

# Driving toward a Greener Future

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## Executive Summary

Climate change is disrupting the global economy and affecting everyone. The transition from fossil fuel vehicles to electric vehicles (EVs) is often considered a critical step in decarbonizing the global transportation system. The adoption of EVs has accelerated over the past few years. Since 2012, global EV sales have grown at a CAGR of 56%<sup>1</sup>. In 2021, sales doubled from the previous year, hitting a record high of 6.75 million units (see Exhibit 1). Going forward, restrictions or even banning the production of fossil fuel vehicles,<sup>2</sup> the tax credits for purchasing EVs,<sup>3</sup> growing preference for EVs among young consumers,<sup>4</sup> and billions of investments in EV charging infrastructure<sup>5</sup> could continue to boost the supply and demand of electric vehicles. For market participants, this global structural shift from traditional engine vehicles to EVs represents meaningful opportunities.

<sup>1</sup> Irle, Roland. "[Global EV Sales for 2021.](#)"

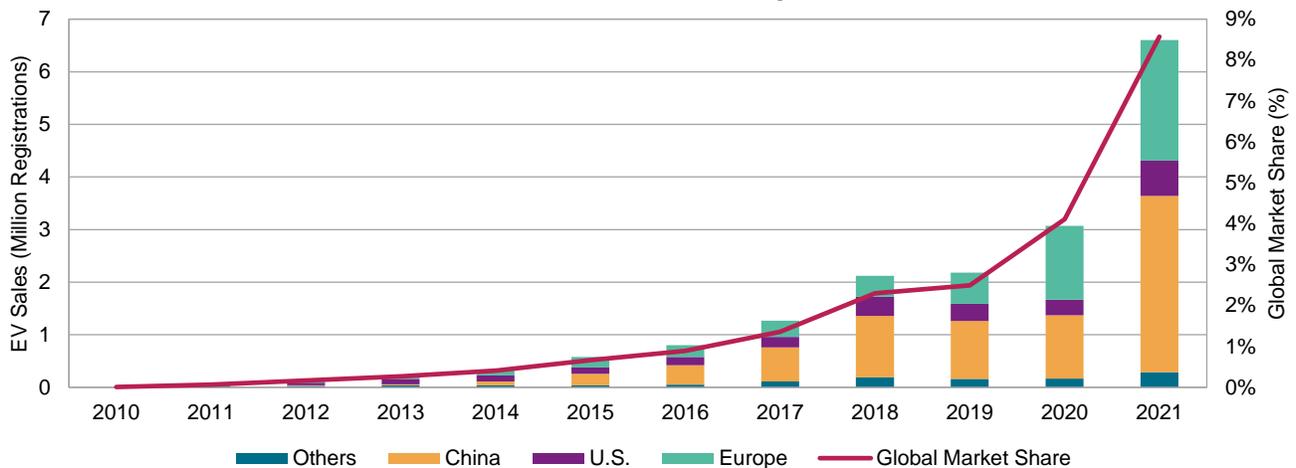
<sup>2</sup> Global EV Outlook 2021. International Energy Agency. June 2020.

<sup>3</sup> Doll, Scooter. "[Here's every electric vehicle that currently qualifies for the US federal tax credit.](#)" Electrek. April 15, 2022.

<sup>4</sup> CR Consumer Reports. "[New CR Survey finds the majority of consumers are interested in getting an electric vehicle.](#)" December 2020

<sup>5</sup> "[President Biden, U.S. Department of Transportation Releases Toolkit to Help Rural Communities Build Out Electric Vehicle Charging Infrastructure.](#)" Department of Transportation. Feb. 2, 2022.

## Exhibit 1: Global Electric Vehicle Sales Have Had Rapid Growth



Source: IEA, Global sales and sales market share of electric cars, 2010-2021, IEA, Paris, <https://www.iea.org/data-and-statistics/charts/global-sales-and-sales-market-share-of-electric-cars-2010-2021>. Data as of year-end 2021. Sales data include passenger vehicles, light trucks, and battery electric vehicle (BEV) and plugin hybrid electric vehicle (PHEV) light commercial vehicles. Chart is provided for illustrative purposes.

