicles, compared to 18 million outside the United States. As a result, based on the announcements to date, U.S.-manufactured electric vehicles would represent about 10% of global light-duty electric vehicle production in 2025. By 2025, the electric vehicle production at only the all-electric plants in China and Europe would represent about 40% of the global light-duty electric vehicle production. Many combustion vehicle plants also have some previous and announced electric vehicle production. By 2025, electric vehicles are estimated to represent one-third of the production at plants that currently produce combustion engine vehicles, which will position China and Europe collectively at 70% of global electric vehicle production. This means U.S.-made electric vehicle production would lag the global average electric vehicle uptake, and especially the electric shares in China and Europe. Volkswagen is expected to have the greatest total vehicle production, with no all-electric plants in the United States but several all-electric assembly plants in Europe and China, including, for example, fully converting its Zwickau plant with a capacity of 330,000 units for electric vehicles by 2021.<sup>8</sup>

The relatively limited showing of all-electric U.S. plants in Figure 3 reflects lower levels of investment in the United States. Based on public announcements, only General Motors and Tesla will have all-electric U.S. plants by 2025. Toyota, Honda, Ford, and Fiat Chrysler stand out with four to six U.S. combustion vehicle plants, each with an annual capacity of more than one million vehicles, but no announced all-electric plants. Noted with an asterisk in the figure, Ford (Dearborn, Flat Rock, Louisville, and Chicago), Nissan (Smyrna), Fiat Chrysler (Warren, Jefferson North, and Toledo North), Mercedes (Tuscaloosa), BMW (Spartanburg), Hyundai (Montgomery), Volkswagen (Chattanooga), and Volvo (Ridgeville) have manufactured some electric vehicles or invested to increase their capacity to do so, but they have not committed to all-electric U.S. assembly facilities. Hyundai, Kia, Subaru, and Volvo each have one U.S. combustion vehicle plant but have not announced their electrification plans. Outside of the United States, Ford manufactures the electric Mustang Mach-E in Mexico (Cuautitlán plant) and has plans to manufacture additional electric models in Canada (Oakville plant). Fiat Chrysler also makes the plug-in hybrid Chrysler Pacifica in Canada.

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8 "Car city Zwickau: From Horch and Audi to e-mobility," Volkswagen Group, November, 2018, <https://www.volkswagenag.com/en/news/stories/2018/11/the-changing-automotive-city-of-zwickau.html#>; "Volkswagen to manufacture electric cars on three continents," Volkswagen Group, January, 2019, <https://www.volkswagenag.com/en/news/stories/2019/01/volkswagen-to-manufacture-electric-cars-on-three-continents.html>

## ANNOUNCED ACTIONS REGARDING ELECTRIC VEHICLE TRANSITION FOR U.S. PLANTS

To more deeply investigate the electric vehicle developments and industry dynamics, we collected further information on the automaker electric vehicle commitments and put it in context of the major U.S. vehicle assembly plants. Specifically, we collected information on 17 automaker actions, which are broadly categorized as manufacturing plant actions (5) or general electric vehicle actions (12). Plant actions relate to company electric vehicle developments at specific U.S. facilities. General electric vehicle actions are broader company electric vehicle commitments in the United States and globally. The actions and their implementation are summarized for the 16 automaker groups that have one or more manufacturing facilities in the United States, which are the same 14 major automakers shown in Figure 3 plus two start-up all-electric companies, Rivian and Lucid Motors.

### PLANT ACTIONS

To assess the range of the announced public commitments made by automakers to transition each plant to manufacture electric vehicles, we collected data on five electric vehicle actions for 44 U.S. assembly plants. Actions include plants that are producing 100% electric vehicles in 2020, announcements for new all-electric vehicle plants by 2025, partial electric vehicle plants in 2020, announcements for partial electric vehicle plants by 2025, and plants that have received federal support to produce electric vehicles.

Based on the research, two of the 44 plants were all-electric in 2020 (Tesla's Fremont and Rivian's Normal). Three plants (General Motors' Detroit Hamtramck, Spring Hill, and Orion) are slated to undergo conversion to produce only electric vehicles beginning in 2021. Two new all-electric plants (Tesla's Austin and Lucid Motors' Casa Grande) are under construction and expect initial deliveries in 2021. Based on these developments, seven of the 44 plants are slated to be all-electric by 2025.

There were four partial electric vehicle plants in 2020 that varied in terms of the share of vehicle production that is electric. At Ford's Chicago plant, the Ford Explorer plug-in hybrid represented about 1% of the plant's light-duty vehicle production volume in 2020. Fiat Chrysler's Toledo North plant started production of the Jeep Wrangler plug-in hybrid in December 2020.<sup>9</sup> These two plants have been producing electric vehicles at relatively lower volume than Nissan's Smyrna and BMW's Spartanburg. At Nissan's Smyrna plant, the battery-electric Nissan Leaf represented about 5% of the plant's annual light-duty vehicle production in 2018, and the plant has produced more than 150,000 units since 2012. At BMW's Spartanburg plant, the X3 and X5 plug-in hybrid models represented about 13% of the plant's volume in 2020.<sup>10</sup> By 2025, the number of partial electric vehicle plants in the United States will increase to 13, based on company announcements.

There are 10 additional plants that are expected to undergo partial electric vehicle conversion or expansion by 2025. Automakers are investing more than \$500 million at five of the plants to significantly increase future electric vehicle production capacity,

9 "Toledo Assembly Complex starts building 2021 Jeep Wrangler hybrid," NBC24, December 11, 2020, <https://abc6onyourside.com/amp/news/local/toledo-assembly-complex-starts-building-2021-jeep-wrangler-hybrid>

10 "BMW Group once again largest US automotive exporter," BMW Group, accessed March 1, 2021, <https://www.press.bmwgroup.com/global/article/detail/T0326049EN/bmw-group-once-again-largest-us-automotive-exporter?language=en>

including Ford's Dearborn and Flat Rock, Mercedes' Tuscaloosa, Volkswagen's Chattanooga, and Volvo's Ridgeville plants. Automaker electric vehicle investments are comparatively limited for the other five plants (Ford's Louisville, Fiat Chrysler's Warren, Mack Avenue, Jefferson North, and Toledo North). Although these plants will produce Ford Escape, Lincoln Corsair, and various Jeep electric vehicle models, the relatively nominal investment dedicated for electric vehicles indicates that they will remain mostly combustion plants. Two plants – Nissan's Smyrna and Tesla's Fremont – received federal loans in 2010, which have helped to create 2,800 jobs.<sup>11</sup>

## GENERAL ELECTRIC VEHICLE ACTIONS

To provide context to the electric vehicle developments at the plant level, we identified and tracked 12 actions related to the broader company electric vehicle developments in the United States and globally. Actions include company electric vehicle sales goals, announcements for new EV model offerings, and announcements for electric vehicle investments; these are catalogued according to whether the automaker announcement was made at the U.S., non-U.S., and global level. Additional company measures include original signatories of California's Clean Car Framework (i.e., supporting California's authority on zero-emission vehicle regulations)<sup>12</sup> or company investments in charging infrastructure in U.S. and non-U.S. markets.

