EQUITIES DisruptiveEdge

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The Road Ahead: Navigating Innovation & Disruption in Autos

Electric, Autonomous & Ecosystem Platforms

Key points

- We believe the auto industry is on the verge of a multi-decade long transformation, driven by disruptive innovation and technology
- History shows big tech disruption winners focused on ecosystem platforms; auto ecosystem platforms will enable new businesses, disrupt existing ones
- Electric & autonomous two critical steps to ecosystem platforms. We identify 10 investable sub-themes, 33 Outperform stocks from 15 Macquarie analysts

Auto Industry Heading into an Unprecedented Era of Tech Disruption

We believe the auto industry is on the precipice of a multi-decade long transformation, driven by disruptive innovation and technology – the same dynamic forces that have transformed many other technology industries. While there have been many vehicular enhancements in the past, the industry has not fully embraced the technological shifts that have created meaningful new business models and revenue streams for others in the technology platform ecosystem. But we believe this is about to change.

OEMs Should take the Ecosystem Platform Route…

We believe the biggest winners from the coming disruption will be those focused on software ecosystem platforms. We envision commercial platforms that will allow companies to write software on the platform to program vehicles to *become* specific applications with the business model revolving around licensing/royalties. Vehicle owners will convert cars into ridesharing vehicles by downloading the app or, later, turn them into delivery vehicles using another app. **We believe the automotive ecosystem platform will enable as-yet-unknown applications and significantly disrupt businesses** in much the same way that the internet enabled e-commerce and disrupted brick & mortar retail, the cloud enabled as-a-service and disrupted servers, and smartphone ecosystems enabled ridesharing and disrupted taxis.

… Electric & Autonomous Are the Mile Markers…

We believe there will be necessary steps – electric & autonomous – along the way to ecosystem platforms and while we expect regulation and lower emissions to be key drivers, we see risk of competition from the Chinese as the biggest driver. History has shown that the Chinese have been able to build scale domestically and use those profits to fund global expansion (smartphones, PCs, telecom equipment).

… With Numerous Investable Themes along the Way

We identify ten investable sub-themes (OEM leaders, electronic content growth, batteries, centralized compute, autonomous driving, lightweighting, power semiconductors, charging, thermal management, and connected car) and 39 Outperform-rated stocks covered by 18 Macquarie analysts globally that we expect will benefit from these trends.

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Introducing Macquarie's DisruptiveEdge

At Macquarie, we strive to uncover opportunities others miss – disrupting our own thinking and challenging our clients to look at the world through a different lens. Our equity research model focuses on discovering the "unknown, unknowns" – and it is those insights that lead us to breakthrough investment ideas for our clients.

Our analysts are empowered to think differently, search the industry and leverage our real asset experience to provide real market insights into the issues and trends that drive companies, industries and markets.

We are pleased to introduce our **DisruptiveEdge** and our first report on Automotive & Disruptive Technology.

The Road Ahead: Navigating Innovation & Disruption in Autos

In this report, our US Automotive & Disruptive team dives into an unprecedented era of tech disruption in the automotive industry. We see the industry entering a multi-decade transformation driven by disruptive innovation and technology – the same forces that have transformed many other technology industries (including IoT, smartphones, pc/tablets, TV and watches).

While advancements in both electrification and autonomous will no doubt enable the development of electric vehicles, it is the *platform ecosystem* that will permit a truly connected electric vehicle, allowing for both consumer and commercial platforms to evolve as the car becomes an application.

Drawing from global technology, internet, battery, semiconductors and materials analysts, we highlight more than 50 relevant stocks across ten key related and investable themes.

We are **initiating on six US Automotive Technology** stocks with this report, and our team is excited to further explore these and other themes for our clients.

Macquarie's Heads of Equity Research

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(US & Europe)	*(Asia)*	*(Australia & NZ)*	*(Canada)*	*(South Africa)*

Electric, Autonomous & Ecosystem Platforms

- When analysing the automotive and disruptive technology space, our global methodology is to take a holistic approach to understanding which companies across the landscape are affected by disruptive megatrends that will accelerate over the coming years.
- This report addresses the reasons why we believe OEMs will need to adopt electric, what will drive consumers to adopt electric, the potential pitfalls industry participants face, where we are in the transformation, who will win, and the ultimate end goal of what the technology platform ecosystem will look like.

