APPLIED
Insights

In Focus: Electric Vehicles

Market trends and value chain analysis Q1 2021

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Market trends

Value chain analysis

Mass adoption of electric vehicles is expected by 2030 as technology advances enable commercial viability and OEMs shift their focus to EVs

Key stats for the EV market

8.5m+
EVs on the road today

2.7%
EV share of total vehicle sales in 2020

500+
EV models expected globally by 2022

13
Countries with plans to phase out ICEs

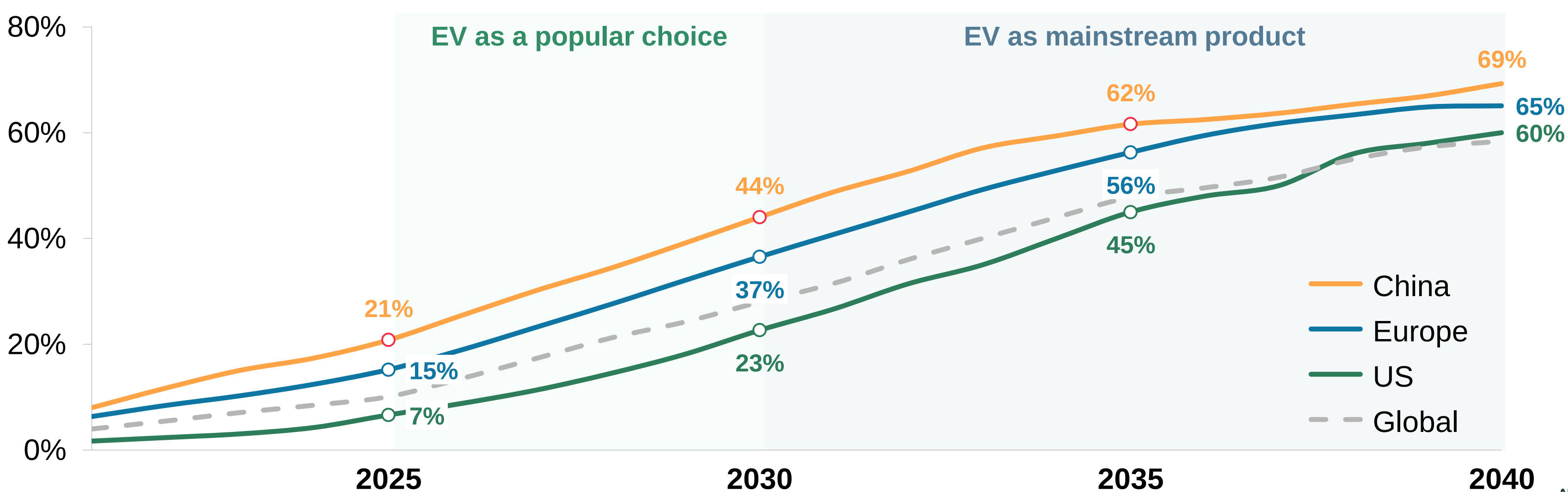
*Electric vehicles are expected to become widely accepted over the next 5-10 years, driven by a few major factors, including **consumer sentiment, commercial viability, OEM vehicle availability,** and **policy & legislation***

2020+
EV shift begins

2025+
EVs widely accepted

2030+
EV mass adoption

2040+
Majority EV



Source: Bloomberg NEF, Electric Vehicle Outlook 2020, Applied Value analysis

Wide-scale changes are needed to support electric vehicle market growth over the next two decades

2025

EV widely accepted

- EVs become more widely accepted by consumers
- Limited commercial EV adoption
- Major OEMs offer a range of EV options
- Battery range 500+ miles
- Expanded charging infrastructure with faster charging
- Extensive mandate from governments

2030

EV mass adoption

- EV becomes the mainstream product for consumers
- Initial commercial EV acceptance
- Major OEMs begin the shift to 100% carbon neutral lines
- Battery range 700+ miles
- Advanced charging infrastructure with common technology

2040

Majority EV

- EV becomes the primary vehicle for consumers
- Widespread use of commercial EVs
- Major OEMs offer only carbon-neutral products
- Most governments working to eliminate ICEs

Four main factors will drive EV market growth over the coming decades

1 Consumer sentiment

Consumer support for EV has increased drastically in the last two years

- **>70% of consumers have changed behavior** to out of concern for climate
- **31% willing to choose EV** when making next vehicle purchase
- Top concerns are **lack of infrastructure** and **limited range**

2 Commercial viability

Large improvements in battery technology, light-weight materials, and infrastructure

- **85% decline in electric battery costs** since 2010
- EVs offer **~40% lower operating costs** vs. diesel engine
- Public charging infrastructure **expanded 4-7x in the US and Europe** since 2013

3 OEM vehicle strategy

Wider variety of passenger and commercial vehicle models becoming available

- Most major OEMs have announced plans to **transition toward EV focus**
- **New entrants** are challenging large OEMs
- Large OEMs will **convert existing models to EV platform** by 2030 and shift to EV only by 2040

4 Policy & legislation

Increasing regulation and incentives in place to drive investment in EV

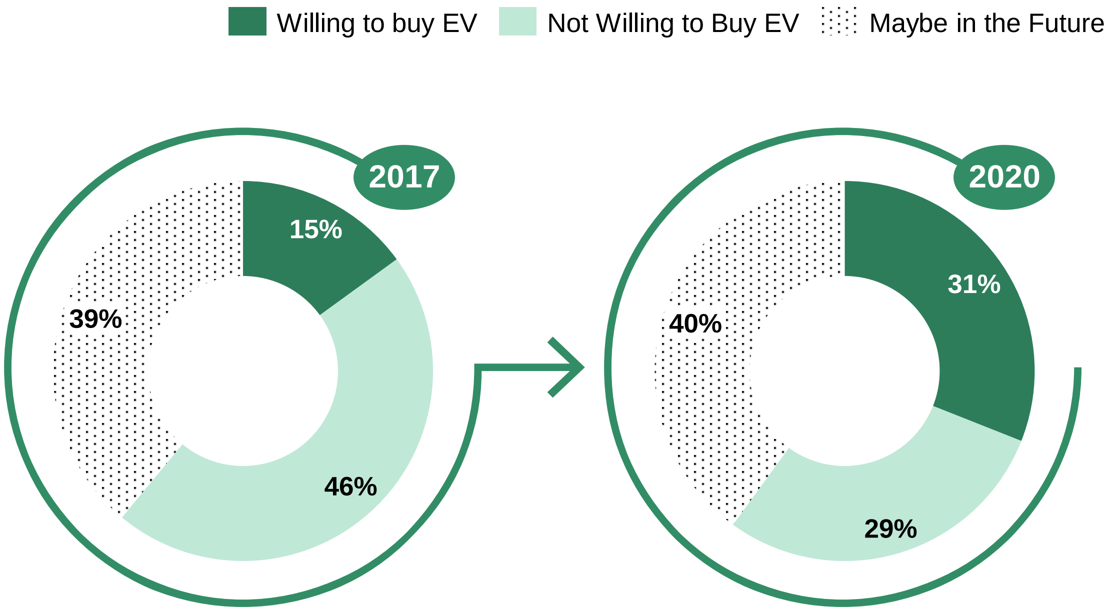
- Global policy support for EVs is high – many **countries aim to ban ICE sales** by 2040
- **China and Nordics are leading** developed nations in making EV policy
- 15 states in US are targeting **zero emissions from heavy trucks by 2050**

Source: BNEF, Applied Value analysis

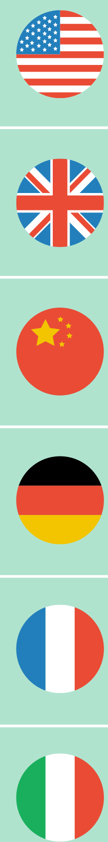
1

Consumer willingness remains a key hurdle for wider adoption, but support is increasing as climate change remains a top concern

Survey on Consumer Willingness to buy Battery Electric Vehicle (BEV)



- Lack of infrastructure support in the region where they live was the most cited reason for unwillingness to buy EV
- High purchase price was cited as the second most important reason for consumer reluctance to purchase an EV
- Insufficient range and lack of choices were cited as two other key reasons for refusal to consider EV



Country	Top Concern for EV 2018	Top Concern for EV 2020
	High Cost	Lack of Infrastructure
	Driving Range	Lack of Infrastructure
	Driving Range	Battery Safety
	Driving Range	Driving Range
	High Cost	Driving Range
	Lack of Infrastructure	Lack of Infrastructure