## An Electric Era Is Coming

More than 20 countries have announced their intention to fully phase out new sales of internal combustion engine (ICE) vehicles over the next 30 years, with many targeting zero carbon emissions by 2050.<sup>6</sup> The U.K. is set to ban new sales of petrol and diesel cars by 2035.<sup>7</sup> The U.S. government has set a target for half of new auto sales to be electric by 2030,<sup>8</sup> with a USD 7.5 billion package to roll out charging stations across the country. Meanwhile, leading traditional automakers are pivoting toward EV manufacturing. General Motors has set an aggressive goal to exclusively produce EVs by 2035,<sup>9</sup> and Ford announced it would target 40% of its vehicle production to be EVs by 2030.<sup>10</sup> To meet the stated targets of all countries, the International Energy Agency's forecast shows that global EV sales would need to increase to 25 million vehicles by 2030, representing 15% of the market share (see Exhibit 2).

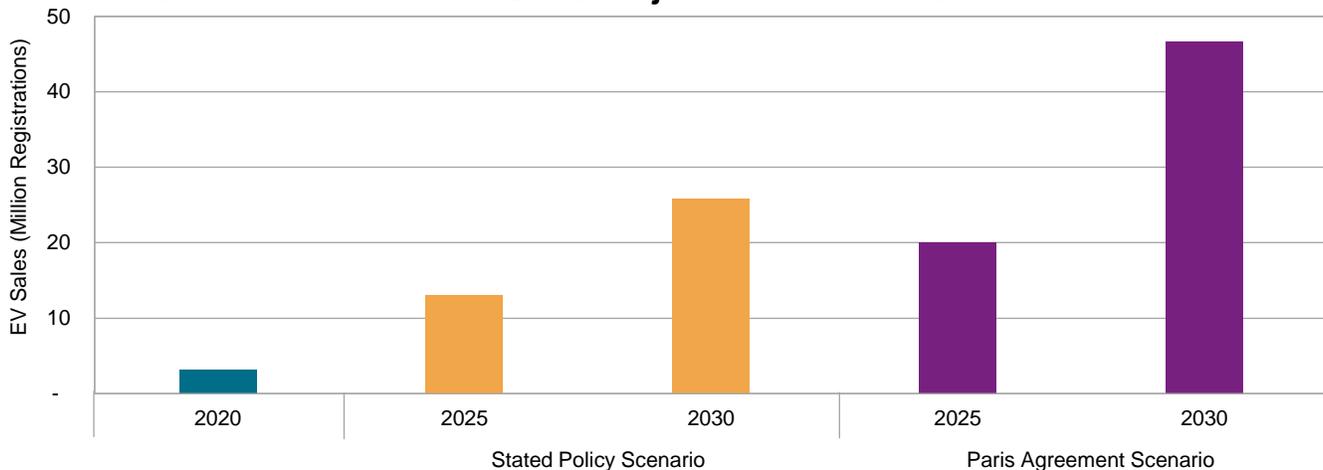
<sup>6</sup> [Global EV Outlook 2021](#). International Energy Agency. June 2020.

<sup>7</sup> ["Petrol and diesel car sales ban brought forward to 2035."](#) BBC News. Feb. 4, 2022.

<sup>8</sup> ["FACT SHEET: President Biden Announces Steps to Drive American Leadership Forward on Clean Cars and Trucks."](#) The White House Briefing Room. Aug. 5, 2021.

<sup>9</sup> Chapman, Michelle. ["General Motors sets goal of going largely electric by 2035."](#) AP News. Jan. 28, 2021.