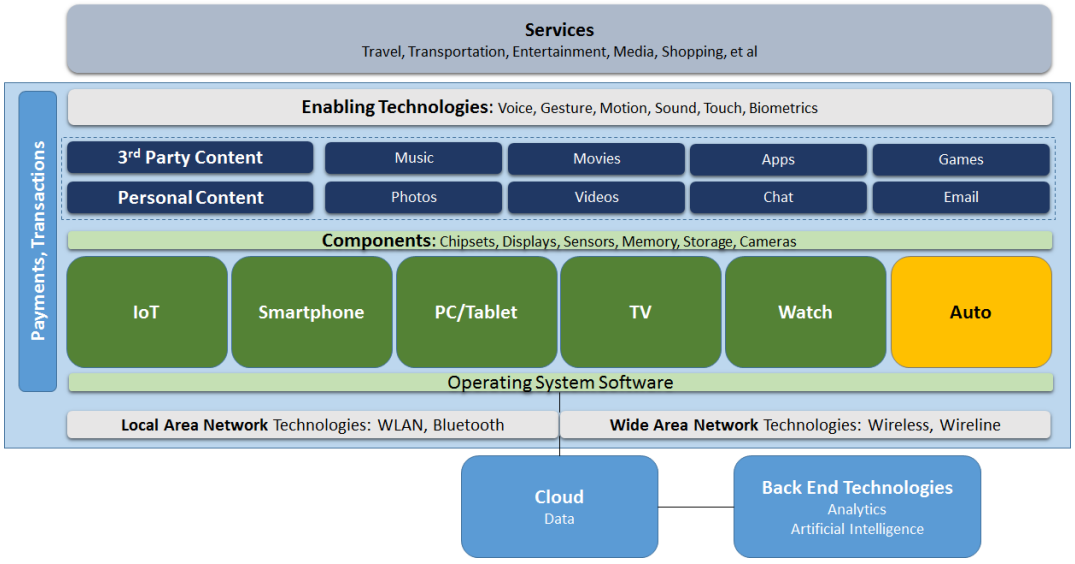
The technology industry is one of rapid change with innovation forcing companies to move at a breakneck pace. We believe the auto industry is on the precipice of a multi-decade long transformation driven by disruptive innovation and technology – the same dynamic forces that have transformed many other technology industries.

Thus far, we believe the automotive industry has largely sheltered itself from the larger ecosystem that has spread across other technology hardware platforms. Figure 1 illustrates our view of the digital ecosystem that was enabled by technology advancements in other legacy industries. We believe these advancements drove transformational shifts and secular growth to varying degrees across each of the hardware segments, further growing each part of the ecosystem. More importantly, this shift created platforms that enabled new services and business models (such as Uber, Didi, Postmates, ZipCar, etc) that eventually came to be built on top of the ecosystems.

The automotive industry has remained in its own walled garden, but we believe this is about to change

While the auto segment has seen many technological enhancements in the past, the industry has not fully embraced the technological shifts that have created meaningful new business models and revenue streams for others in the technology hardware ecosystem. The automotive industry, in our opinion, has largely remained inside its own walled garden, closed off from the rest of the ecosystem. But we believe this is about to change.

Fig 1 The Digital Ecosystem – Autos To Enter in a Bigger Way



Source: Macquarie Capital (USA), October 2018

Auto OEMs would be wise to learn from the mistakes of market leaders in other markets that have lost their leadership positions

We believe the automotive industry is now in the early stages of technological advancements that will enable vehicles to become platforms and allow new transformational services and business models. Auto OEMs, in our opinion, would be wise to look back at history to avoid the mistakes of former market leaders in other industries that lost their respective market positions – companies such as Nokia, Motorola, or BlackBerry and those that were left to commoditization and forced to reinvent themselves such as Hewlett Packard or Dell. We believe the big challenge for auto OEMs will be the lack of software expertise as well as culture, which we believe were the key challenges and ultimate downfalls for Nokia and Motorola. We explore this in detail further in this report.

We believe where auto OEMs can differentiate their platforms from the likes of Apple or Google is in the potential to create commercial platforms that will turn the vehicle into any number of applications – a ridesharing vehicle, a delivery vehicle, etc. We believe this will disrupt the industry by enabling companies to provide new services where hardware barriers to entry were too high. We envision this, alongside a consumer platform similar to Apple and Google, is the most logical path – one platform focused on commercial capabilities of the car and one focused on in-vehicle content delivery for passengers. Additionally, with a common underlying operating system and assuming a degree of smartphone commoditization, we believe OEMs could also offer smartphones provided as key fobs using its operating system and hooking into its ecosystem of applications.