Source: Consumer Reports, Deloitte Global Auto Consumer Study

2

Three major obstacles stand in the way of mass market manufacturing and commercial viability for electric vehicles

Challenges to EV commercial viability | **Key players**

1 Battery Advances

- Increases in range with higher charge capacity and longer lifespan
- Decreases in production costs and battery weight
- Improved battery safety and reliability

Key players: Panasonic, CATL, LG Chem, Samsung SDI, Envision AESC, SK innovation, BYD, CALB, northvolt, Clarios, American Battery Solutions, Toshiba

2 Light-Weighting and Safety

- Shift from Mild Steel to Aluminum, lighter but more expensive
- Developments in Advanced High-Strength Steel (AHSS) – stronger, lighter, and more formable than traditional mild steel
- Expansion of composites, including fiberglass, carbon fiber, and thermoplastics – lightest, strongest, but most expensive

Key players: USS, JFE, Unity Aluminum, thyssenkrupp, ArcelorMittal, covestro, Constellium, Nucor, Saint-Gobain, Showa Denko

3 Charging Accessibility

- Range anxiety – many consumers still lack awareness that charging stations exist, and feel charging takes too long
- Too few stations to get from point A to point B, meaning EV driving is limited to regional trips

Key players: chargepoint, IONITY, Tesla, ABB, EVgo, EVBox, electrify america, bp chargemaster, Webasto

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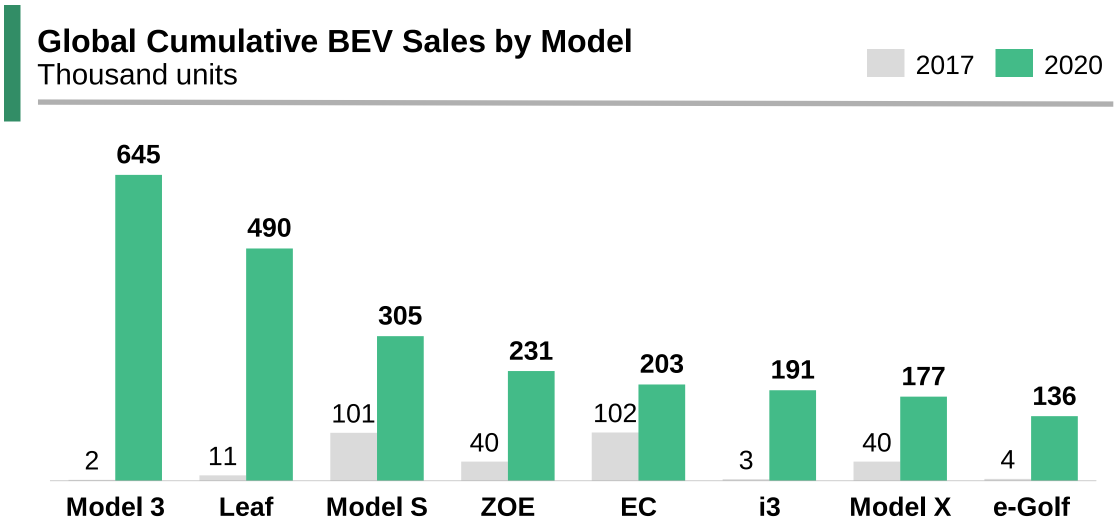
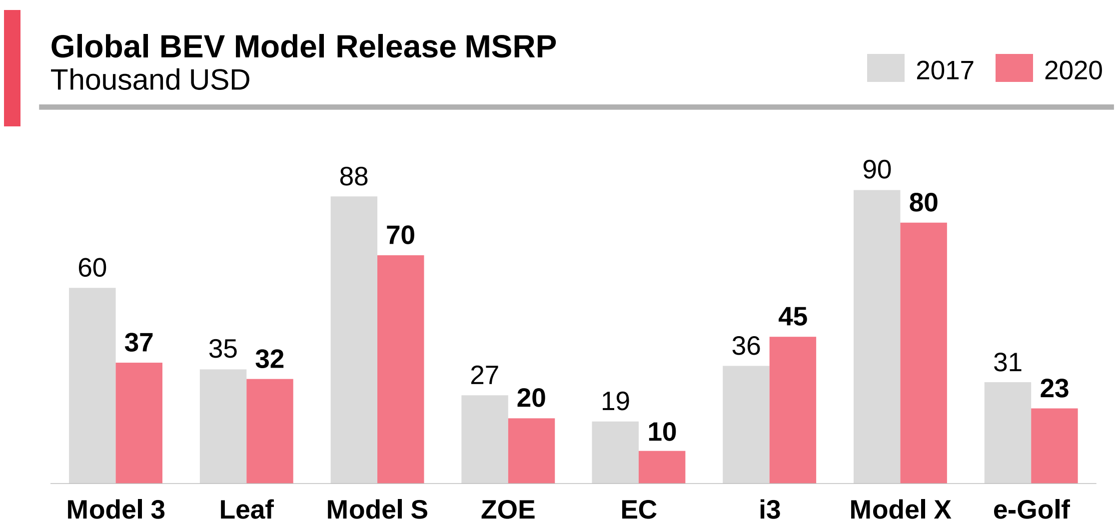
As battery costs decrease, EV prices are becoming more affordable, encouraging mass-adoption in the near future





- Since 2017, **average EV prices have declined by over 30%** driven by reduction in battery costs
- Currently, battery costs an average of $140 per KWh, **when battery reaches $100 per KWh, up-front cost of an EV is expected to be lower than an average ICE,** providing strong economical incentive for consumer to choose EV over ICE
- Prior to 2017, EV is mainly a niche product with majority of new vehicle sold been more expensive Tesla Model S and Model X
- Since 2017, EV acceptance has expanded by a wide margin due to the introduction of the cheaper Model 3 and new Nissan Leaf

Source: InsideEV, Cars.com, Edmunds, Applied Value analysis

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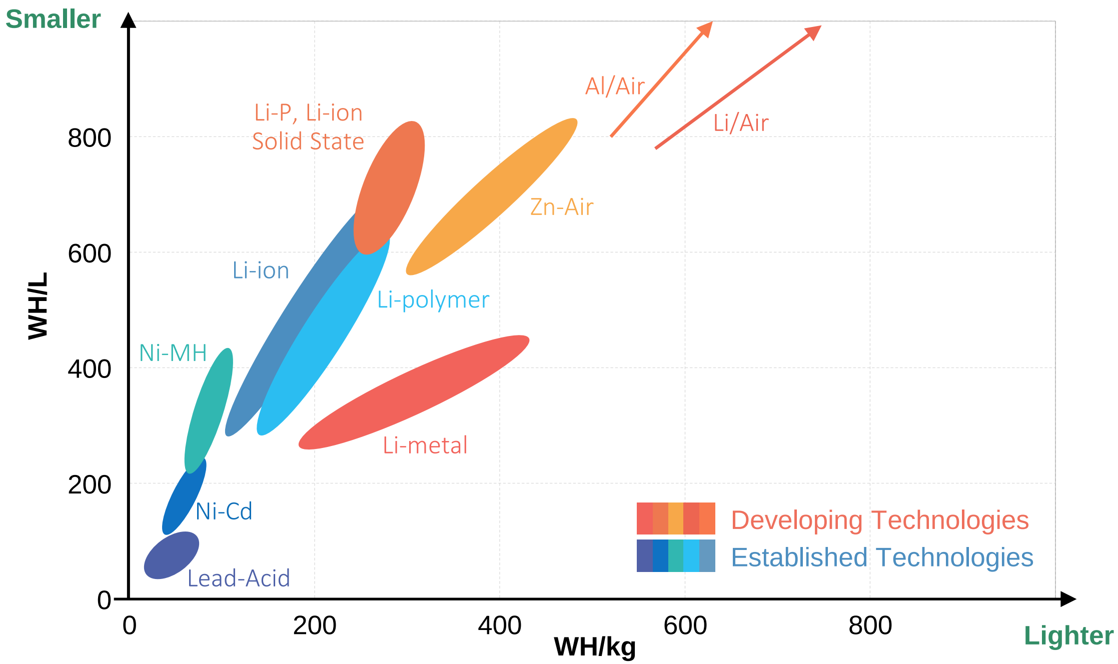
Future battery technology is expected to push EV range to beyond 700 miles, greatly increasing EV viability and propel the mass-adoption of EV