Most automakers have announced some type of electric vehicle sales goal. For the U.S. market, six of the 16 companies aim for electric vehicles to make up at least 50% of their U.S. sales by 2030; Tesla, Rivian, and Lucid Motors are 100% electric, Mercedes has a goal of 50% electric, Volkswagen has a goal of 50% electric, and Volvo has plans to be 100% electric. We interpret one company announcement, General Motors' 100% electric vehicles by 2035, as amounting to 25% to 50% electric share of its 2030 sales. Honda has announced it will strive for battery electric and fuel cell vehicles to represent 40% of its sales in North America by 2030. No other companies have announced goals for electric vehicles to make up more than 25% of their U.S. sales by 2030. Outside the United States, five of the 14 companies have goals for electric vehicles to make up at least 50% of their 2030 sales in China and Europe (Tesla, BMW, Mercedes, Volkswagen, and Volvo), and three companies have goals for electric vehicles to make up from 25% to 50% of sales (General Motors, Honda, Kia). In terms of global goals, three companies aim for at least 50% electric vehicle sales by 2030 (Tesla, Mercedes, Volvo) and another seven aim for 25% to 50% electric vehicle sales (General Motors, Honda, Nissan, BMW, Kia, Ford, and Volkswagen).

Because consumer vehicle preferences for brand, body type, and specifications vary so greatly, deploying a wide range of available electric models is key to meeting company sales goals. Five of the 16 automakers have announced that electric vehicles would represent more than 50% of their global lineup of models available and another four have announced about 20% to 50% electric models by 2030. Company announcements for electric model offerings in specific markets are comparatively limited. In the U.S., 100% of models by Tesla, Rivian, and Lucid Motors will be electric by 2030, whereas about 30% of Toyota models and 40% of General Motors models will be electric. In non-U.S. markets such as China, Europe, or Japan, automakers Ford, Tesla, and Toyota plan for electric vehicles to make up at least half of their available

11 Tesla, Department of Energy Loan Programs Office, accessed March 1, 2021, <https://www.energy.gov/lpo/tesla>;  
Nissan, Department of Energy Loan Programs Office, accessed March 1, 2021, <https://www.energy.gov/lpo/nissan>

12 California Air Resources Board, Framework Agreements on Clean Cars, <https://ww2.arb.ca.gov/news/framework-agreements-clean-cars>

models by 2030. These developments reflect how automakers' announced future electric vehicle models are more limited in the United States than in China or Europe, mirroring the previously noted findings about companies' electric sales goals.

Announced investments, globally and in specific markets, are another way to measure automakers' planning for the transition to high-volume electric vehicle production. Eight of the 16 companies assessed have announced global investments of at least \$10 billion for electric vehicles, and three others that have publicly specified an amount are each investing over \$1 billion. In terms of specific markets, eight companies (General Motors, Ford, Toyota, Nissan, Tesla, BMW, Mercedes, and Volkswagen) are each investing at least \$1 billion, and another two are investing less than \$1 billion, in a non-U.S. market, including China and Europe. Relatively greater investments appear destined for China and Europe compared to the United States. Eight companies (General Motors, Ford, Tesla, Mercedes, Hyundai, Kia, Rivian, and Lucid Motors) are investing at least \$1 billion in the United States, and another three are investing less than \$1 billion (BMW, Volkswagen, and Volvo). Overall, we estimate that about 15% of the approximately \$345 billion in global electric vehicle investments are destined for the United States.<sup>13</sup>

Several automakers are also supporting charging infrastructure to functionally extend electric vehicles' range and ensure driver convenience. Tesla stands out as the automaker with the most substantial global charging infrastructure network. For example, Tesla's network accounts for more than 20,000 chargers globally and more than half of the United States' 17,000 fast chargers.<sup>14</sup> In Europe, the IONITY joint venture consisting of BMW, Daimler, Ford, Kia, and Volkswagen is constructing 400 DC fast chargers (350 kW) along highway corridors, showing direct investment in the charging network. In the United States, Volkswagen's \$2 billion investment through its Electrify America subsidiary is largely focused on public charging infrastructure. Two other automakers are investing in their own U.S. networks, one by establishing a new company (General Motors) and the other by partnering with its own dealer network (Kia).<sup>15</sup> Other companies including Ford, Nissan, and BMW have partnerships with charging providers such as EVGo and ChargePoint to expand their U.S. charging network.<sup>16</sup>

Automakers' public recognition and support for California and other states' clean vehicle standards has also been critical to advancing electric vehicle innovation and progress. Under California's Framework Agreement on Clean Cars, automakers

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13 Based on Slowik, Lutsey, and Hsu, *How technology, recycling, and policy can mitigate ZEV supply risks*, and Lienert and Chan, "A Reuters analysis of 29 global automakers found that they are investing at least \$300 billion in electric vehicles" with updates from Table 1.

14 Tesla, Supercharger, <https://www.tesla.com/supercharger> and Alternative Fuels Data Center, [https://afdc.energy.gov/fuels/electricity\\_locations.html#/analyze?fuel=ELEC&ev\\_networks=Tesla%20Destination&ev\\_networks=Tesla](https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?fuel=ELEC&ev_networks=Tesla%20Destination&ev_networks=Tesla)

15 Peter Valdes-Dapena, "First on CNN Business: GM and Bechtel plan to build thousands of electric car charging stations across the US," CNN, May 28, 2019, <https://www.cnn.com/2019/05/28/business/gm-bechtel-electric-car-charging-stations/index.html>; Kia, "Kia Motors accelerates business transformation to become a leading EV brand," September 16, 2020, [https://press.kia.com/en/home/media-resources/press-releases/2020/KiaMotors\\_to\\_become\\_a\\_leading\\_EV\\_brand.html](https://press.kia.com/en/home/media-resources/press-releases/2020/KiaMotors_to_become_a_leading_EV_brand.html)

16 Peter Valdes-Dapena, "Ford announces launch of largest electric vehicle charging network in the US," CNN, October 17, 2019, <https://www.cnn.com/2019/10/17/cars/ford-electric-vehicle-charging-network/index.html>; Kristen Korosec, "Nissan and EVgo to add 200 fast chargers as more electric vehicles hit US road," TechCrunch, August 6, 2019, <https://techcrunch.com/2019/08/06/nissan-and-evgo-to-add-200-fast-chargers-as-more-electric-vehicles-hit-u-s-roads/>; "BMW, Volkswagen and ChargePoint announce completion of electric vehicle express charging corridors on the East and West Coasts," ChargePoint, 2016, <https://www.chargepoint.com/about/news/bmw-volkswagen-and-chargepoint-announce-completion-electric-vehicle-express-charging/>

voluntarily agree to reduce greenhouse gas emissions from light-duty vehicles through 2026 model year at 3.7% per year and recognize California’s regulatory authority to establish standards that drive zero-emission vehicles to achieve clean air and climate mitigation goals.<sup>17</sup> The agreement also provides automakers incentives to develop, produce, and distribute more electric vehicles. Five of the 14 companies (BMW, Ford, Honda, Volkswagen Group, and Volvo) were signatories to California’s framework. In addition, all-electric companies Tesla, Rivian, and Lucid Motors supported the state emission regulations.