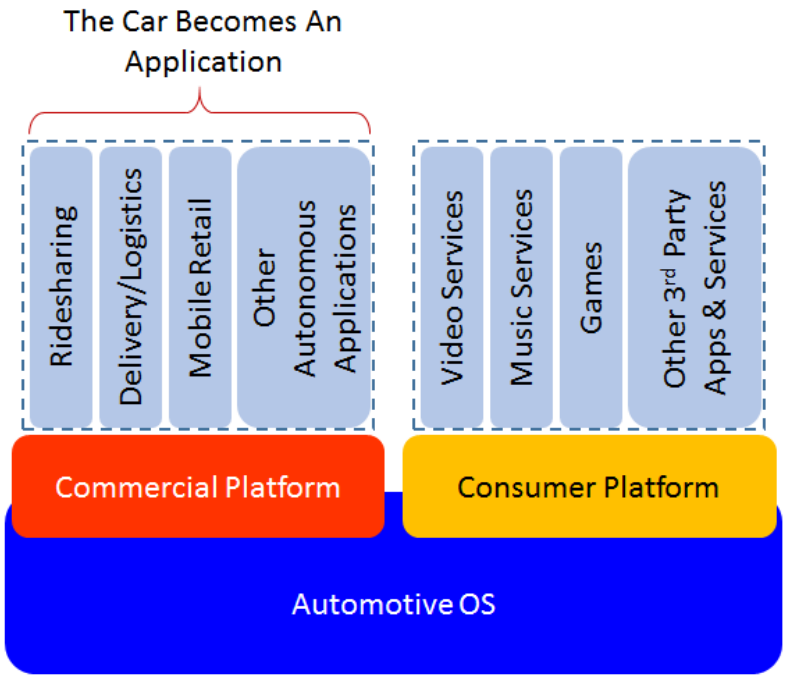
Companies can turn vehicles into a ridesharing or delivery vehicle by turning on that application

The commercial platform would enable companies to turn the vehicle into an application. A commercial platform would allow ridesharing companies, as one example, to write a ridesharing application directly onto the platform that directly interfaces with and controls the vehicle, its wireless connectivity, and leverages the in-vehicle compute. The application would program the vehicle to become a ridesharing vehicle, allowing it to understand where it needs to go, who to pick up, etc.

Vehicle owners would also be able to turn their cars into ridesharing or delivery vehicles when not in use

Vehicle owners could also conceivably enable these various commercial applications and put their own vehicles into a ridesharing or delivery fleet when they’re not using them to make a little extra cash. Allowing the vehicle to become a Swiss Army Knife of applications may also drive greater adoption as smartphone adoption ramped when it became capable of doing more than just make phone calls and text messages. We believe OEMs could charge a platform licensing fee or revenue share agreement for use of the platform.

Fig 2 Automotive Operating System Model



Source: Macquarie Capital (USA), October 2018

What is more exciting is how these platforms will enable businesses we haven't even thought of yet. Every disruptive platform in recent history brought with it new applications that, before the disruptive platform, was probably unfathomable and that disrupted major established industries. **We believe the automotive ecosystem platform will enable and disrupt** in much the same way.

Fig 3 Disruptive Technologies and Their Impacts

Disruptive Platform	New Application	Industry Disrupted
Internet	E-Commerce	Brick & Mortar
Smartphone Ecosystem	Ridesharing	Taxis
Cloud	As-A-Service	Applications & Servers
Automotive Ecosystem	???	???

Source: Macquarie Capital (USA), October 2018

The consumer platform would be similar to the platform ecosystems of Apple and Google where companies build applications and services to be served up in-vehicle on large screens. The business model would similarly be based on platform license fees. Utilizing this model would leave content and services in the hands of individual companies that have domain expertise in those industries, allowing OEMs to focus on their core competencies.