Battery Technology Development Roadmap



Battery Development Trend

Cathode	Anode	Electrolyte	Manufacturing
Cobalt reduction to cut cost and prevent price fluctuation. Various OEMs working on Lithium Iron Phosphate	Replace graphite with silicon which is more naturally abundant	Replace flammable liquid electrolyte with solid-state options, in order to promote safety and energy density.	Dry electrode coating to eliminate solvent toxicity and improve cell performance

2020

Technology:	Lithium-Ion
Specific Energy:	~250 Wh per kg
Range Potential:	~ 400 miles

2025 +

Development Focus:	Solid State Lithium-Ion
Specific Energy:	~400 Wh per kg
Range Potential	500 - 550 miles
Development Cost	Medium

Technology Disruption

2030 +

Development Focus:	Zn-Air
Specific Energy:	400 - 500 Wh per kg
Range Potential	> 600 miles
Development Cost	Very High
Development Focus:	Lithium/Aluminum Air
Specific Energy:	~500 Wh per kg
Range Potential	> 600 miles
Development Cost	Very High

Source: Battery2030.eu, AltEnergyMag, Applied Value analysis

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2 b

As the industry embraces electrification, efforts to shift the material composition of cars are also being accelerated

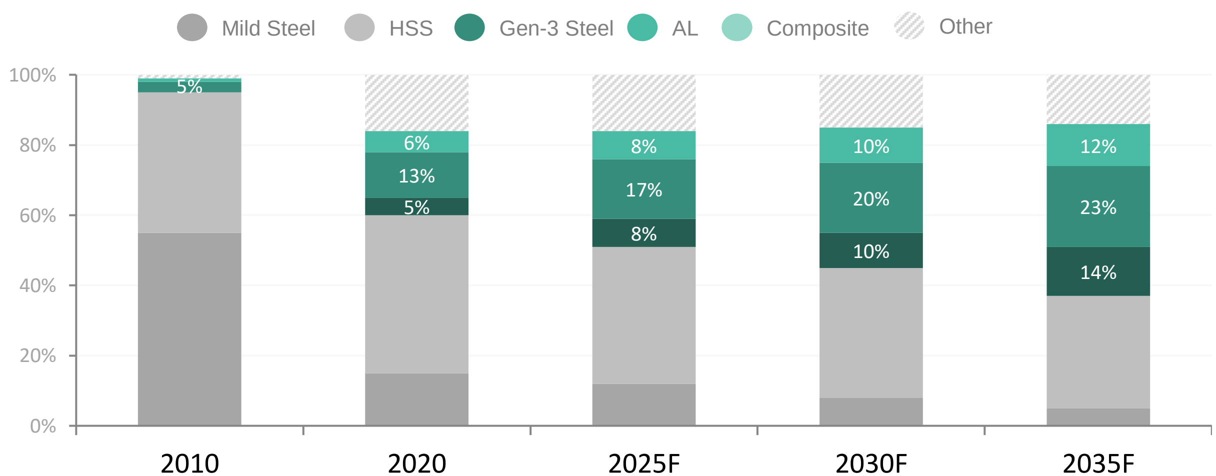
With a fundamental shift in the automotive industry, OEM manufacturers now require lighter parts to counterbalance the additional weight of batteries

- BEV weighs an average of 300 lbs. more than similar ICE vehicle due to the battery
- Sensors and infotainment systems could require an additional 300-400 lbs.

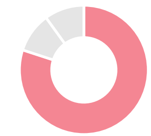
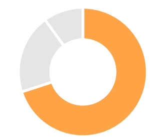
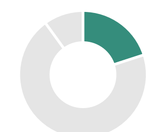
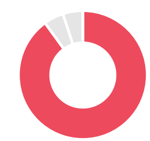
This shift is having a severe impact on various segments of the Tier 1 supply chain, as suppliers are pushed toward advanced materials and new processing methods

- Parts made of Gen3 Steel could result in **~20% weight reduction** vs. standard HSS
- Parts made of Aluminum can be up to **~65% lighter** compared to mild steel or HSS
- Advanced composite material could provide for **~25% weight reduction** for chassis parts and up to **35% weight reduction** for body parts
- Bio-degradable resins and fibers can provide **~25% weight reduction** for interior parts

Change in Material Mix of Vehicle Structure Parts
% of total units



Source: Center for Automotive Research

	Immediacy	Severity
Chassis	Immediate	
Powertrain	Mid-term	
Electronics	Long-term	
Body	Immediate	
Interior	Mid-term	

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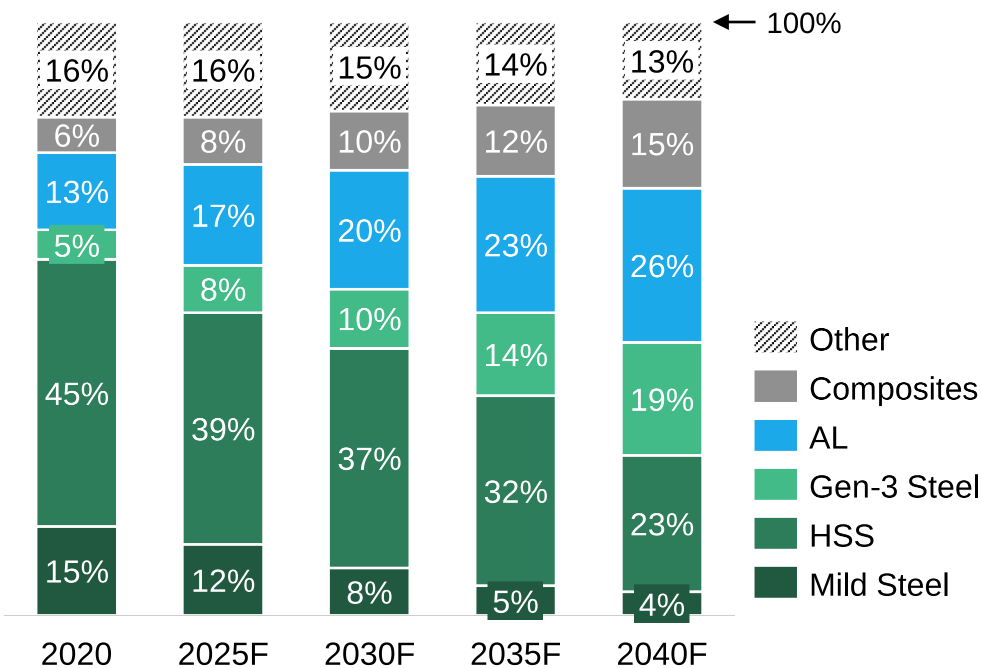
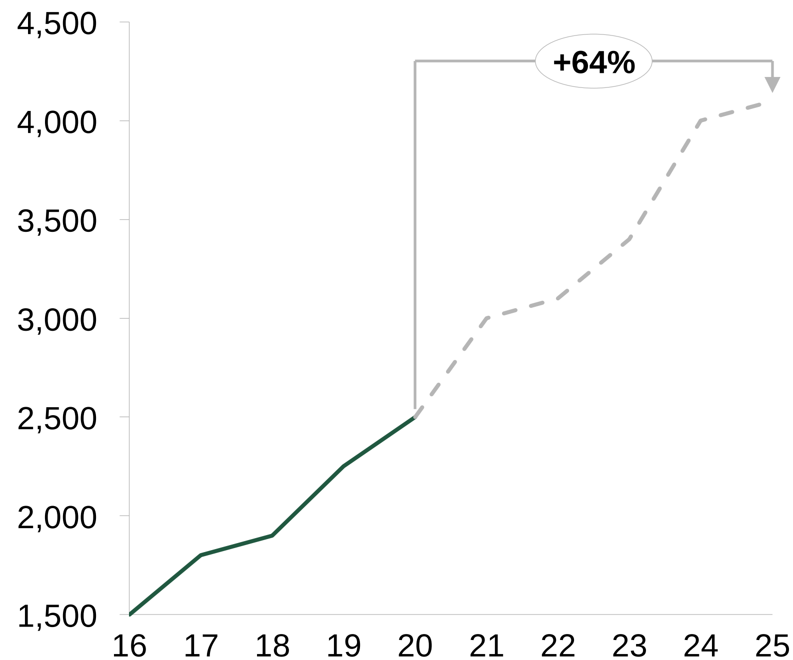
Auto demand for Aluminum is expected to increase ~64% in the next 5 years as it constitutes an increasingly larger portion of vehicle bodies