<sup>10</sup> ["Ford To Lead America's Shift To Electric Vehicles With New Mega Campus In Tennessee And Twin Battery Plants In Kentucky: \\$11.4B Investment To Create 11,000 Jobs And Power New Lineup Of Advanced EVs."](#) Ford. Sept. 27, 2021.

**Exhibit 2: Global Electric Vehicle Sales Projection toward 2030**

Source: International Energy Agency analysis developed with the [Mobility Model](#). Data as of Feb 25, 2022. Chart is provided for illustrative purposes.

For market participants, the rise of the EV industry could potentially provide multifaceted opportunities.

- 1. Capturing a key long-term growth opportunity.** The automotive industry, which contributed 3.0%-3.5% of the U.S. GDP as of April 2010,<sup>11</sup> is in a major transition. EVs will need to become mainstream in order to achieve a low-carbon economy over the coming decades.
- 2. Aligning with sustainable investment goals.** Producing zero carbon dioxide in use and lower emissions than ICE vehicles during their lifecycle, EVs are important for reaching the goal of limiting global warming to below 2°C or 1.5°C. For climate-conscious investors, considering EVs could align their portfolios with sustainable investment goals and help manage climate risks.
- 3. Accessing the broader autonomous driving ecosystem.** EVs are the gateway to autonomous driving. A survey indicated that the average driver in the U.S. spent about 293 hours behind the wheel annually as of September 2016,<sup>12</sup> and EVs and autonomous driving would change how people spend those hours. Just like smartphones opened up an era of mobile internet, EVs could initiate a new era of vehicle to everything (V2X), when communication is enabled between a vehicle and any entity that may affect or may be affected by the vehicle.

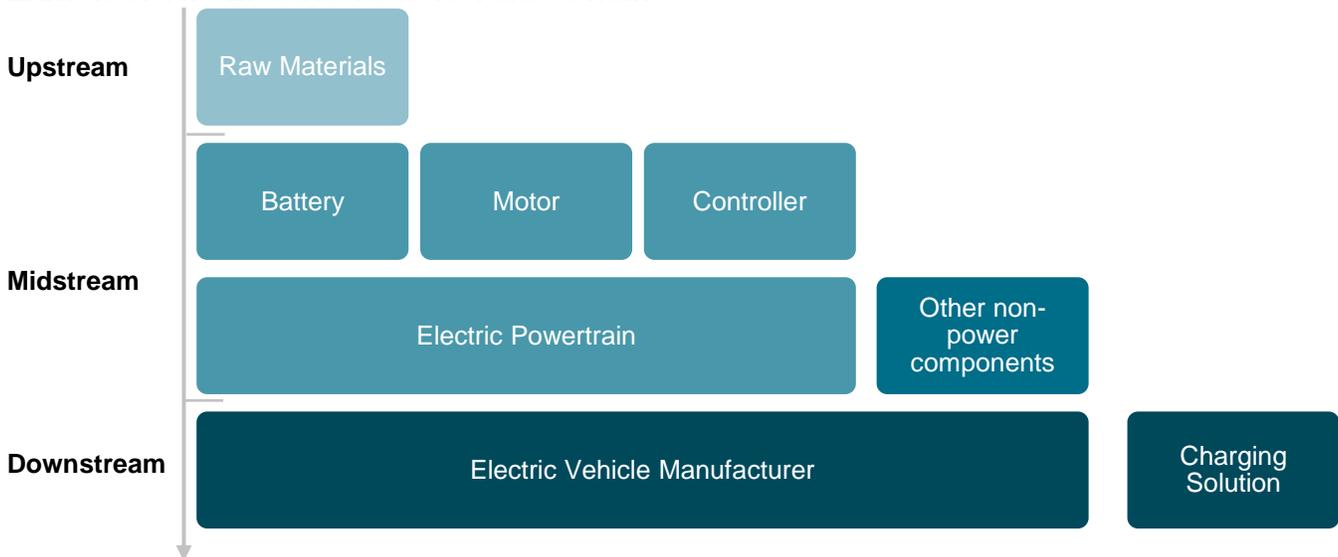
<sup>11</sup> ["Contribution of the Automotive Industry to the Economies of all Fifty States and the United States."](#) Center for Automotive Research. April 2010.