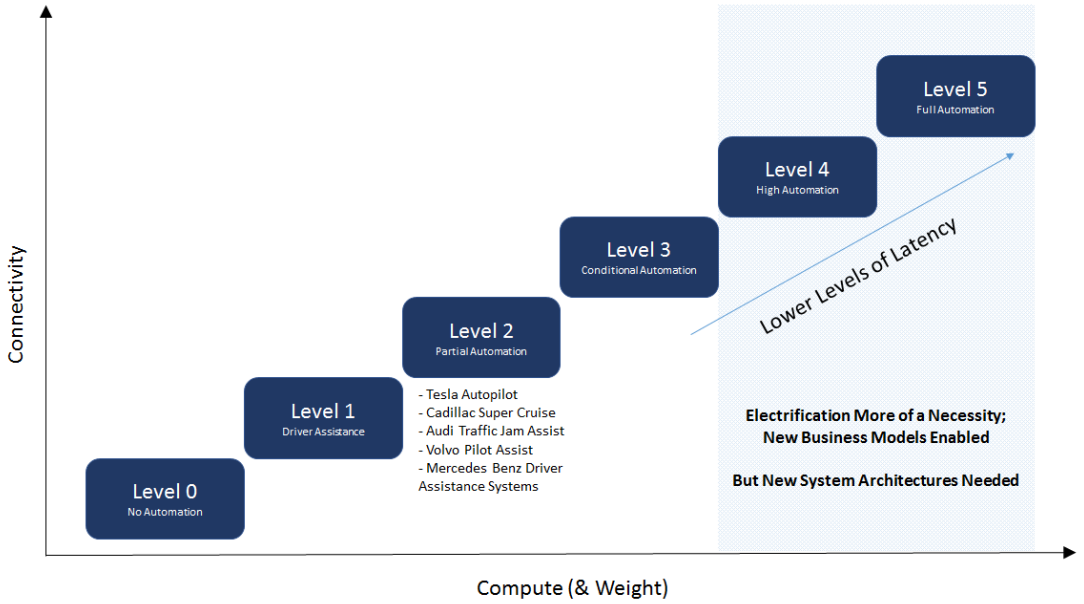
There Will Be Key Steps & Key Drivers along the Way – Electrification & Autonomous

There will be a number of smaller journeys between the trends of electrification, autonomous, and tech platform ecosystems

We believe there will be key mile markers along the journey with a key first step being electrification, followed by autonomous, before the tech platform ecosystem becomes possible. In this report, we address the key drivers of the move to electric for OEMs and consumers as well as the importance of autonomous in the disruptive journey. For those that may be skeptical of the growth in electric vehicles, we note that the biggest driver, in our opinion, will be the risk of competition from the Chinese, as history in numerous technology industries has shown that the Chinese have been able to build scale domestically and use profits to fund global expansion (smartphones, PCs, telecom equipment, et al). We provide deeper analysis further in this report.

In addition to these larger trends, we believe there will be many smaller journeys that will each enable some part of the electric and autonomous path – for example, the journey to electrification will require more than just the movement to an electric powertrain. It will require new architectures around in-vehicle compute that is more centralized to allow for more minute over-the-air system control and will allow for lower latencies.

Fig 4 Stages of Autonomous Drive



Source: Society of Automation Engineers (SAE), Macquarie Capital (USA), October 2018

Key Investable Themes to Play Around Electric, Autonomous, and Autonomous

We believe the road to electric and autonomous will be a multi-decade journey and see a number of key themes and stocks that we believe are investable around these trends. We identify nine investable sub-themes and identify 33 Outperform-rated stocks across multiple sectors covered globally by 15 Macquarie analysts that we expect will benefit from these trends.

These themes include:

1) OEMs with an advantage in electric/autonomous
2) Increasing electronic content driven by electrification including
    a. Connectors
    b. Passive Components
    c. PCBs
3) Batteries, including materials
4) Centralized compute
5) ADAS
6) Connected cars
7) Autonomous drive
8) Lightweighting
9) Charging

Figure 5 highlights the key investable trends, key stocks covered by Macquarie analysts, as well as stocks not under coverage that relate to those themes.

Fig 5 Key Investment Themes and Associated Companies (continued in Fig 6)