Vehicle Body Weight Distribution by Material
% of total vehicle weight



Aluminum Sheet Demand for Vehicle Body, N. America
Millions of pounds



- OEMs face significant pressure on several fronts to reduce weight in the vehicle
  - *Fuel efficiency and emissions requirements*
  - *Offset incremental weight from new EV batteries*
  - *Offset incremental weight from ADAS technology*

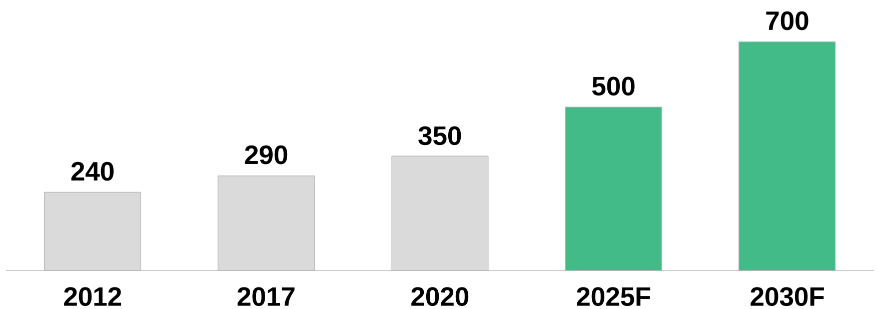
- Aluminum demand is expected to increase by ~64% in the next 5 years
- Aluminum's ability to offset more weight than Gen-3 Steels makes it an attractive option despite the cost

Sources: Center for Automotive Research, Ducker Worldwide Analysis

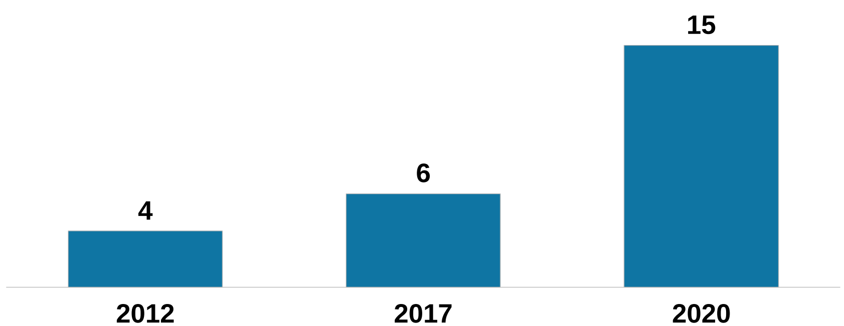
2 c

Advances in battery chemistry and fast-charging technology are making significant impact in improving the viability of EV for everyday use

Range per 500kg of Battery Pack
Miles per 500kg of battery weight



Newest Generation Fast-Charger Speed
Miles per minute of charging under optimal conditions



Average charging time has declined by ~50% since 2015

With the introduction of newest generation of fast chargers as well as better batteries, the amount of time spend charging vs on the road has declined drastically in the last five years.

Source: MotorTrend, AltEnergy Magazine, Applied Value analysis

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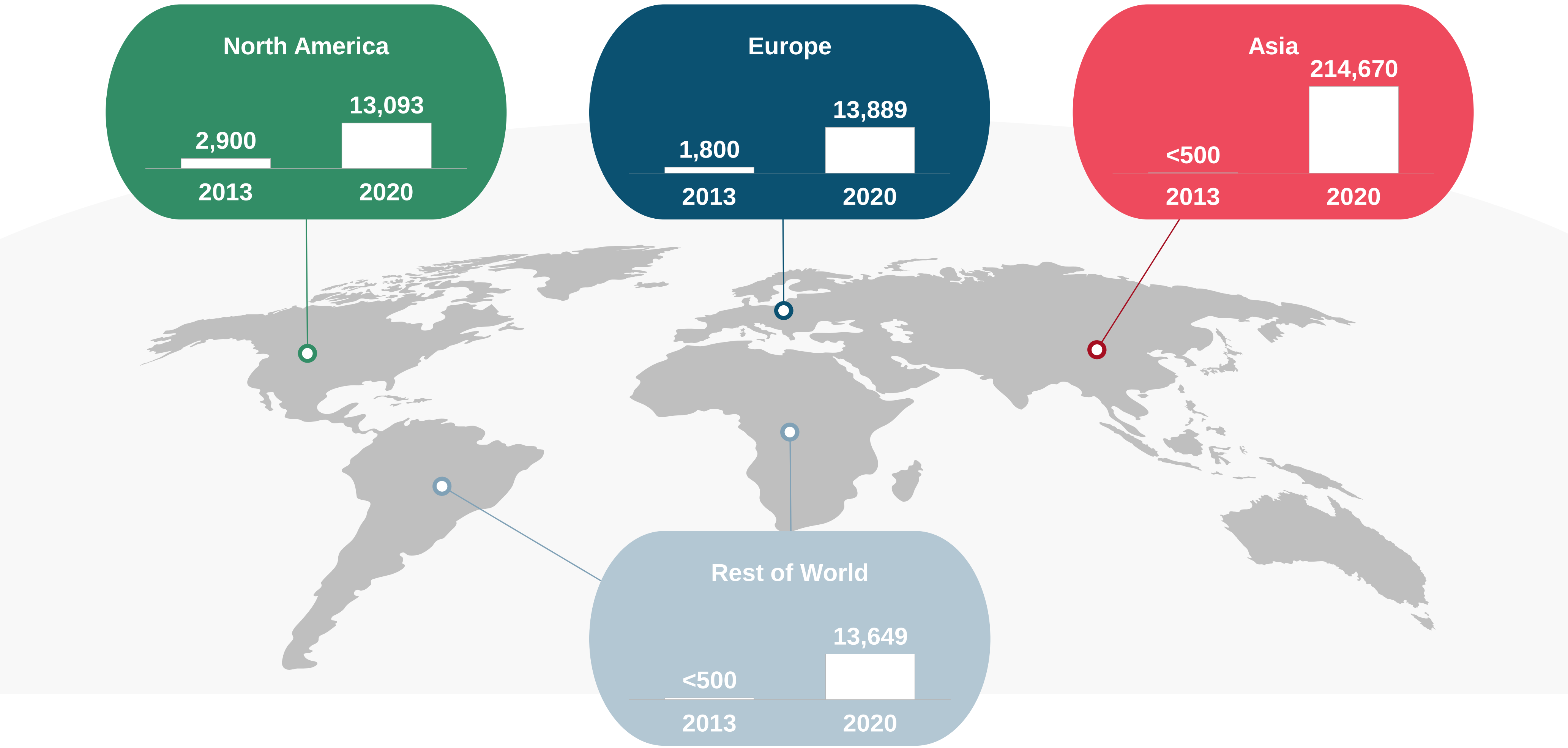
In addition, EVs are no longer restricted to short-distance commutes as established public charging infrastructure now supports long-range travel

Number of Public Fast Chargers, by Region



Source: IEA, Applied Value analysis

3

Major automotive OEMs have announced strategic objectives and high-level roadmaps targeting a wide-scale shift to EV