Table 2 summarizes the actions and their implementation for each of the 44 major assembly plants in the United States for the major automakers that manufacture light-duty vehicles in the United States. The companies are listed from top to bottom based on number of U.S. light-duty vehicle assembly plants. Each “X” in the table denotes that the action is generally met, and each “/” denotes that the action is partially met.

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<sup>17</sup> “Framework Agreements on Clean Cars,” California Air Resources Board, August 17, 2020, <https://ww2.arb.ca.gov/news/framework-agreements-clean-cars>

**Table 2.** Summary of automaker electric vehicle developments.

| Automaker      | Assembly plant location    | Assembly plant action                 |   |                                   |   |                                       | General automaker action                  |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|----------------|----------------------------|---------------------------------------|---|-----------------------------------|---|---------------------------------------|---|---|---|--------------------------------------|-------------------------------|---|---|---|--|------------------------------------|------------------------------------|------------------------------------|
|                |                            | All electric vehicle assembly in 2020 | Announced all electric assembly by 2025 | Partial electric assembly in 2020 | Announced partial electric assembly by 2025 | Federal support for electric assembly | United States electric vehicle sales goal | United States electric vehicle model goal | United States electric vehicle investment | United States public charger support | California regulatory support | Non-United States electric vehicle sales goal | Non-United States electric vehicle model goal | Non-United States electric vehicle investment | Non-United States public charger support | Global electric vehicle sales goal | Global electric vehicle model goal | Global electric vehicle investment |
| General Motors | Detroit-Hamtramck, MI      | X                                     |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Spring Hill, TN            | X                                     |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Orion, MI                  | X                                     |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Fort Wayne, IN             |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Fairfax, KS                |                                       |   |                                   |   |                                       | /   | /   | X   | X                                    |                               | /   | /   | X   |  | /                                  | /                                  | X                                  |
|                | Arlington, TX              |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Lansing Delta Township, MI |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Lansing Grand River, MI    |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Bowling Green, KY          |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Ford           | Dearborn, MI               |                                       |   |                                   | X   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Flat Rock, MI              |                                       |   |                                   | X   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Louisville, KY             |                                       |   |                                   | /   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Chicago, IL                |                                       |   | /                                 | /   |                                       |   | X   | /   | X                                    |                               | X   | X   | X   | /  | /                                  | X                                  |                                    |
|                | Kansas City, MO            |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Wayne, MI                  |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Fiat Chrysler* | Warren, MI                 |                                       |   |                                   | /   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Mack Avenue, MI            |                                       |   |                                   | /   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Jefferson North, MI        |                                       |   |                                   | /   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Toledo North, OH           |                                       |   | /                                 | /   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    | /                                  |
|                | Sterling Height, MI        |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Belvidere, IL              |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Toledo South, OH           |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Toyota         | Georgetown, KY             |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Princeton, IN              |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | San Antonio, TX            |                                       |   |                                   |   |                                       |   | /   |   |                                      |                               | X   | X   |   |  |                                    |                                    |                                    |
|                | Blue Springs, MS           |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Huntsville, AL             |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Honda          | Marysville, OH             |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | Lincoln, AL                |                                       |   |                                   |   |                                       |   | /   |   | X                                    | /                             | /   | /   |   |  |                                    |                                    |                                    |
|                | Greensburg, IN             |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
|                | East Liberty, OH           |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Nissan         | Smyrna, TN                 |                                       |   | X                                 | X   | X                                     |   |   | /   |                                      |                               | X   |   |   | /  |                                    |                                    |                                    |
|                | Canton, MS                 |                                       |   |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Tesla          | Fremont, CA                | X                                     | X                                       |                                   |   | X                                     | X   | X   | X   | X                                    | X                             | X   | X   | X   | X  | X                                  | X                                  | X                                  |
|                | Austin, TX                 |                                       | X                                       |                                   |   |                                       |   |   |   |                                      |                               |   |   |   |  |                                    |                                    |                                    |
| Subaru         | Lafayette, IN              |                                       |   |                                   |   |                                       |   |   |   |                                      |                               | /   |   |   |  |                                    | /                                  |                                    |
| BMW            | Spartanburg, SC            |                                       |   | X                                 | X   |                                       |   | /   | /   | X                                    | X                             |   | X   | X   | X  | X                                  | X                                  |                                    |
| Hyundai        | Montgomery, AL             |                                       |   |                                   |   |                                       |   | X   |   |                                      |                               |   |   |   |  | X                                  | X                                  |                                    |
| Kia            | West Point, GA             |                                       |   |                                   |   |                                       |   | X   | X   |                                      | /                             |   |   | X   | /  | /                                  | X                                  |                                    |
| Mercedes       | Tuscaloosa, AL             |                                       |   |                                   | X   |                                       | X   | X   |   | X                                    |                               | X   | X   | X   | X  | /                                  | X                                  |                                    |
| Volkswagen     | Chattanooga, TN            |                                       |   |                                   | X   |                                       | X   | /   | X   | X                                    | X                             |   | X   | X   | /  | X                                  | X                                  |                                    |
| Volvo          | Ridgeville, SC             |                                       |   |                                   | X   |                                       | X   | /   |   | X                                    | X                             |   |   |   | X  | X                                  | /                                  |                                    |
| Rivian         | Normal, IL                 | X                                     | X                                       |                                   |   |                                       | X   | X   | X   | X                                    |                               |   |   |   |  |                                    |                                    |                                    |
| Lucid Motors   | Casa Grande, AZ            |                                       | X                                       |                                   |   |                                       | X   | X   | X   |                                      | X                             |   |   |   |  |                                    |                                    |                                    |

Note: "X" denotes action is generally met; "/" denotes action partially met.