OEM	Tesla	TSLA (US)	Maynard Um	Outperform	Target Price: 430.00	10/4/18 Close: 281.83
	Toyota	7203 (JP)	Janet Lewis	Outperform	Target Price: 8,650	10/4/18 Close: 7,005
	BYD	1211 (HK)	Allen Yuan	Underperform	Target Price: 25.80	10/4/18 Close: 51.95
	NIO	NIO (US)				10/4/18 Close: 6.25
Passive Component Content Increase	KEMET	KEM (US)	Maynard Um	Outperform	Target Price: 25.00	10/4/18 Close: 18.70
	Murata	6981 (JP)	Damian Thong	Outperform	Target Price: 21,750	10/4/18 Close: 17,805
	Samsung Electro Mechanics	009150 (KS)	Daniel Kim	Outperform	Target Price: 235,000	10/4/18 Close: 138,500
	Taiyo Yuden	6976 (JP)	Damian Thong	Outperform	Target Price: 3,800	10/4/18 Close: 2,608
	TDK Corporation	6762 (JP)	Damian Thong	Outperform	Target Price: 14,400	10/4/18 Close: 11,890
	Samwha Capacitor	001820 (KS)				10/4/18 Close: 70,400
	Vishay	VSH (US)				10/4/18 Close: 19.55
	Yageo	2327 (TW)				10/4/18 Close: 446.00
PCB Content Increase	TTM Technologies	TTMI (US)	Maynard Um	Outperform	Target Price: 20.00	10/4/18 Close: 15.31
	Chin-Poon Industrial	2355 (TW)				10/4/18 Close: 37.00
	CMK Corp	6958 (JP)				10/4/18 Close: 0,846
	Meiko Electronics	3787 (JP)				10/4/18 Close: 1,258
Connector Content Increase	TE Connectivity	TEL (US)	Maynard Um	Outperform	Target Price: 105.00	10/4/18 Close: 86.16
	Hirose Electric	6806 (JP)	Damian Thong	Neutral	Target Price: 12,500	10/4/18 Close: 12,320
	IRISO Electronics	6908 (JP)				10/4/18 Close: 6,010
Battery	LG Chem	051910 (KS)	Anna Park	Outperform	Target Price: 475,000	10/4/18 Close: 329,500
	Panasonic	6752 (JP)	Damian Thong	Outperform	Target Price: 1,685	10/4/18 Close: 1,357
	Samsung SDI	006400 (KS)	Daniel Kim	Outperform	Target Price: 340,000	10/4/18 Close: 244,000
	SK Innovation	096770 (KS)	Anna Park	Outperform	Target Price: 270,000	10/4/18 Close: 223,000
	BYD	1211 (HK)	Allen Yuan	Underperform	Target Price: 25.80	10/4/18 Close: 51.95
	CBAK Energy Technology	CBAK (US)				10/4/18 Close: .67
Battery Materials	Albemarle Corporation	ALB (US)	Cooley May	Outperform	Target Price: 140.00	10/4/18 Close: 104.22
	Bacanora Lithium	BCN (LN)	Grant Sporre	Outperform	Target Price: .70	10/4/18 Close: .30
	Clean TeQ Holdings	CLQ (AU)	Hayden Bairstow	Outperform	Target Price: 1.20	10/4/18 Close: .57
	Galaxy Resources	GXY (AU)	Ben Crowley	Outperform	Target Price: 4.00	10/4/18 Close: 2.80
	Glencore	GLEN (LN)	Grant Sporre	Outperform	Target Price: 4.40	10/4/18 Close: 3.33
	Neo Lithium	NLC (CA)	Grant Sporre	Outperform	Target Price: 1.70	10/4/18 Close: 1.07
	Orocobre	ORE (AU)	Andrew Hodge	Outperform	Target Price: 4.40	10/4/18 Close: 4.60
	Pilbara Minerals	PLS (AU)	Ben Crowley	Outperform	Target Price: 1.20	10/4/18 Close: .86
	Syrah Resources	SYR (AU)	Ben Crowley	Outperform	Target Price: 3.80	10/4/18 Close: 2.16
	Western Areas	WSA (AU)	Hayden Bairstow	Outperform	Target Price: 3.40	10/4/18 Close: 2.82
	Altura Mining	AJM (AU)	Ben Crowley	Underperform	Target Price: .22	10/4/18 Close: .26
	Independence Group	IGO (AU)	Hayden Bairstow	Underperform	Target Price: 4.20	10/4/18 Close: 4.85
Centralized Compute	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Intel Corp	INTC (US)	Srini Pajjuri	Outperform	Target Price: 60.00	10/4/18 Close: 48.13
	Renesas	6723 (JP)	Damian Thong	Outperform	Target Price: 1,265	10/4/18 Close: 0,742
	NVIDIA	NVDA (US)	Srini Pajjuri	Neutral	Target Price: 240.00	10/4/18 Close: 279.29
	Visteon Corp	VC (US)				10/4/18 Close: 92.01
Autonomous Driving	Alphabet	GOOGL (US)	Ben Schachter	Outperform	Target Price: 1,250.00	10/4/18 Close: 1,177.07
	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	Apple	AAPL (US)	Ben Schachter	Outperform	Target Price: 235.00	10/4/18 Close: 227.99
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Nexteer	1316 (HK)	Janet Lewis	Outperform	Target Price: 16.60	10/4/18 Close: 11.72
	NVIDIA	NVDA (US)	Srini Pajjuri	Neutral	Target Price: 240.00	10/4/18 Close: 279.29
	Veoneer	VNE (US)	Maynard Um	Neutral	Target Price: 53.00	10/4/18 Close: 48.95
	General Motors	GM (US)				10/4/18 Close: 34.25
Lightweighting	Minth Group	425 (HK)	Janet Lewis	Outperform	Target Price: 44.20	10/4/18 Close: 29.25
	Nexteer	1316 (HK)	Janet Lewis	Outperform	Target Price: 16.60	10/4/18 Close: 11.72
	Gestamp Automocion	GEST (MCE)				10/4/18 Close: 6.22
	Shiloh Industries	SHLO (US)				10/4/18 Close: 9.33