<sup>12</sup> ["Americans Spend 293 Hours Driving Each Year."](#) Automotive Fleet. Sept. 8, 2016.

# The Electric Vehicle Value Chain

Unlike traditional ICE vehicles, which use energy from fuel combustion to propel a vehicle, EVs apply electromagnetism to convert electricity into mechanical power. As the performance is highly dependent on the capacity of energy storage and efficiency of electricity conversion, the EV value chain is centered around the electric powertrain (see Exhibit 3). The manufacturing of EVs starts from upstream companies supplying raw materials such as metals that can be used in the production of battery cells, moves to the midstream, consisting of EV parts and components suppliers that produce electric powertrain and other non-power components, and then completes the process at EV automakers who assemble the final vehicles and sell them to consumers. While not part of the supply chain, charging solution providers are essential to the EV ecosystem as well.

**Exhibit 3: The Electric Vehicle Value Chain**



Source: S&P Dow Jones Indices LLC. Chart is provided for illustrative purposes.

## Raw Materials

Raw materials are a vital input for battery cell manufacturing. More than two-thirds of the total cost per battery cell goes to raw materials. The cathode is the most expensive component, making up about 51% of total battery cell cost as of 2021.<sup>13</sup> In comparison, the anode only accounts for one-fourth of the cathode’s cost. The difference comes from metals used to produce cathode and anode—the lithium, nickel, cobalt and manganese to produce the cathode are more expensive than the graphite in the anode. Raw material supply is concentrated in mineral-rich regions such as Africa, South America and Australia.

<sup>13</sup> Bhutada, Govind. “[Breaking Down the Cost of an EV Battery Cell.](#)” Visual Capitalist. Feb. 22, 2022.

The heart of an EV, the electric powertrain, consists of three parts: a battery pack that stores electrical power, a motor that converts electrical power into mechanical energy, and a controller that interfaces between battery and motor to control speed and acceleration (see Exhibit 3).

## Battery

The battery is a key differentiator between various EV models in terms of performance and cost. Manufacturing EV battery cells begins with processing metals such as lithium, nickel and cobalt, as well as specialty chemicals. Each battery cell consists of a cathode, an anode and an electrolyte. Multiple battery cells are organized in a case with terminals attached to form a module. From there, battery packs are assembled to specific EV models by attaching battery modules with electrical connections and cooling equipment.

Currently, two types of batteries dominate the EV battery market—Nickel Manganese Cobalt (NMC)/Nickel Cobalt Aluminum (NCA) lithium batteries and Lithium Iron Phosphate (LFP) batteries. The difference between the two is primarily in cathode materials. High-performance vehicles such as the Tesla Model X often have an NMC/NCA lithium battery, as it is lighter with a higher energy density and better charging efficiency. Meanwhile, the LFP battery is the choice of many daily commuters for its higher safety level and longer lifecycle.

Manufacturers are actively seeking various innovations to lower cost and enhance performance. Sophisticated battery cell packing is one potential way to improve efficiency. In 2020, BYD's Han model adopted blade battery packing to improve the energy density of the LFP battery pack by 50%.<sup>14</sup> New material may bring potential breakthroughs. Researchers are extensively exploring new materials such as silicon-carbon-based anodes for higher performance. Thanks to technology development, average lithium-ion battery pack prices have fallen 89% to USD 132 per kilowatt-hour over the past 11 years.<sup>15</sup> In the long term, the decreasing cost of battery packs could make EVs more affordable, which would ultimately speed up the transition into a low-carbon economy.

<sup>14</sup> Kane, Mark. "BYD Reveals Ultra-Safe Blade Battery: Pierces It With A Nail." Inside EVs. March 30, 2020.