\* Fiat Chrysler automaker actions do not account for any new developments since its 2021 merger with PSA

As Table 2 indicates, there are only two assembly plants in the United States that manufacture only electric vehicles as of 2020, but there are announcements for an additional five new or converted electric vehicle assembly plants. In addition, 13 of the 44 plants have indicated partial assembly plant conversions or expansions to make electric vehicles by 2025. The columns on the right show the additional actions taken at a company level to commit to higher electric vehicle sales, increased electric vehicle model deployment, or public charger deployment in the United States, in a non-U.S. market (typically in China or Europe), or globally. The table illustrates that, even though there have been relatively few new and converted electric vehicle assembly plants in the United States, the companies have made a number of statements and actions that more broadly signal their intent to transition to electric in other markets.

## U.S. ELECTRIC VEHICLE ASSEMBLY PLANTS

This section summarizes the plant-specific developments for new, converted, and expanded electric vehicle production capacity based on company announcements and estimates the overall 2025 U.S. light-duty electric and combustion vehicle production at the plant-level.

Table 3 summarizes the company announcements for new, converted, and expanded light-duty vehicle assembly plants in the U.S. that have at least some electric vehicle capacity. The table is based on company announcements and media sources.<sup>18</sup> The 10 companies in the table collectively have plans for three new, eight converted, and five expanded assembly plants before 2025. Although the details vary, based on company announcements, the assembly plants listed in the first six rows of the table will produce only electric vehicles, including General Motors' Detroit-Hamtramck, Orion, and Spring Hill plants. The rest of the plants will produce both combustion and electric vehicles,

18 Marklines, (2020), <https://www.marklines.com/>  
Edward Ludlow, "Electric cars are about to start rolling out of the Arizona Desert," *Bloomberg*, May 22, 2020, <https://www.bloomberg.com/news/articles/2020-05-22/electric-cars-are-about-to-start-rolling-out-of-the-arizona-desert>  
David Ferris, "With Hummer and \$2B factory push, GM roars 'electric'," *EENews*, October 21, 2020, <https://www.eenews.net/energywire/2020/10/21/stories/1063716707>  
Ian Thibodeau, "Ford Flat Rock plant shifts to electric vehicles, Mustang," *Detroitnews*, March 20, 2019, <https://www.detroitnews.com/story/business/autos/ford/2019/03/20/ford-flat-rock-plant-shifts-electric-vehicles-mustang/3221693002/>  
"Contract summary: Hourly workers," UAW Ford, November, 2019, [https://uaw.org/wp-content/uploads/2019/11/NUMBERS-CORRECTED\\_FRI-11-1\\_1140-AM\\_Hourly-graphics.pdf](https://uaw.org/wp-content/uploads/2019/11/NUMBERS-CORRECTED_FRI-11-1_1140-AM_Hourly-graphics.pdf)  
Stellantis, "FCA to expand production capacity in Michigan to grow core brands, electrify Jeep vehicles," 2019, <https://media.stellantisnorthamerica.com/newsrelease.do?id=20661&mid=18>  
Fiat Chrysler Automobiles, "Mack Avenue Engine Complex and Jefferson North Assembly Plant investment", FCA, [https://s3.amazonaws.com/chryslermedia.ionicweb.com/mediasite/attachments/FCA\\_plant\\_expansion\\_presentation9u35hjuvi3ko50lsavvfj9h2.pdf](https://s3.amazonaws.com/chryslermedia.ionicweb.com/mediasite/attachments/FCA_plant_expansion_presentation9u35hjuvi3ko50lsavvfj9h2.pdf)  
"BMW Group plant Spartanburg more than doubles capacity for battery assembly, 2020 BMW X5 xDrive45e Plug-in Hybrid electric vehicle begins production in Spartanburg, SC on August, 1," BMW Group, accessed March 1, 2021, [https://www.press.bmwgroup.com/usa/article/detail/T0299183EN\\_US/bmw-group-plant-spartanburg-more-than-doubles-capacity-for-battery-assembly-2020-bmw-x5-xdrive45e-plug-in-hybrid-electric-vehicle-begins-production-in-spartanburg-sc-on-august-1?language=en\\_US](https://www.press.bmwgroup.com/usa/article/detail/T0299183EN_US/bmw-group-plant-spartanburg-more-than-doubles-capacity-for-battery-assembly-2020-bmw-x5-xdrive45e-plug-in-hybrid-electric-vehicle-begins-production-in-spartanburg-sc-on-august-1?language=en_US)  
Ford Rouge Electric Vehicle Center, "Ford Authority, September 25, 2020, <https://fordauthority.com/fmc/ford-motor-company-plants-facilities/ford-motor-company-usa-plants-facilities/ford-rouge-electric-vehicle-center-dearborn-michigan-usa/>  
Gail Allyn Short, "Mercedes moves toward electric," *Business Alabama*, February 10, 2020, <https://businessalabama.com/mercedes-moves-toward-electric/>  
"Volkswagen breaks ground on expansion for electric vehicle production in United States," Volkswagen US Media site, accessed March 1, 2021, <https://www.media.vw.com/en-us/releases/1227#:~:text=Production%20of%20that%20vehicle%20is,on%20the%20same%20assembly%20line>  
David Wren, "Volvo to build Charleston-area battery plant to power SC-made vehicles," *Post and Courier*, September 14, 2020, [https://www.postandcourier.com/business/volvo-to-build-charleston-area-battery-plant-to-power-sc-made-vehicles/article\\_c44113a4-33cd-11ea-a049-5f0cafb689af.html](https://www.postandcourier.com/business/volvo-to-build-charleston-area-battery-plant-to-power-sc-made-vehicles/article_c44113a4-33cd-11ea-a049-5f0cafb689af.html)

but the relative volumes are unknown. Based on production capacity, all these plants together could produce up to 1.7 million annual electric vehicles (near full capacity of all-electric plants) up to a maximum of 4.5 million (if all the plants shown in the table eventually transition to all electric vehicles). The right-most column of Table 3 shows the associated announced investment of about \$17 billion and represents about 5% of the total \$345 billion in global announced investments in Table 1.