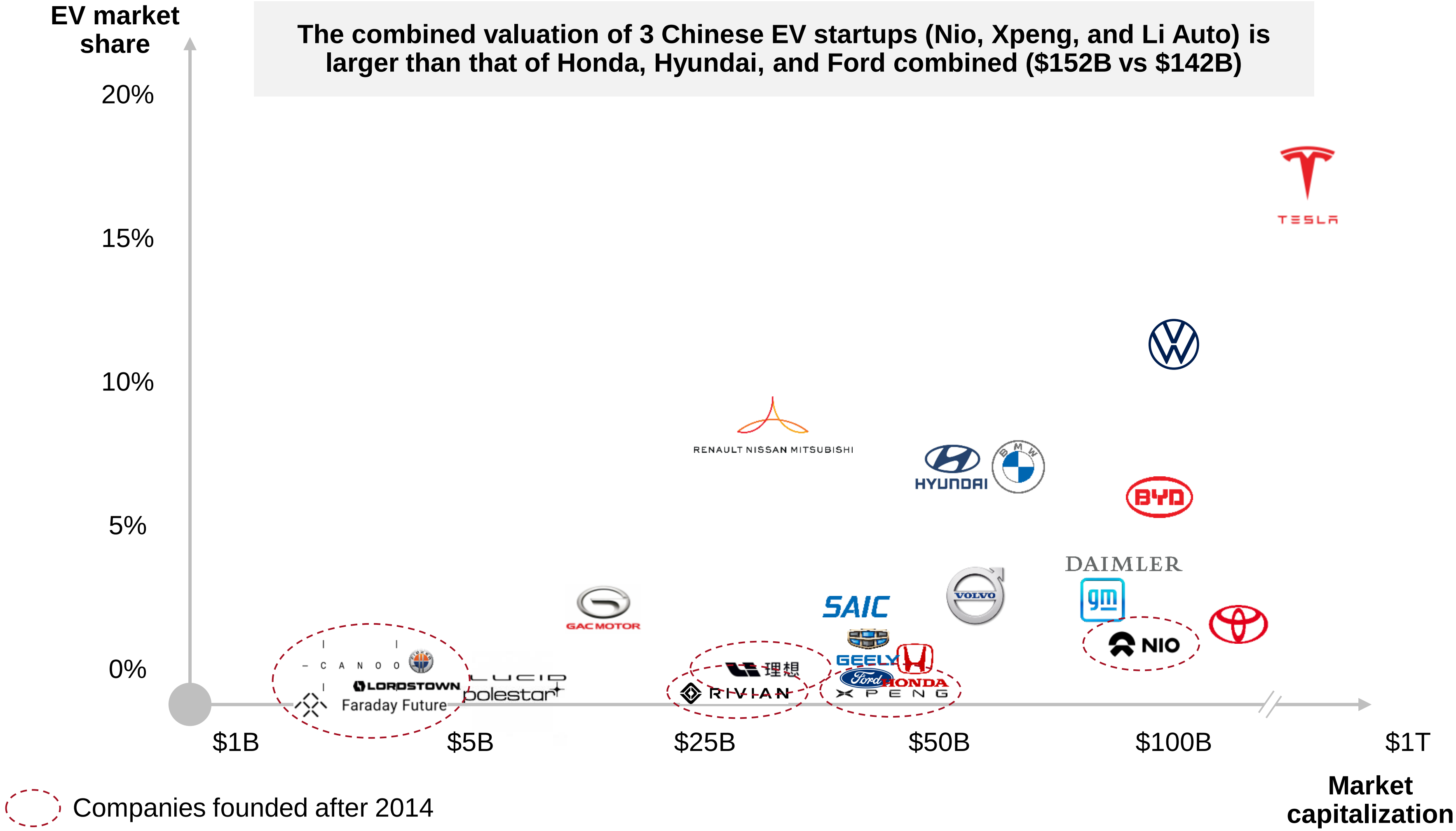
	2020	2025	2030	2040+
DAIMLER	*Announces 10 new EV models by 2022*		*Aims to reach 50% sales in EV*	*Plans to offer only carbon-neutral product lines*
gm	*Pledges $27B for EV over next five years*	*Plans to offer 30 new EV models and 40% EV sales*		*Plans to offer vast majority EVs*
Volkswagen	*Commits €73B to EV and smart cars over next five years*	*Goal of 1.5m units in annual EV sales*	*Plans to offer EV of every model in its product line*	
Toyota	*Offering 10 electric models*	*Aims to offer EV of every model in its product line*	*Goal of 5.5m+ units in annual EV sales*	
HYUNDAI	*Announces Ioniq EV line to be launched by 2022*	*Goal of 560k units in annual EV sales with Ioniq*	*Plans to "drastically" expand EV offering starting in 2030*	*Goal of 10% of total global EV market share*
NISSAN	*Announces plan for 8 new BEV models*	*Aims to reach 1 million annual EV sales by 2023*	*Plans to offer majority EV products*	
Ford	*Current offering 6 EV models, including one all-electric*	*Plans to invest >$11.5 billion in EVs through 2022*		*Commits to carbon neutrality by 2050*

Source: Company press releases

3

New entrants are challenging established passenger vehicle OEMs to seize market share within EVs…

The combined valuation of 3 Chinese EV startups (Nio, Xpeng, and Li Auto) is larger than that of Honda, Hyundai, and Ford combined ($152B vs $142B)



…some entrants are valued well above major OEMs despite limited commercial production, indicating investor enthusiasm for EVs

Source: Yahoo Finance, Statista "Global plug-in electric vehicle market share", Applied Value analysis

3 The expansion of commercial EVs depends on a range of issues – these will be at the forefront for major OEMs and challengers to solve in coming years

	Major players	Startup challengers	Key issues to be solved
Light-duty *Class 1-3*	Ford, gm, NISSAN, FCA	RIVIAN, LIGHTNING eMOTORS, TESLA, BOLLINGER MOTORS, LORDSTOWN, CANOO, ATLIS MOTOR VEHICLES	› Lack of readily available cost-equivalent models › Conservative customer base – developing positive sentiment for adoption of EVs will be gradual › Vehicle maintenance issues – trained technicians needed for new electronic software systems
Medium-duty *Class 4-6*	IVECO, DAIMLER, VOLVO, SCANIA	chanje, RIVIAN, WORKHORSE, ARRIVAL, CANOO, BYD	› Battery range and long charging times limit usage for long-haul trips › High upfront costs – difficulties estimating total cost of ownership vs. traditional diesel vehicles › Vehicle maintenance issues – trained technicians needed for new electronic software systems
Heavy-duty *Class 7-8*	DAIMLER, SCANIA, IVECO, VOLVO, TRATON, PACCAR, MAN	NIKOLA, TESLA, BYD, HYLIION, VOLTA, PROTERRA, ARRIVAL	› Divergent technologies being used to solve for range – fuel cell vs. hybrid vs. all-electric battery › High upfront costs – difficulties estimating total cost of ownership vs. traditional diesel vehicles › Lack of open standards for charging technology (HW and SW) limits scalability for fleets

Source: Center for Climate and Energy Solutions "Insights on Electric Trucks for Retailers and Trucking Companies", Applied Value analysis

3

Current initiatives for Commercial OEMs indicate a focus on expanding EV applications with multiple energy technologies vying for prominence

Battery Electric Focus

Tesla: Tesla is developing The Tesla Semi, a battery all-electric Class-8 truck with a planned delivery date of 2021.

Volkswagen: Volkswagen is developing a modular battery electric truck under the "E-Delivery" program with production starting in 2020.

DFM: China's Dongfeng is currently offering several variants of full battery electric trucks with future development focused on BEV.

Hydrogen Fuel-cell Focus

Nikola / Iveco: Nikola currently offers a Class 8 fuel-cell semi under Nikola One Brand. Nikola partnered with Iveco to develop fuel-cell technologies

Toyota / Hino: Toyota currently working with Hino Motors in the development of hydrogen fuel-cell truck which is expected to release in mid-2021

Hyundai: Hyundai is a strong believer in hydrogen fuel-cell technology and launched the XCIENT Class-8 fuel cell truck in 2020

Scania: Scania delivered and currently focusing on fuel-cell for heavy-duty truck developments. It has battery-electric technology for buses

Both in Development

Daimler: Daimler is currently developing hydrogen fuel-cell technology in partnership with Volvo while promoting various battery trucks to be marketed beginning 2021.

Volvo: Volvo is currently developing hydrogen fuel-cell technology in partnership with Daimler while also launched lines of battery truck sold in California.

MAN: Man is developing long-range fuel-cell truck with partners Anleg & TU Braunschweig. It also launched battery eTGM truckline in 2019.

Paccar: Paccar is developing both battery electric trucks under the Peterbilt line and Hydrogen fuel-cell trucks under Kenworth line in collaboration with Toyota.

Source: Company press releases

4

Government incentives and mandates are also an enticing factor for consumers to switch to electric vehicles

Incentive

- UK has bonus of 25% vehicle cost (up to £5,000) for private car and up to £20,000 for businesses that replace IC truck with electric truck, expiring 2025.

Policy & Mandates

- Mandate in place to ban sales of new ICE vehicle by **2030**

Incentive

- Federal government give tax credit up to $7,500 for purchase of electric vehicle including trucks, reducing by 25% each year after 2019, expiring in 2022.

Policy & Mandates

- State by State, California to ban sale of new ICE vehicle by **2035**, New York in discussion to ban ICE sales by **2040**

Incentive

- Private buyer receives up to €5,000 and corporate buyer up to €3,000 subsidy on electric vehicle, incentive reduce by €500 every year after 2020.