<sup>15</sup> BloombergNEF. "[Battery Pack Prices Fall to an Average of \\$132/kWh, But Rising Commodity Prices Start to Bite.](#)" Annual Battery Price Survey 2021. Nov. 30, 2021.

## Motor and Controller

For EVs, the motor and controller are the muscle and brain. They work together to ensure that EVs function efficiently and accurately.

The motor is where electromagnetism converts electricity into mechanical rotation. When a driver steps on the accelerator, electricity flows from the battery pack into a typical asynchronous motor. A coiled wire inside called a stator creates a rotating magnetic field, which causes the rotor to run, subsequently turning the car's gears and ultimately moving the wheels.

The controller consists of multiple power electronics and micro-computing elements. With its ability to process commands, calculate the energy needed and modify the energy flow from the battery, the controller can precisely regulate the EV's speed and direction.

In general, there are two mainstream types of electric motors in EVs— asynchronous motors and synchronous motors. For an asynchronous motor, the rotor is pulled by a stator-created rotating magnetic field, thus it always turns slower than the stator field. For a synchronous motor, the rotor itself, often with ferromagnetic rare earth metals, generates a magnetic field that moves at the same speed as the stator. While synchronous motors are mostly used in urban-driving EVs like the Nissan Leaf for their efficiency at low speeds, asynchronous motors can be found in high-performance EVs such as the Tesla Model S.

EV automakers are either producing motors and controllers internally (e.g., Tesla and BYD) or sourcing them from third-party suppliers. Major motor suppliers include Siemens, Hitachi and Continental. The core technology in the controller is the IGBT inverter, which inverts direct current from the battery into alternating current for the motor. Its market share is highly concentrated among several top players such as Infineon, Mitsubishi and Fuji.

## Other Non-Power Components

Other than the power system, EVs share similar components with traditional ICE vehicles. Non-technological components including the car body, interior, seats and wheels, and technological components such as advanced driving assistance system (ADAS) and its sensors and automotive electronics are necessary for EVs to function.

Meanwhile, demand for technological components with semiconductor chips is likely to increase. EVs are evolving to utilize electronic control units for almost every component, from powertrain to breaks and headlights. Over the next five years, ADAS and its sensors and automotive electronics are estimated to be the fastest-growing non-power segments, at a rate of 150% and 22%, respectively.<sup>16</sup>

## Electric Vehicle Manufacturer

Global EV automakers can be divided into two types: pure players such as Tesla and NIO, which started with designing and manufacturing only EVs, and legacy automakers such as Ford and General Motors who are adding EVs to their lineups. Tesla is leading the race, with a 14.4% market share of global EV sales in 2021, followed by Volkswagen Group, SAIC, BYD and Stellantis, according to EV volumes. The top five sellers together make up more than one-half of total EV sales.<sup>17</sup>

Depending on the power system, EV models can be classified into two types: plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). PHEVs are equipped with both a fuel-based engine and an electric powertrain, which could support average daily commutes with a range of 20-40 miles entirely on electricity. Many legacy automakers offer PHEV models such as BMW 3 Series and BYD Qin. In contrast, BEVs are entirely powered by an electric powertrain, with larger batteries to support longer travel distances of more than 200 miles. Popular BEV models include Tesla Model 3, Nissan Leaf and Volkswagen ID.3.

In 2009, Tesla pioneered the first highway-legal BEV, called Roadster, and has been able to maintain the first-mover advantage since then. The success of Tesla inspired the automotive industry. Nissan followed in 2010 with the introduction of Leaf, which could travel 73 miles on a single charge. After a decade, most available models in the market could provide a range of more than 200 miles. In 2020, Volkswagen ID.3 debuted as an affordable and long-range BEV model, which soon became the best seller in Europe. With legacy automakers and new startups catching up, it is reasonable to believe that increasing competition in the EV market could encourage further technological breakthroughs.