**Table 3.** Announced new, converted, and expanded electric vehicle capacity at U.S. assembly plants.

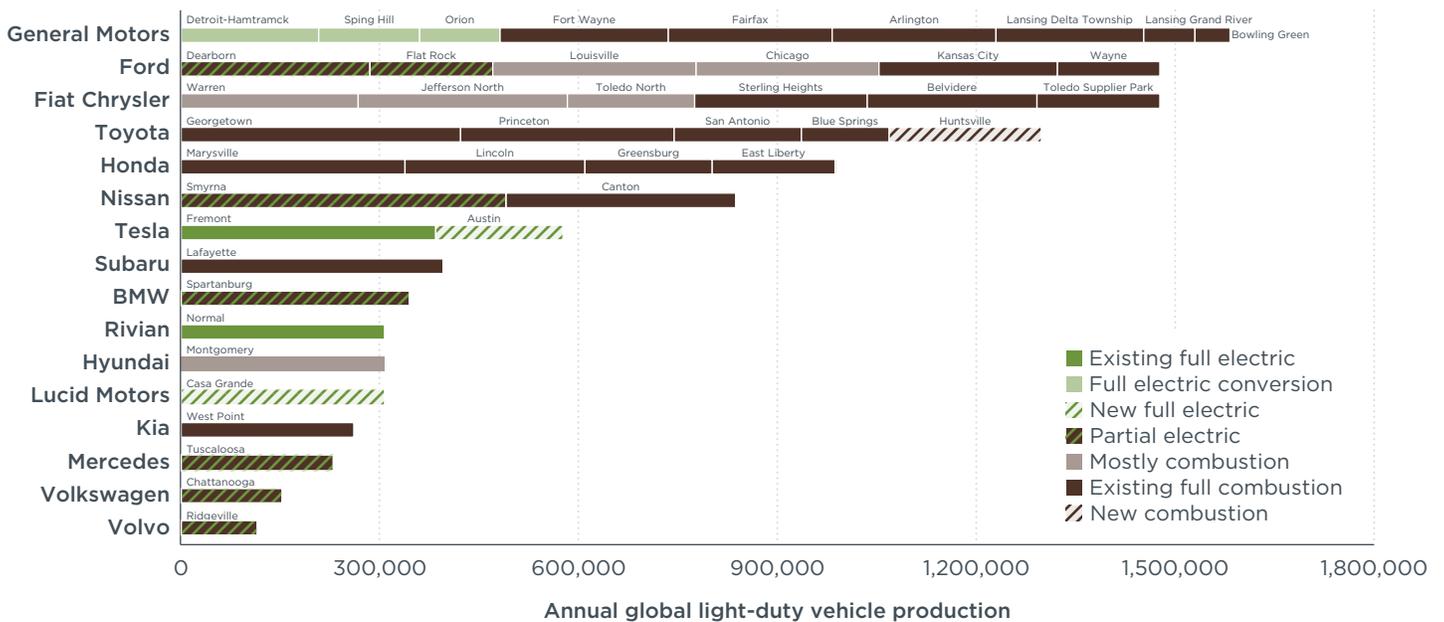
| Type       | Automaker      | Assembly plant location | State          | Maximum production capacity (vehicles) | Potential timing for initial production | Percent of production that will be electric | Investment (million USD) |
|------------|----------------|-------------------------|----------------|--|---|---|--------------------------|
| New        | Tesla          | Austin                  | Texas          | 250,000                                | 2021                                    | 100%  | \$1,000                  |
|            | Rivian         | Normal                  | Illinois       | 400,000                                | 2021                                    | 100%  | \$750                    |
|            | Lucid Motors   | Casa Grande             | Arizona        | 380,000                                | 2021                                    | 100%  | \$700                    |
| Conversion | General Motors | Detroit-Hamtramck       | Michigan       | 270,000                                | 2021                                    | 100%  | \$2,200                  |
|            | General Motors | Orion                   | Michigan       | 160,000                                | 2021                                    | 100%  | \$300                    |
|            | General Motors | Spring Hill             | Tennessee      | 198,000                                | 2022                                    | 100%  | \$2,000                  |
|            | Ford           | Flat Rock               | Michigan       | 240,000                                | 2023                                    | Not specified                               | \$900                    |
|            | Ford           | Louisville              | Kentucky       | 400,000                                | 2020                                    | Not specified                               | \$100                    |
|            | Fiat Chrysler  | Mack Avenue             | Michigan       | Not available                          | 2021                                    | Not specified                               | \$1,600 <sup>a</sup>     |
|            | Fiat Chrysler  | Warren                  | Michigan       | 350,000                                | 2021                                    | Not specified                               | \$1,500 <sup>a</sup>     |
|            | Fiat Chrysler  | Jefferson North         | Michigan       | 410,000                                | 2021                                    | Not specified                               | \$900 <sup>a</sup>       |
| Expansion  | BMW            | Spartanburg             | South Carolina | 450,000                                | 2020                                    | Not specified                               | \$20                     |
|            | Volvo          | Ridgeville              | South Carolina | 150,000                                | 2022                                    | Not specified                               | \$600                    |
|            | Ford           | Dearborn                | Michigan       | 350,000                                | 2022                                    | Not specified                               | \$700                    |
|            | Mercedes       | Tuscaloosa              | Alabama        | 300,000                                | 2022                                    | Not specified                               | \$1,054                  |
|            | Volkswagen     | Chattanooga             | Tennessee      | 200,000                                | 2022                                    | Not specified                               | \$800                    |

<sup>a</sup> These announced investments appear to be mostly for combustion vehicles, whereas others in this column are mostly for electric vehicles.

As indicated in Table 3, no incumbent automakers have announced new electric vehicle plants, but several are making efforts to convert or expand existing combustion vehicle facilities to produce electric vehicles. General Motors' multi-plant investment is the largest at more than \$4 billion, with the intent to fully convert its Detroit-Hamtramck, Orion, and Spring Hill plants for all electric vehicles. BMW, Ford, Mercedes, Volkswagen, and Volvo are collectively investing more than \$4 billion, including plant conversions (Ford's Flat Rock and Louisville) and expansions of existing facilities (BMW's Spartanburg, Mercedes' Tuscaloosa, Volkswagen's Chattanooga, and Volvo's Ridgeville). Although these plants will produce both combustion and electric vehicles, the majority of the investment is expected to increase the capacity for electric vehicle and battery assembly.

Figure 4 shows the estimated 2025 light-duty vehicle production for the same 44 U.S. assembly plants that are shown in Table 2 with one exception: production capacity data are not available for Fiat Chrysler's Mack Avenue plant, which is being converted from an engine plant to a vehicle assembly plant. Thus, there are 43 assembly plants shown in Figure 4. Companies are ordered from top to bottom based on estimated

2025 U.S. production volume and range from about 1.6 million vehicles (General Motors) to 115,000 vehicles (Volvo). As above, incumbent automakers are assumed to increase sales by 1% annually through 2025, and annual production is assumed to average 75% of plant capacity. The labels are the names or locations of the 43 distinct assembly plants, which are shown by each individual brick in the horizontal bars. The different shades of green represent different types of electric vehicle plants, including all-electric (dark green), all-electric conversion (light green), new all-electric (green and white hatch), and partial electric (green and brown hatch). Different shades of brown represent different combustion plants, including mostly combustion (light brown), all combustion (dark brown) and new combustion (brown and white hatch). The figure is based on 2020 assembly plant production capacity data and the company electric vehicle announcements for new, converted, and expanded assembly plants from Table 3 where data are available.<sup>19</sup>



**Figure 4.** Estimated annual U.S. light-duty vehicle production by automaker and assembly plant capacity.

The combined production for the automakers in 2025 shown in Figure 4 is about 10.6 million light-duty vehicles. Assuming full conversion as announced by General Motors of three plants and the new plants by Tesla, Rivian, and Lucid Motors, electric vehicles would make up at least 16% of the total U.S. production. Assuming that electric vehicles represent one-third of the total production at each partial electric plant by 2025 would put U.S. electric vehicle production at 2.3 million – 10% of global electric vehicle production – and an electric share of U.S. vehicle production at about 22%. Although comprehensive data are not available, the relative share of electric vehicle production at each mostly combustion vehicle plant is assumed to be 3%. If all the partial electric plants and mostly combustion plants were converted to all-electric plants by 2025, the U.S. share of global electric vehicle production would increase from about 10% to about 23%.