Policy & Mandates

- Government has **no policy or plan** yet to ban ICE vehicle sales, however, major automotive OEMs are shifting focus to EV

Incentive

- China provides 13% tax exemption on electric vehicles in addition to incentives of up to ¥50,000 on purchase of clean energy vehicles.

Policy & Mandates

- Currently researching timetable, likely to issue mandate to ban the sale of new ICE vehicle by as early as **2030** and likely no later than **2040**

Incentive

- France has bonus of up to €6,000 for vehicle up to €60,000. This bonus is to decline by €1,000 every year after 2020 and expire fully by 2025.

Policy & Mandates

- Mandate in place to ban the sale of new ICE vehicle by **2040**

Incentive

- Japan provides sales tax reduction and purchase incentives up to $9,600 for consumer cars and up to $19,000 for commercial buses and trucks.

Policy & Mandates

- Policy to ban the sale of new ICE vehicle by **2035** and switching to hydrogen-based fuel economy

Source: SP Global, UK.gov, Bloomberg, AutoNews, CA.gov, Reuters, Applied Value analysis

4 China currently leads the world in EV adoption and infrastructure largely driven by its strong pro-EV policies

China	% Auto Sale by 2030	Unique Market Trends	Major OEMs
	44% Policy Support **High**	• Majority of public busses in Tier 1 and Tier 2 cities are already electric • Highly developed charging infrastructure in large cities and main road networks • Consumer mainly concerned with potential battery fire due to several incidents	TESLA, BYD, HYUNDAI

United States	% Auto Sale by 2030	Unique Market Trends	Major OEMs
	23% Policy Support **Med-Low**	• Majority of electric vehicle in larger coastal cities • Developed charging infrastructure in larger cities, but lacking on larger highway networks • Consumer mainly concerned with lack of available charging stations to support long-range travel	TESLA, gm, Ford, NISSAN

Europe	% Auto Sale by 2030	Unique Market Trends	Major OEMs
	37% Policy Support **Med-High**	• Nordic region leads in EV adoption with Norway at 56% market share for EV • Large European traditional auto OEM have all announced major transition plans to EV • Consumer concerned with lack of charging infrastructure hindering long-distance travel	DAIMLER, TESLA, BMW

Source: Bloomberg NEF, AutoNews, Applied Value analysis

Market trends

Value chain analysis

The automotive passenger vehicle value chain represents a wide array of technology solutions with several opportunity areas

	Raw Materials Metals, resins, glass, etc.	**Tier 2+** Sub-components	**Tier 1** OEM components	**OEMs** Vehicle assembly	**Distribution & aftermarket** Sales & in-life service
Details	› Highly concentrated market with several major mining & processing companies › Primary materials for existing ICE value chain are carbon steel, aluminum, resins, glass, composites, etc. › **Expanding need for lightweight and battery materials (e.g., lithium, nickel, cobalt, copper)**	› Highly fragmented market with many different segments and small players › Often small family-owned business with some middle market players › **Expanding need for electronic components and light-weight fabrication**	› Moderately fragmented market with several major segments – exterior, chassis, powertrain, interior, and electronics › Mostly Fortune 1000 and upper middle market publicly-traded companies › **Expanding need to invest in electrical systems to integrate the chassis and powertrain**	› Highly concentrated market with recent entrants focused on EV production › Mostly Fortune 100 companies with some startup challengers › **Expanding focus on electrification, infotainment, and autonomous solutions**	› Highly fragmented, mostly localized market operated through dealership network and service partners › **Expanding need to support aftermarket parts and service for electric vehicle systems and electronics**
Selected players	Glencore, Alcoa, Rio Tinto, ArcelorMittal, USS, BASF (We create chemistry), thyssenkrupp, MP Materials	OSRAM, JTEKT, NHK (NHK Spring Co., Ltd.), Zexel, CIE, Infineon, Stanadyne, Ryobi	Bosch, Continental, ZF, BorgWarner, Dana, AAM, Nidec, Magna, Aptiv	GM, Daimler, Volkswagen, Nissan, Ford, Toyota, BYD, Tesla, NIO, Hyundai, Rivian, Stellantis	AutoNation, Penske, Lithia Motors, Inc., Group 1 Automotive, Sonic Automotive, Tesla, Hendrick Automotive Group, Asbury Automotive Group, Larry H. Miller Dealerships

Significant investment is being put toward the technologies that will drive electric vehicle commercialization across the automotive value chain – electrical components, light-weight material fabrication, and battery technology

Source: Applied Value analysis

The commercial vehicle market also presents a significant opportunity for existing players and new entrants

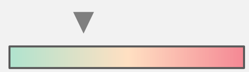
Rental & distribution

	Raw Materials Metals, resins, glass, etc.	Tier 2+ Sub-components	Tier 1 OEM components	OEMs Vehicle assembly	Commercial vehicles End-use markets
Details	› Highly concentrated market with several major mining & processing companies › Primary materials for existing ICE value chain are carbon steel, aluminum, resins, glass, composites, etc. › **Expanding need for lightweight and battery materials (e.g., lithium, nickel, cobalt, copper)**	› Highly fragmented market with many different segments and small players › Often small family-owned business with some middle market players › **Expanding need for electronic components and light-weight fabrication**	› Moderately fragmented market with several major segments – exterior, chassis, powertrain, interior, and electronics › Mostly Fortune 1000 and upper middle market publicly-traded companies › **Expanding need to invest in electrical systems to integrate the chassis and powertrain**	› Highly concentrated market with several major segments focused on various applications – several entrants working on EV › Mostly Fortune 100 companies with some startup challengers › **Expanding focus on electrification and autonomous solutions**	› Fragmented, differentiated application markets e.g., logistics, construction, public transport › **Expanding need for aftermarket parts and service for electric vehicle systems and electronics**
Selected players	Glencore, Alcoa, Rio Tinto, ArcelorMittal, USS, BASF (We create chemistry), thyssenkrupp, MP Materials	OSRAM, JTEKT, NHK Spring Co., Ltd., Zexel, CIE, Infineon, Stanadyne, Ryobi	Bosch, Continental, ZF, BorgWarner, Dana, Nidec, Meritor, Magna, Aptiv	Volvo, Daimler, Tesla, Nikola, BYD, Workhorse, Caterpillar, Komatsu, Paccar Inc, Hyliion, Rivian	Penske, FedEx, UPS, Bechtel, XPO Logistics, amazon, Ryder Ever better., Herc Rentals, Fluor, Metro, cta, DART, MTA

Significant investment is being put toward the technologies that will drive electric vehicle commercialization across the automotive value chain – electrical components, light-weight material fabrication, and battery technology

Source: Applied Value analysis

The emergence of electric vehicles will impact how vehicles are designed – in some cases, entirely new structures will replace existing components

Vehicle systems	Change severity	Major changes for electric vehicles	Key players
Chassis *Axles, exhaust, suspension, wheels, brakes, 4WD components, fuel tank, and bearings*		• Shift toward **self-contained "skateboard" chassis** design – integrated motor, suspension, and braking system • **Regenerative braking** will push brake systems away from conventional disc and drum brake mechanisms • **Removal of fuel tank** in favor of battery powered system	AISIN, DANA, R3E, Gestamp, BENTELER, MERITOR, Motiv (it's inEVitable)
Powertrain *Drive controls, engine, transmission, pistons, heads, cooling system, injectors, turbochargers, etc.*		• Addition of battery pack will **simplify powertrain design** • **Single-speed transmission** for many EVs – potential for multi-speed mechanisms over time • Elimination of **radiators**, **fuel injectors**, **valvetrains**, and **exhaust systems**	BOSCH, Continental, ZF, Nidec, BorgWarner, MAGNA, MITSUBISHI ELECTRIC
Electronics *Anti-lock brake system, lamp and headlights, battery harnesses, infotainment system, regulators, etc.*		• Increased need for **more sophisticated electronics systems** across the board • Expanded use of **sensors and electronic controls** to support vehicle safety and energy efficiency • **Battery management** needed to control power system	APTIV, DENSO, Valeo, Texas Instruments, Visteon, HI-LEX, Stoneridge, Panasonic, HELLA
Exterior body *Class A & non-structural stampings, frame & subframe components, body hardware glass, paint, molding, etc.*		• **Light-weight materials** may replace steel in some standard structural elements • Potential long-term implications of modular skateboard chassis for **personal or commercial functionality**	JFE, G-TEKT Corporation, MAGNA, NGWOO HITECH, NUCOR, Unity Aluminum, Constellium
Interior *Seats, seat belts, safety systems, trim, carpet, headlines, mirrors, climate control, etc.*		• **Climate control systems** connected to battery, affecting vehicle range – potentially causing A/C energy trade-off • **Noise control** – quieter engines resulting in greater emphasis on road noises, noise cancellation tech needed • **More seating design options** with skateboard chassis	faurecia, LEAR Corporation, autoneum, BASF We create chemistry, Autoliv