<sup>16</sup> Coffman, Jason, Raj Iyer and Ryan Robinson.. [2021 Global Automotive Supplier Study](#). Deloitte. January 2022.

<sup>17</sup> Kane, Mark. ["World's Top 5 EV Automotive Groups Ranked By Sales: 2021."](#) Inside EVs. Feb. 2, 2022.

## Charging Solution

Built-in powertrains cannot continuously work without a charging system to refill electric power when the battery runs out. The efficiency and coverage of charging systems also affect how far an EV can travel. Recognizing the importance of charging infrastructure to broad EV adoption, the Biden administration has committed USD 7.5 billion to installing charging stations across the U.S.<sup>18</sup>

Looking ahead, energy efficiency, raw materials and environmental impact present three major challenges and opportunities for EVs. The industry is continuously exploring various new technologies for better battery efficiency and slower depreciation, such as solid-state batteries and hydrogen fuel cells. To mitigate the risk of raw material shortage and to lower costs, many downstream automakers are seeking upstream integration by directly cooperating with or investing in battery cell producers. For example, Tesla built “Gigafactories” with Panasonic to produce its battery modules and packs in the U.S.<sup>19</sup> and signed a supply contract with Piedmont trying to ensure lithium supply.<sup>20</sup> Finally, as demand for EVs grows, the use of lithium-ion batteries will likely surge. Reducing toxic materials such as cobalt in batteries and recycling batteries in a cost effective way may help to alleviate the impact on the environment.

## S&P Kensho Electric Vehicles Indices

The S&P Kensho Electric Vehicles Index Series seeks to track companies focused on producing electric road vehicles and associated subsystems, including:

- Companies that manufacture electric road vehicles;
- Companies that make powertrain systems, motors or energy storage systems for EVs;
- Producers of EV energy storage systems and related management systems, as well as zero-emission clean fuel technology such as hydrogen fuel cells; and,
- Companies that produce charging systems for electric vehicles, not including charging networks or associated infrastructure.

<sup>18</sup> [“President Biden, U.S. Department of Transportation Releases Toolkit to Help Rural Communities Build Out Electric Vehicle Charging Infrastructure.”](#) Department of Transportation. Feb. 2, 2022.

<sup>19</sup> “Panasonic and Tesla Sign Agreement for the Gigafactory.” Tesla. July 30, 2014.