<sup>19</sup> Sales data and plant production capacity are from Marklines, (2020), [https://www.marklines.com/portal\\_top\\_en.html](https://www.marklines.com/portal_top_en.html)

Tesla and General Motors have the greatest estimated electric production by 2025, with about 600,000 and 500,000 vehicles, respectively. All of the vehicles produced by Tesla are electric. Electric vehicles represent about 30% of General Motors' estimated 1.6 million vehicle production by 2025 in the United States, based on its announced full conversion of three plants. Several automakers, including Ford, Mercedes, Volkswagen, and Volvo, have plants that produce both electric and combustion vehicles, but the exact electric vehicle capacity is unclear. There was production at Ford's Wayne plant in Michigan for approximately 50,000 Ford C-Max Energi PHEV and Focus BEV in total, but production ceased in 2018. The company does not appear to have plans for future EV assembly at the plant. Ford has also announced its conversion to electric Transit commercial van production, but not for its light-duty Ford F150, in its Kansas City plant.

High-volume companies Fiat Chrysler, Toyota, Honda, and Nissan that produce between 800,000 and 1.5 million light-duty vehicles annually in the United States stand out with no announced all-electric vehicle assembly plants. Similarly, Subaru, Hyundai, and Kia each have one combustion-only plant and no electric vehicle plants. Notably, the Toyota Huntsville, Alabama, plant is the only case of an announced new assembly plant that has not stated it will include electric vehicle production.<sup>20</sup>

Mapping the 43 U.S. electric and combustion vehicle assembly plants expected by 2025 illustrates the industry developments geographically. The major U.S. light-duty vehicle assembly plants are shown in Figure 5, along with the total light-duty vehicle production capacity in each state. Overall, the production capacity is about 33% greater than the estimated production shown above, accounting for the fact that plants typically do not operate at full capacity. Each plant is labeled by name and automaker, and its estimated 2025 production capacity is illustrated by the width of the bar. Green bars represent all-electric vehicle plants, brown bars represent combustion vehicle plants, and hatched green and brown bars represent partial electric vehicle plants. The total light-duty vehicle production capacity in each state is shown by the background shading, with lighter shades representing lower capacity and darker shades representing greater capacity.

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20 A joint manufacturing plant for Toyota and Mazda with an announced \$2.3 billion investment, 4,000 jobs, and expected 2021 vehicle production. See "Mazda and Toyota Further Commitment to U.S. Manufacturing with Additional Investment," Toyota Motor Corporation, August 13, 2020, <https://pressroom.toyota.com/mazda-and-toyota-further-commitment-to-u-s-manufacturing-with-additional-investment/>



regulations have been rolled back<sup>21</sup> and federal electric vehicle purchasing incentives have been phased out for the automakers with the highest electric vehicle sales.<sup>22</sup> Comparatively, China and Europe have continued to spur electric vehicle market and assembly developments with sustained and broad regulatory, consumer incentive, and industrial policies.<sup>23</sup>

Several industry statements indicate how automakers prioritize markets with zero-emission vehicle (ZEV) policy developments. China is the market with the most comprehensive ZEV policy package with robust market development and industrial support policies. A combination of government national strategies, decade-long pilots, incentives, and regulations have cultivated the world's largest electric vehicle market and industry.<sup>24</sup> In reference to China's position to lead global electric vehicle developments, Volkswagen chair Herbert Diess said: "The future of Volkswagen will be decided in the Chinese market ...What we find (in China) is really the right environment to develop the next generation of cars ... We have very clear policies established here in China. Policymakers and regulators are requiring [a shift to electric vehicles]."<sup>25</sup>

A similar dynamic is apparent in Europe, where the industry investments and market developments are accelerating. In Europe, announced electric vehicle and battery investments amounted to 60 billion euros in 2019, which was an increase from 2018 values by a factor of more than 19.<sup>26</sup> In terms of market development, Europe's electric vehicle market surpassed China's for the first time in 2020, both in terms of new electric vehicle sales and electric vehicle sales share. These recent trends are the result of stronger regulatory policies in Europe and declining incentives and in China.<sup>27</sup> Volkswagen, for example, has said that increasingly stringent CO<sub>2</sub> standards in Europe will lead the company to increase the share of hybrid and electric vehicles it sells in Europe from 40% to 60% by 2030.<sup>28</sup> More broadly, senior vice president of Honda Motor Europe, Tom Gardner, described the Europe situation: "The pace of change in regulation, the market, and consumer behavior in Europe means that the shift towards electrification is happening faster here than anywhere else in the world."<sup>29</sup>

To further explain industry electric vehicle assembly plant decisions, Table 4 summarizes non-U.S. and U.S.-related electric vehicle investment details for Volkswagen Group,

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21 Aaron Isenstadt and Nic Lutsey, *Summary of the Trump Administration's fatally flawed U.S. light-duty vehicle efficiency standards*, (ICCT: Washington, DC, 2020), <https://theicct.org/publications/fatally-flawed-trump-nhtsa-analysis>

22 Internal Revenue Service, IRC 30D New Qualified Plug-In Electric Drive Motor Vehicle Credit, <https://www.irs.gov/businesses/irc-30d-new-qualified-plug-in-electric-drive-motor-vehicle-credit>

23 Lutsey, Grant, Wappelhorst, and Zhou, *Power play: How governments are spurring the electric vehicle industry*; Slowik, Lutsey, and Hsu, *How technology, recycling, and policy can mitigate ZEV supply risks*; and Cui, Hall, and Lutsey, *Update on the global transition to electric vehicles through 2019*

24 Lingzhi Jin, Hui He, Hongyang Cui, Nic Lutsey, Chuqi Wu, and Yidan Chu, *Driving a green future: A retrospective review of China's electric vehicle development and outlook for the future*, (ICCT: Washington, DC, 2021) <https://theicct.org/sites/default/files/publications/China-green-future-ev-jan2021.pdf>

25 Paul Lienert, Norihiko Shirouzu, and Edward Taylor, "Exclusive: VW, China spearhead \$300 billion global drive to electrify cars." *Reuters*, January 10, 2019, <https://www.reuters.com/article/us-autoshow-detroit-electric-exclusive/exclusive-vw-china-spearhead-300-billion-global-drive-to-electrify-cars-idUSKCN1P40G6>

26 Eoin Bannon, "Record €60bn investment in electric cars and batteries in Europe secured last year," *Transport & Environment*, May 25, 2020, <https://www.transportenvironment.org/press/record-%E2%82%AC60bn-investment-electric-cars-and-batteries-europe-secured-last-year>

27 Jin, He, Cui, Lutsey, and Wu. *Driving a green future: A retrospective review of China's electric vehicle development*.