Source: Applied Value analysis

Two key innovations are driving the next generation EV platforms – integrated drive systems and the rise of the "skateboard" chassis

Electric drive systems

The centerpiece of a battery-electric vehicle, the e-Drive provides a centralized powertrain unit for a modular drivetrain architecture

Integrated e-Drive
Combined electric motor, power electronics and transmission

Electric motor
Converts electricity into mechanical energy for vehicle propulsion

Transmission
Mostly single-speed using calculated gear ratios for motor efficiency

Power electronics
Delivers power to the board net by transforming energy from the battery

BOSCH, BorgWarner, MAGNA, DANA, ZF, vitesco TECHNOLOGIES, MERITOR BLUE HORIZON, Nidec, GKN, Allison Transmission, SCHAEFFLER

Skateboard chassis design

A self-contained platform that can be scaled to various vehicle sizes and body types to support more novel vehicle use-cases

Skateboard chassis
An integrated platform with the electronic motors, battery, and driving components

Battery / housing
Primary vehicle power source encased in central metal structure

Electric motor
One or multiple motors – some are working on in-wheel motors for stability

Drive-by-wire
Transfers driver input without a mechanical connection

TESLA, VW, REE, RIVIAN, MOTIV it's inEVitable, KARMA, CANOO, BOLLINGER MOTORS

Source: driving.ca, Applied Value analysis

APPLIED Insights

Several major powertrain suppliers are investing heavily in these next generation platforms to provide scalable e-mobility solutions

Strategic activity

Chassis and Powertrain suppliers are working on integrated EV platforms for a variety of commercial applications

BorgWarner** has made several acquisitions to expand its EV solutions portfolio, including acquiring **Delphi Technologies** and investing in battery startup **Romeo Power

***REE Automotive** is an Israeli startup that manufactures integrated "skateboard" chassis systems and is working with several key partners to support commercialization*

*In 2019, **GKN** unveiled the world's first battery electric vehicle with a two-speed transmission and torque vectoring, which supplements its eDrive system*

*Since 2017, **Dana** has made 8 acquisitions in the electrification space to combine battery-management system, electric powertrain controls and integration expertise in-house*

*In 2016 **Volkswagen** launched an electric vehicle platform with a re-designed chassis structure, establishing partnerships with **Continental**, **ZF**, **NXP**, and others*

*In 2019, **Bosch** took full control of EM-motive, one of the largest electric-motor suppliers in Europe, which started as a 50/50 joint venture between Bosch and **Daimler***

*In 2018, **Meritor** announced the creation of its Blue Horizon brand, focusing on its electric drivetrain capabilities, which were expanded with its acquisition of **TransPower** in 2019*

***Magna** and **LG Electronics** are launching a joint venture that will make key components for electric cars, including e-motors, inverters and onboard chargers*

Cummins** has made 3 strategic acquisitions since 2018 to expand on its electric drivetrain solutions, including fuel cell capabilities with the addition of **Hydrogenics

Source: Company press releases, Applied Value analysis

Battery manufacturers are vying for position as the EV market expands rapidly, primarily driven by a few major OEM partners like Tesla and VW

Annual GWh sales | Tier 1 | Tier 2 | Tier 3

CATL
- Struck a two-year deal with Tesla in February to supply batteries
- Announced viability of battery with 1m+ mi range and 16yr lifespan

30.7 GWh

LG Chem
- Formed JV with GM in early 2020, Ultium Cells, to produce EV batteries
- Will invest $500M to increase battery capacity at its Nanjing plant

28.8 GWh

Panasonic
- Recently formed JV with Toyota to produce Li-ion batteries starting in 2022
- Working on cobalt-free batteries for Tesla, target launch within 2-3 years

24.3 GWh

Samsung SDI
- Plans to introduce in 2021 ternary batteries with Ni content >80%
- Appointed a new head of its electric car battery business in Jan 2021

7.4 GWh

SK innovation
- Investing $1.2B to build a 30GWh battery plant in Hungary by 2024
- Acquired minority stake in BPSE, a Chinese EV battery swap service

7.1 GWh

BYD
- In Jan 2021, launched its DM-i super hybrid technology
- Recently launched Blade Battery to improve safety and energy density

6.9 GWh

Envision AESC
- Recently partnered with FreeWire Technology for ultrafast charging solutions
- Working with Johnson Matthey to develop first two-seater electric car

3.6 GWh

CALB
- Formed JV with Continental to produce 48-volt systems
- Plans to build European battery factory in near future to expand EU sales

2.9 GWh

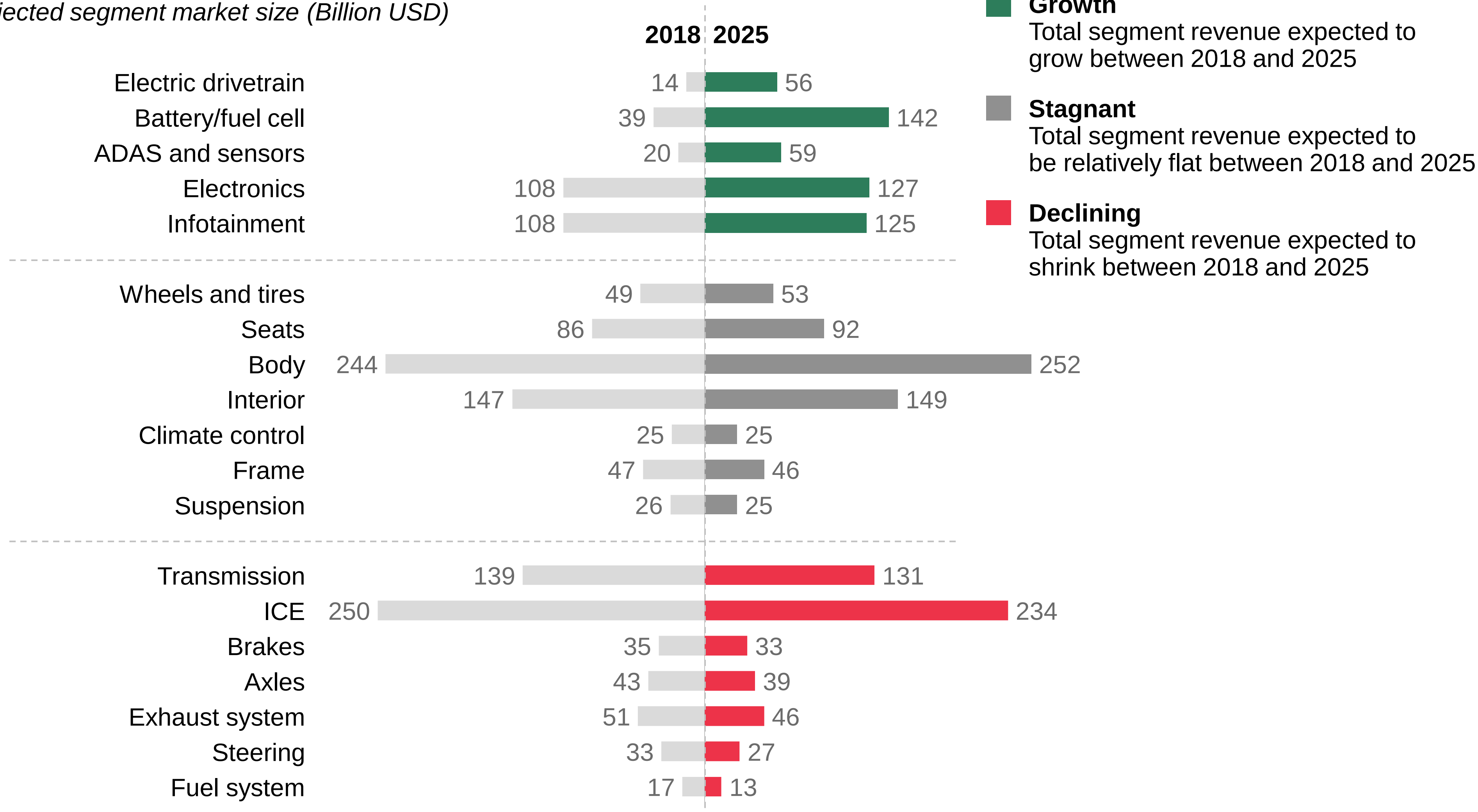
Others
American Battery Solutions, northvolt, CLARIOS, A123 SYSTEMS, TOSHIBA