Note: Stocks with no associated analyst and data are Not rated.
Source: FactSet, Macquarie Capital (USA), October 2018

Fig 6 Key Investment Themes and Associated Companies

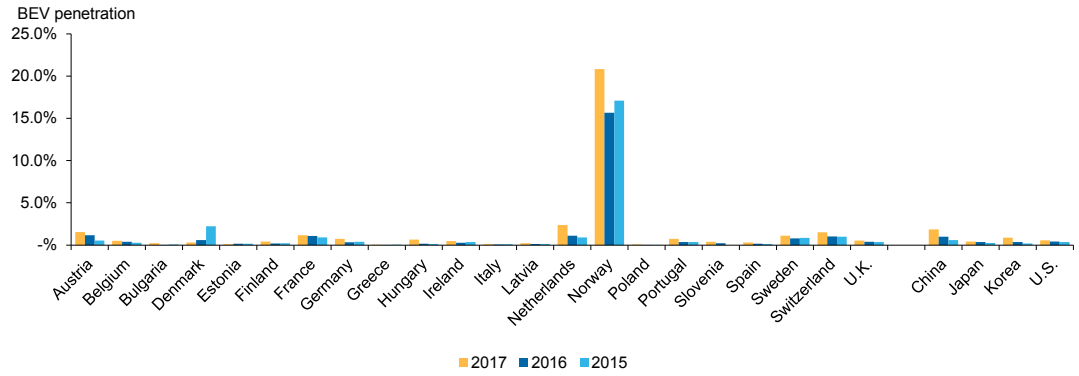
Power Semiconductors	Rohm	6963 (JP)	Damian Thong	Outperform	Target Price: 12,100	10/4/18 Close: 8,210
	Fuji Electric	6504 (JP)	Damian Thong	Neutral	Target Price: 4,785	10/4/18 Close: 4,585
	Mitsubishi Electric	6503 (JP)	Damian Thong	Neutral	Target Price: 1,480	10/4/18 Close: 1,552
	Cree	CREE (US)				10/4/18 Close: 36.75
	Infineon	IFX (DE)				10/4/18 Close: 20.15
Charging	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	Tesla	TSLA (US)	Maynard Um	Outperform	Target Price: 430.00	10/4/18 Close: 281.83
	Blink Charging	BLNK (US)				10/4/18 Close: 2.30
	Envision Solar International	EVSI (US)				10/4/18 Close: .19
	KS Terminals	3003 (TW)				10/4/18 Close: 47.40
Thermal Management	Hanon Systems	018880 (KS)	James Hong	Outperform	Target Price: 17,000	10/4/18 Close: 12,650
	Dana Incorporated	DAN (US)				10/4/18 Close: 18.50
	Denso	6902 (JP)				10/4/18 Close: 5,745
	Gentherm Incorporated	THRM (US)				10/4/18 Close: 43.50
	Mahle-Metal Leve S.A.	LEVE3 (BR)				10/4/18 Close: 24.74
	Modine	MOD (US)				10/4/18 Close: 15.02
	Sanden	6444 (JP)				10/4/18 Close: 1,567
	Tecogen	TGEN (US)				10/4/18 Close: 3.05
	Toyota Industries	6201 (JP)				10/4/18 Close: 6,480
	Valeo SA	FR (FR)				10/4/18 Close: 32.50
Connected Car	Amazon	AMZN (US)	Ben Schachter	Outperform	Target Price: 2,200.00	10/4/18 Close: 1,909.42
	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	AT&T	T (US)	Amy Yong	Outperform	Target Price: 35.00	10/4/18 Close: 34.12
	BT Group	BT/A (LN)	Guy Peddy	Outperform	Target Price: 3.55	10/4/18 Close: 2.28
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Intel Corp	INTC (US)	Srini Pajjuri	Outperform	Target Price: 60.00	10/4/18 Close: 48.13
	Orange	ORA (FP)	Guy Peddy	Outperform	Target Price: 16.30	10/4/18 Close: 13.73
	Panasonic	6752 (JP)	Damian Thong	Outperform	Target Price: 1,685	10/4/18 Close: 1,357
	Qualcomm	QCOM (US)	Srini Pajjuri	Outperform	Target Price: 84.00	10/4/18 Close: 72.38
	Renesas	6723 (JP)	Damian Thong	Outperform	Target Price: 1,265	10/4/18 Close: 0,742
	Sony	6758 (JP)	Damian Thong	Outperform	Target Price: 7,650	10/4/18 Close: 6,613
	Maxim	MXIM (US)	Srini Pajjuri	Neutral	Target Price: 60.00	10/4/18 Close: 55.71
	Sierra Wireless	SWIR (US)	Gus Papageorgiou	Neutral	Target Price: 24.00	10/4/18 Close: 19.37
	Texas Instruments	TXN (US)	Srini Pajjuri	Neutral	Target Price: 110.00	10/4/18 Close: 105.87
	Verizon	VZ (US)	Amy Yong	Neutral	Target Price: 55.00	10/4/18 Close: 55.02