28 "VW boosts investment in electric and autonomous car technology to \$86 billion," *Reuters*, November 13, 2020, <https://www.reuters.com/article/volkswagen-strategy/vw-boosts-investment-in-electric-and-autonomous-car-technology-to-86-billion-idUSKBN27T240>

29 "Honda accelerates its 'electric vision' strategy with new 2022 ambition," Honda European Media Newsroom, October 23, 2019, <https://hondanews.eu/en/cars/media/pressreleases/193797/honda-accelerates-its-electric-vision-strategy-with-new-2022-ambition>

Toyota, General Motors, and Ford. The table includes company statements about their relative distribution of planned electric vehicle supply and model offerings in priority markets. Details about the overall and plant-level U.S. and non-U.S. investments are shown in the columns on the right. Overall, the announcements show a clear trend for companies prioritizing electric vehicle supply and investments primarily in China, followed by Europe and North America. The details of the Volkswagen Group’s electric vehicle “offensive” best portray this dynamic, with 60% of its sales destined for China, followed by Europe (26%) and North America (11%).<sup>30</sup> Volkswagen’s \$800 million electric vehicle expansion at the Chattanooga (Tennessee) plant in the United States represents about 2% of its overall announced global electric vehicle investment.

**Table 4.** Example automaker announcements for electric vehicle deployment and associated investment details outside and within the United States.

| Automaker               | Electric vehicle supply announcements  | Investment details outside the United States   | Investment details in the United States   |
|-------------------------|--|--|---|
| <b>Volkswagen Group</b> | <ul style="list-style-type: none"> <li>Electric vehicle sales through 2028 projected for China (60%) and Europe (26%), followed by North America (11%) and rest of world (3%)</li> </ul>   | <ul style="list-style-type: none"> <li>\$17 billion overall by 2025 in China</li> <li>\$3 billion for the all-electric Anting factory in China</li> <li>\$1.45 billion for the all-electric Zwickau factory (Germany)</li> <li>\$1.2 billion for the all-electric Emden factory (Germany)</li> </ul>   | <ul style="list-style-type: none"> <li>\$800 million expansion for EVs in Chattanooga out of \$42 billion on BEVs globally by 2025 (2%)</li> </ul>  |
| <b>Toyota</b>           | <ul style="list-style-type: none"> <li>10 electric vehicle models by the early 2020s</li> <li>First target market is China then Japan, India, United States, and Europe</li> </ul>         | <ul style="list-style-type: none"> <li>\$1.2 billion investment in Tianjin electric vehicle plant with FAW</li> <li>New joint venture with BYD for electric vehicles in China</li> </ul>   | <ul style="list-style-type: none"> <li>None identified (0%)</li> </ul>  |
| <b>General Motors</b>   | <ul style="list-style-type: none"> <li>1 million global annual electric vehicle sales by 2025</li> <li>30 electric models globally by 2025, with 20 available in North America</li> </ul>  | <ul style="list-style-type: none"> <li>Joint venture with manufacturer of China’s highest-selling electric vehicle in 2020, the Wuling MINI</li> <li>Nine electric models by 2020 in China</li> <li>40% of new model launches will be electric vehicles in China by 2025</li> <li>Revamp plants in Shanghai, Wuhan, and Liuzhou to make electric vehicles</li> <li>\$1 billion electric vehicle manufacturing complex in Mexico</li> </ul>   | <ul style="list-style-type: none"> <li>\$4.5 billion to upgrade plants for electric vehicle production and additional \$4.5 billion battery manufacturing investment out of \$35 billion globally by 2025 (25%)<sup>31</sup></li> <li>40% of models offered will be battery electric by 2025</li> </ul> |
| <b>Ford</b>             | <ul style="list-style-type: none"> <li>40% of global sales electric by 2030</li> <li>100% models in Europe plug-in electric by mid-2026</li> <li>All-electric in Europe by 2030</li> </ul> | <ul style="list-style-type: none"> <li>\$420 million investment for Mustang Mach-E production in Mexico</li> <li>\$1.5 billion investment in electric vehicle retooling in Oakville, Ontario (Canada)</li> <li>\$1 billion investment in Cologne electric vehicle plant (Germany)</li> <li>Most early Mach-E electric vehicles to Europe for CO<sub>2</sub> regulation compliance</li> <li>Mach-E produced in China for China customers</li> <li>Explorer PHEV is manufactured in the United States and delivered to Europe</li> </ul> | <ul style="list-style-type: none"> <li>\$1.7 billion to upgrade plants for electric vehicle production out of \$30 billion globally by 2025 (6%)</li> </ul>   |

30 Frank Witter, “Shaping the transformation together,” Volkswagen, November 29-30, 2018, [https://www.volkswagenag.com/presence/investorrelation/publications/presentations/2018/11\\_november/2018\\_11\\_29-30\\_Volkswagen\\_Group\\_Presentation\\_Investor\\_Meetings\\_Frankfurt\\_London.pdf](https://www.volkswagenag.com/presence/investorrelation/publications/presentations/2018/11_november/2018_11_29-30_Volkswagen_Group_Presentation_Investor_Meetings_Frankfurt_London.pdf)

31 General Motors’ June 2021 announcement indicates additional U.S. battery production investments but the details are not available. “GM will boost EV and AV investments to \$35 billion through 2025,” GM Corporate Newsroom, accessed June 16, 2021, <https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2021/jun/0616-gm.html>

Table 4 shows that the majority of announced electric vehicle deployment and investments are going to non-U.S. markets, primarily China and Europe. For example, Toyota is investing \$1.2 billion with FAW and is launching an electric vehicle joint venture with BYD in China, compared to no announced U.S. electric vehicle manufacturing plans. General Motors has a joint venture with SAIC and Wuling (which has the highest-selling electric model in China) and in 2020 offered nine electric vehicle models in China, compared to one in the United States. Ford has announced all of its models in Europe will be plug-in electric by mid-2026 and all-electric by 2030, but has not made similar announcements for the United States. Based on available company statements, the U.S. electric vehicle investments for the four automakers shown represent 0% (Toyota), 2% (Volkswagen Group), 6% (Ford), and 25% (General Motors) of their global electric vehicle investments.