- Northvolt JV Hydrovolt started construction on a battery recycling plant in Norway
- VW is investing ~€900M in joint battery activities with Northvolt
- In August 2019, American Battery Solutions completed its acquisition of high-voltage battery assets from Bosch Battery Systems
- In mid-2019, Johnson Controls sold its Power Solutions division to Brookfield Business Partners, launching Clarios to focus on battery technology for automotive and other vehicles
- Toshiba recently partnered with Suzuki and Denso on a factory in India initially to assemble battery packs but ultimately with the aim of producing Li-ion cells by 2024

Source: InsideEVs, SNE Research, Company press releases, Applied Value analysis

The market for several key elements of ICE vehicles is declining, paving the way for investments in new structures and technologies…

Content mix by revenue
Projected segment market size (Billion USD)

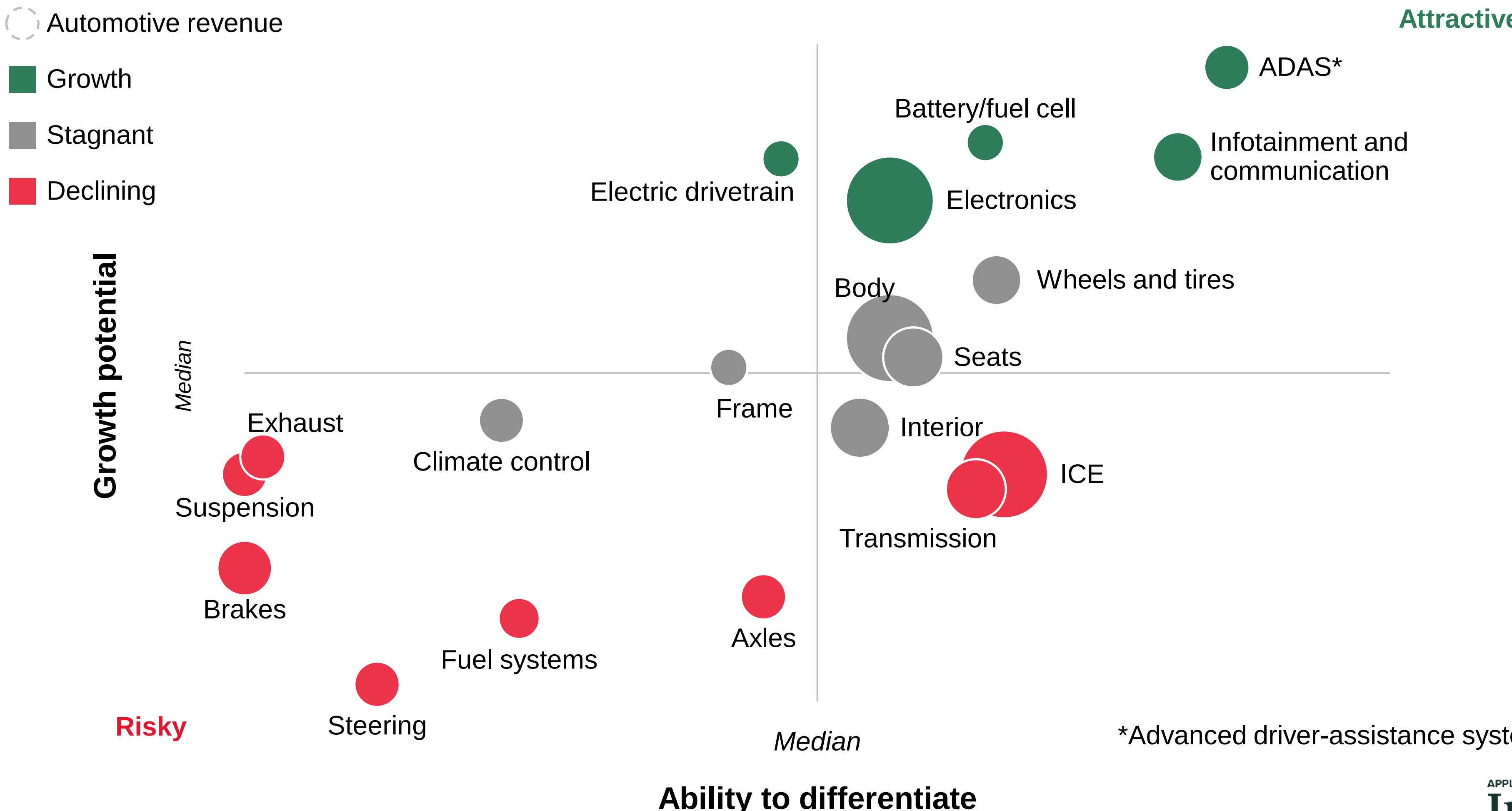


Source: IHS Markit; Deloitte, *Transformation and disruption for automotive suppliers*

…many of these new technologies will replace or heavily impact existing segments, with some sectors looking more attractive for the future

Impact of electric vehicle disruption

Each part of the automotive ecosystem will be impacted differently by the various technology changes, leading to a divergent future based on segment, as some thrive while others struggle



*Advanced driver-assistance systems

Source: IHS Markit; Deloitte, *Transformation and disruption for automotive suppliers*

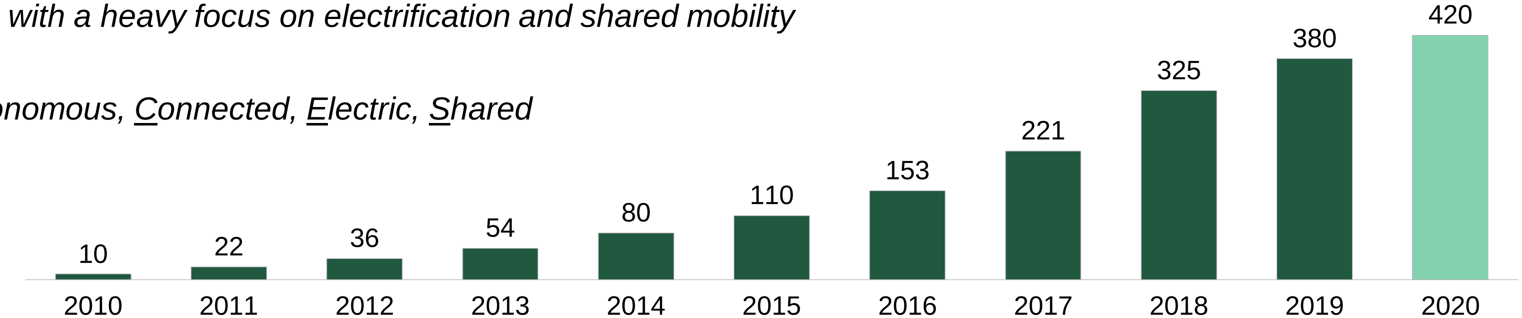
APPLIED Insights

Strategic activity across the automotive value chain is expanding, with a shift toward autonomous, connected, electric, and shared mobility

"ACES" partnerships by year, total

The past decade has seen a fortyfold increase in the number of ACES partnerships, with a heavy focus on electrification and shared mobility

ACES = Autonomous, Connected, Electric, Shared



Example recent activity		Details
LG Electronics JV with Magna	**Jan 2021**	The venture will produce e-motors, inverters and onboard chargers in LG's factories in Incheon, South Korea, and Nanjing in China
Hyundai partners with Ineos	**Nov 2020**	The companies will explore opportunities for the production and supply of hydrogen and the worldwide deployment of hydrogen applications and technologies
Volkswagen invests In Chinese e-mobility	**May 2020**	Volkswagen is the first global automaker to invest directly in a Chinese battery supplier (Gotion High-Tech), along with expanding its investment in its JAC Volkswagen JV
Showa Denko acquires Hitachi Chemical	**April 2020**	Showa Denko acquired Hitachi Chemical in a bid to scale up its lithium-ion battery and advanced materials businesses

Source: Company press releases, McKinsey Insights, *Reimagining the auto industry's future*

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