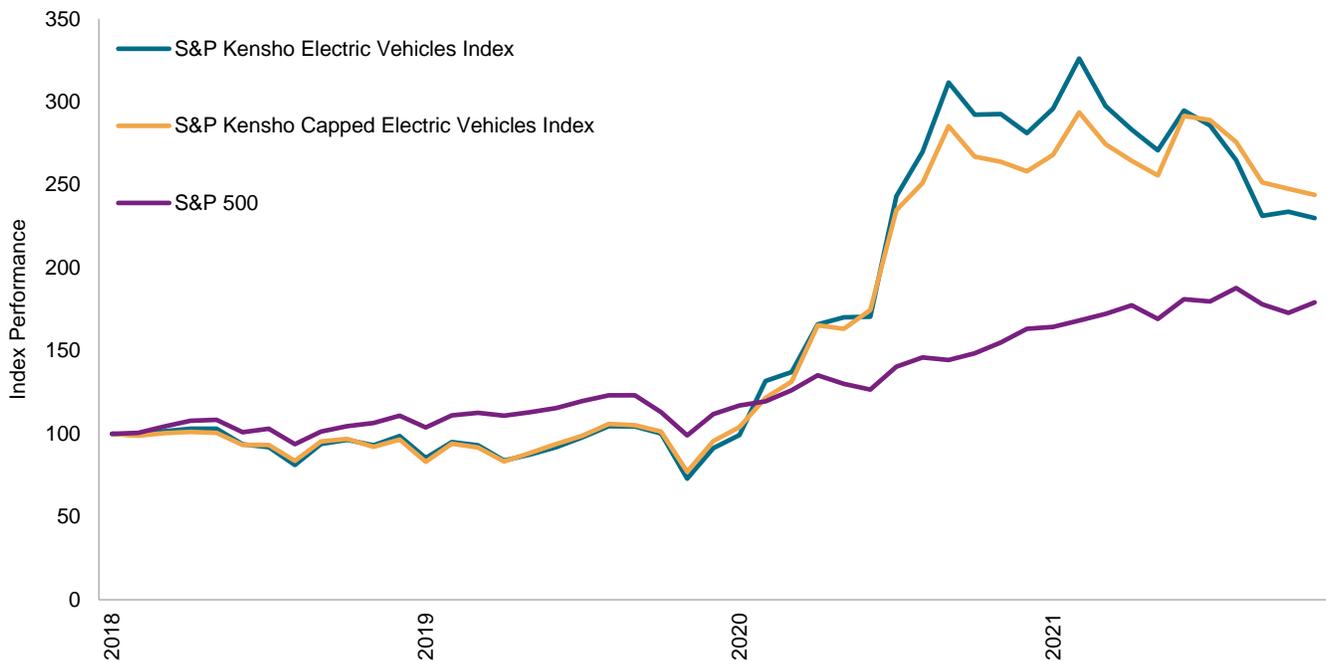
<sup>20</sup> [“Piedmont Lithium Signs Sales Agreement with Tesla.”](#) Piedmont Lithium. Sept. 28, 2020.

There are currently two indices in the series: the [S&P Kensho Electric Vehicles Index](#)<sup>21</sup> and the [S&P Kensho Capped Electric Vehicles Index](#).<sup>22</sup> The major difference between the two indices is that the S&P Kensho Electric Vehicles Index starts by equally weighting the constituents and then adjusts the final weights by tilting toward more liquid names, while the S&P Kensho Capped Electric Vehicles Index starts by float market capitalization weighting the constituents and then adjusts the final weights by capping individual constituents.

## Performance

Both the S&P Kensho Electric Vehicles Index and the S&P Kensho Capped Electric Vehicles Index outperformed the S&P 500® in over the back-tested three-year period ending March 31, 2022 (see Exhibit 4). Since 2013, the S&P Kensho Electric Vehicles Index has outperformed the S&P 500 by 2.67% per year (see Exhibit 5).

**Exhibit 4: Historical Back-Tested Performance of S&P Kensho EV Indices versus the S&P 500**



Source: S&P Dow Jones Indices LLC. Data as of March 31, 2022. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. S&P Kensho Electric Vehicles Index was launched Sept. 17, 2018. S&P Kensho Electric Vehicles Capped Index was launched March 21, 2022. All data prior to index launch date is back-tested data. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

<sup>21</sup> For detailed methodology, please visit [S&P Kensho New Economy Indices Methodology](#).

<sup>22</sup> For detailed methodology, please visit [S&P Kensho Capped Indices Methodology](#).

### Exhibit 5: Back-Tested Risk/Return Profiles of S&P Kensho EV Indices versus the S&P 500

Period	S&P Kensho Electric Vehicles Index	S&P Kensho Capped Electric Vehicles Index	S&P 500
<b>Annualized Return (%)</b>			
1-Year	-21.43	-7.58	15.65
3-Year	35.21	38.37	18.92
5-Year	21.73	-	15.99
Since May 31, 2013	17.13	-	14.46
<b>Annualized Volatility (%)</b>			
1-Year	24.13	22.74	13.62
3-Year	45.27	39.17	17.76
5-Year	37.21	-	15.78
Since May 31, 2013	30.40	-	13.68
<b>Risk-Adjusted Return</b>			
1-Year	-0.89	-0.33	1.15
3-Year	0.78	0.98	1.07
5-Year	0.58	-	1.01
Since May 31, 2013	0.56	-	1.06
<b>Maximum Drawdown (%)</b>			
Since May 31, 2013	34.99	27.2	19.6