Although not shown in Table 4, additional company statements reveal the importance of policy on automakers' electric vehicle activities. Fiat Chrysler's annual report cites regulatory measures as a key driver for the company's compliance-focused vehicle sales initiatives by region. From 2018 to 2019, the company's plan for electric vehicle sales shifted; Fiat Chrysler increased its electric vehicle ambitions in China but lowered them in the United States. The company previously aimed for 20% of its 2022 U.S. sales to be hybrid or electric, with a focus on plug-in vehicles, but has since reduced these goals to 5%.<sup>32</sup> This decision was made while the U.S. vehicle regulations were weakened from over 4% per year annual greenhouse gas emission reduction through 2025, to approximately 1.5% per year through 2026.<sup>33</sup> All these electric vehicle assembly plant decisions, automaker electric vehicle deployment allocations, and associated policies warrant deeper investigation.

## CONCLUSIONS

The global electric vehicle transition is underway, with hundreds of billions of dollars of automaker investments supporting the transition to electric vehicles. These investments provide a great opportunity for countries of the world to benefit economically from the evolution of vehicle manufacturing. We conclude with the following four takeaway points related to the U.S. position in the transition to electric vehicle manufacturing.

**The United States is the third largest electric vehicle producer, behind China and Europe, and the gap has widened.** From 2017 to 2020, the U.S. share of cumulative global electric vehicle production since 2010 decreased from 20% to 18%. Comparatively, electric vehicle manufacturing has increased at a faster rate in China, which made up 44% of global electric vehicles manufactured through 2020, up from 36% in 2017. Similarly, European manufacturing accounted for 25% of global electric vehicles through 2020, up from 23% in 2017. In terms of annual electric vehicle production, Europe's 1.1 million nearly matched China's 1.27 million in 2020, followed by 450,000 in the United States and about 110,000 each in Japan and South Korea.

32 Fiat Chrysler Automobiles N.V., "Annual report and form 20-F for the year ended December 31, 2018," 2019, [https://www.fcagroup.com/en-US/investors/financial\\_regulatory/financial\\_reports/files/FCA\\_NV\\_2018\\_Annual\\_Report\\_on\\_Form\\_20F.pdf](https://www.fcagroup.com/en-US/investors/financial_regulatory/financial_reports/files/FCA_NV_2018_Annual_Report_on_Form_20F.pdf); Fiat Chrysler Automobiles N.V., "Annual report and form 20-F for the year ended December 31, 2019," 2020, [https://www.fcagroup.com/en-US/investors/financial\\_regulatory/financial\\_reports/files/FCA\\_NV\\_2019\\_Annual\\_Report.pdf](https://www.fcagroup.com/en-US/investors/financial_regulatory/financial_reports/files/FCA_NV_2019_Annual_Report.pdf)

33 U.S. Environmental Protection Agency and National Highway Traffic Safety Administration, *Federal Register*, 85 FR 24174, <https://www.federalregister.gov/documents/2020/04/30/2020-06967/the-safer-affordable-fuel-efficient-safe-vehicles-rule-for-model-years-2021-2026-passenger-cars-and>

### **Electric vehicle manufacturing grows where policies are spurring electric vehicle**

**growth.** The electric vehicle production dynamics reflect where there has been the most electric vehicle market growth, which depends heavily on policy developments. Of the 10 million cumulative electric vehicles sold globally, 80% were produced in the same region in which they were sold. The U.S. market has remained steady with fewer than 360,000 electric vehicle sales annually from 2018 through 2020, whereas over the same period Europe saw explosive growth from 390,000 to more than 1.3 million and China grew from about 1 million to more than 1.25 million. These trends reflect recent policy actions. In Europe, automakers deployed 30 new models with increased volume to meet the vehicle CO<sub>2</sub> emission standards. China has the most comprehensive system of demand- and supply-side policies and has extended its consumer incentives and is implementing stronger electric vehicle regulations. Vehicle regulations in the United States have been rolled back and incentives have not been extended.

### **Most automaker electric vehicle commitments and investments are destined for**

**China and Europe.** About 15% of the approximately \$345 billion in global automaker electric vehicle investments appear to be destined for the United States. Based on the company announcements through 2020, about 5% of this global total is actively being invested in specific U.S. assembly plants to increase electric vehicle production. Similarly, of the automakers' announcements that sum to 22 million annual electric vehicle sales by 2025, about 2.3 million (or about 10%) are slated to be manufactured in the United States. Global automakers have made more substantial commitments to electric vehicles in China and Europe. About 25% of General Motors' \$35 billion electric vehicle commitment is being invested in specific U.S. vehicle assembly and battery plants. Ford has pledged to offer an all-electric variant for every model it sells in Europe by 2030 but has not made similar commitments in the United States, and about 6% of its \$30 billion electric vehicle investment is actively being made in specific U.S. plants.

### **Seven of the 44 major U.S. vehicle assembly plants are slated to be making all electric vehicles by 2025.**

Based on company announcements and industry developments, seven of the 44 major U.S. assembly plants, representing about 16% of U.S. vehicle production and capacity, will manufacture only electric vehicles in 2025. The U.S. electric plants include three owned by General Motors, two by Tesla, and one each by emerging electric vehicle companies Rivian and Lucid Motors. Five automakers (Ford, Fiat Chrysler, Toyota, Honda, and Nissan) that each produce about 900,000 to 1.5 million vehicles annually have not announced plans for electric vehicle-only assembly plants. However, many automakers have developed limited capacity for some electric vehicle production (typically less than 15% of a plant's production capacity as of 2020) and are making additional investments to partially convert or expand their electric vehicle capacity.

Based on this assessment, more investigation is needed to identify and recommend targeted electric vehicle policy actions to bolster the U.S. auto industry. With 44 major manufacturing plants and production volume of more than 10 million light-duty vehicles, the United States has both a risk of continuing to lag developments in China and Europe and also an opportunity to increase its share of global electric vehicle production. Global developments to date demonstrate how the markets with the greatest electric vehicle market and industry success through 2020 are those that have implemented a comprehensive policy package of market development and industrial support policies. Sustained regulatory, incentive, and infrastructure support are all

likely part of the mix needed to spur the manufacturing industry to strengthen the U.S. position in the global electric vehicle industry.

There is global competition among countries to seize the economic benefits from the transition to electric vehicles. Despite the United States lagging through 2020, major automakers appear to be well-positioned to transition if guided with the right policy signals. This research points to several critical areas for further investigation: how the transition to electric vehicle assembly plants is occurring faster in China and Europe, the U.S. risks and opportunities related to electric vehicle imports and exports, the prospects for U.S. battery manufacturing and other supply chain growth, the workforce implications, and broader potential for direct and indirect economic benefits. Such research would help in understanding the potential for a growing role for the U.S. automotive industry as the world continues to transition to electric vehicles.