Source: S&P Dow Jones Indices LLC. Data as of March 31, 2022. Index performance based on monthly total return in USD. Past performance is no guarantee of future results. S&P Kensho Electric Vehicles Index was launched Sept. 17, 2018. S&P Kensho Electric Vehicles Capped Index was launched March 21, 2022. All data prior to index launch date is back-tested data. Chart is provided for illustrative purposes and reflects hypothetical historical performance. Please see the Performance Disclosure at the end of the document for the inherent limitations associated with back-tested performance.

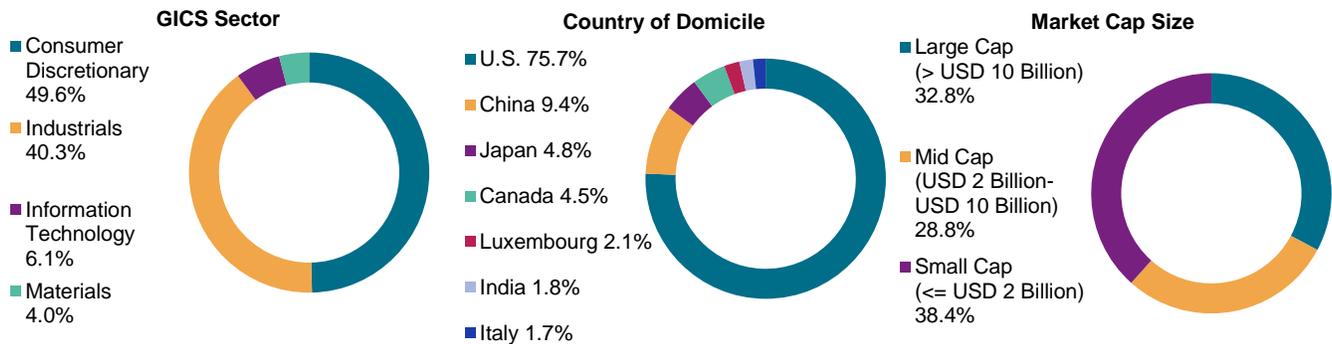
# Appendix

## Exhibit 6: Top 10 Constituents by Market Cap in the S&P Kensho Electric Vehicles Index

Company	Ticker	Country of Domicile
Tesla, Inc	TSLA	U.S.
Honda Motor Co ADR	HMC	Japan
Cummins Inc	CMI	U.S.
Borgwarner Inc	BWA	U.S.
Allison Transmission Holdings Inc	ALSN	U.S.
Visteon Corp	VC	U.S.
Meritor Inc	MTOR	U.S.
Gentherm Inc	THRM	U.S.
Hyzon Motors Inc.	HYZN	U.S.
Garrett Motion Inc.	GTX	U.S.

Source: S&P Dow Jones Indices LLC. Data as of March 31, 2022. Table is provided for illustrative purposes.

## Exhibit 7: GICS Sector, Country of Domicile and Market Cap Size Breakdowns of the S&P Kensho Electric Vehicles Index



Source: S&P Dow Jones Indices LLC. Data as of March 31, 2022. Charts are provided for illustrative purposes.

## Performance Disclosure/Back-Tested Data

The S&P Kensho Electric Vehicles Index was launched September 17, 2018. The Kensho Electric Vehicles Capped Index was launched March 21, 2022. All information presented prior to an index's Launch Date is hypothetical (back-tested), not actual performance. The back-test calculations are based on the same methodology that was in effect on the index Launch Date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. Complete index methodology details are available at [www.spglobal.com/spdji](http://www.spglobal.com/spdji). Past performance of the Index is not an indication of future results. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results. Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations. Back-tested performance is for use with institutions only; not for use with retail investors.

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