Note: Stocks with no associated analyst and data are Not rated.
Source: FactSet, Macquarie Capital (USA), October 2018

Electric Vehicles a Necessary First Step

The market for electric vehicles is small with less than 1% global penetration in 2017. In total, there are only three countries with penetration rates above 2% and only eight with penetration rates above 1%. However, off this small base, the electric vehicle market has been seeing significant growth and in this report, we explain in great detail why we believe this growth is set to accelerate.

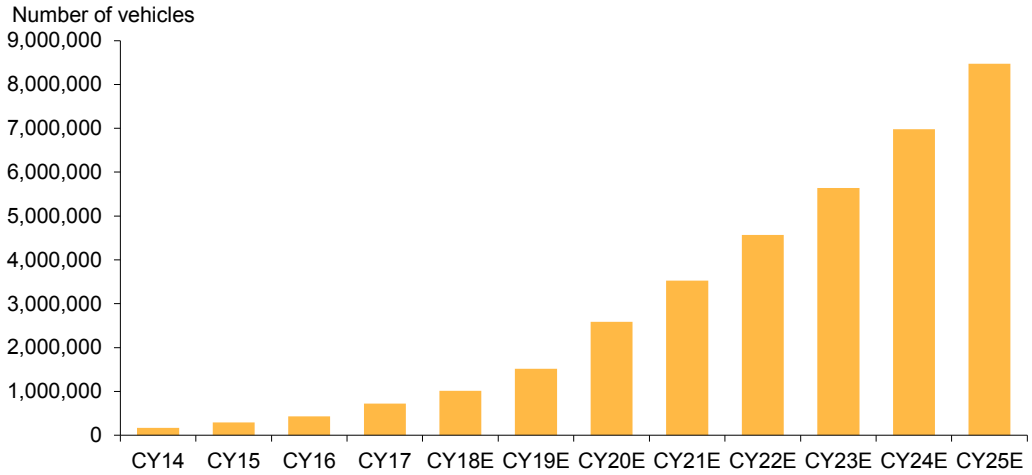
Fig 7 BEV Sales as Percentage of New Car Sales by Country – Adoption Rate Is Low Today



Source: ACEA, LMC Automotive, Macquarie Capital (USA), October 2018

LMC Automotive estimates the market for electric vehicles in 2017 was just shy of 720,000 and expects this to grow to over one million in 2018, or more than 40% growth year over year, and to almost 8.5 million by 2025, or 7.5% penetration, which we believe could prove to be conservative. The following sections detail the key reasons why we believe OEMs and consumers will increasingly adopt electric vehicle technologies to drive growth of the EV market.

Fig 8 Battery Electric Vehicle Market Growth



Source: LMC Automotive, Macquarie Capital (USA), October 2018

Drivers to Push OEMs to Electric

Electric Vehicles Pose an Opportunity & Risk

We see three reasons that should compel OEMs to electric, in a world that would otherwise not behove them to move away from internal combustion engine vehicles where they have built higher barriers to entry:

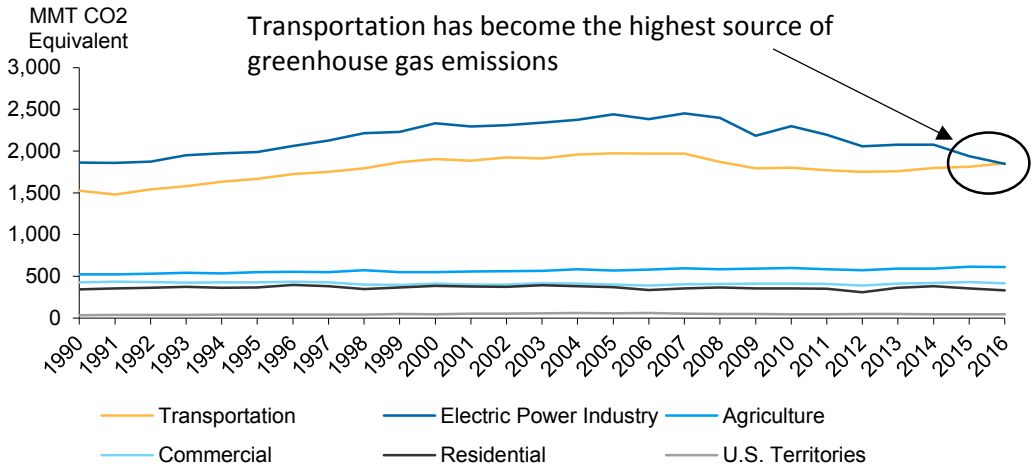
1) government regulation,
2) electric advantages in autonomous, and
3) competition

Government Regulations – Just a Matter of Time

Regulations are becoming stricter as governments look to reduce greenhouse gas emissions and some countries placing a timeline on the ban of internal combustion engine vehicles. While these bans could get pushed in some cases, the broader trend of internal combustion engine vehicles is still expected to be a decline while new energy vehicles continue to rise.

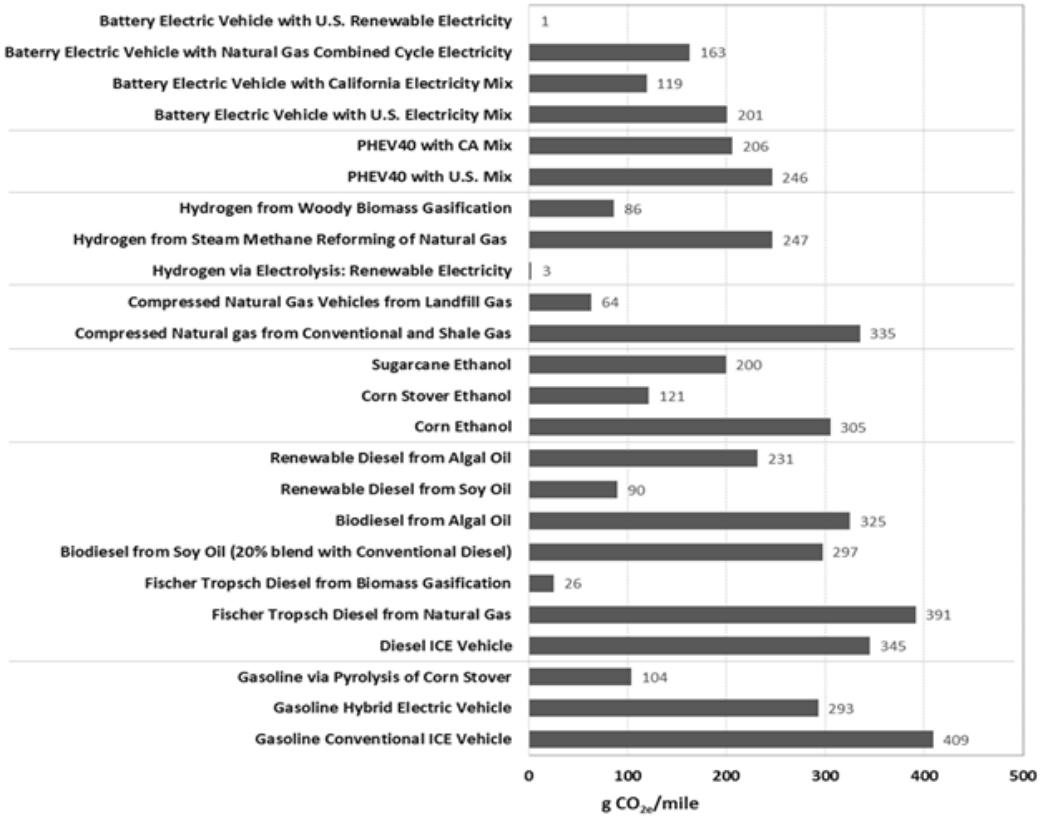
The reason? In the US, the transportation industry is the second highest contributor of greenhouse gas emissions. While electricity generation is higher, its pace of decline has been greater than that of the transportation industry, and at the more recent pace of the two, the transportation sector runs the risk of becoming the greatest contributor of greenhouse gas emissions over the next several years.

Fig 9 Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO_2 Eq.)



Source: U.S. EPA, Macquarie Capital (USA), October 2018

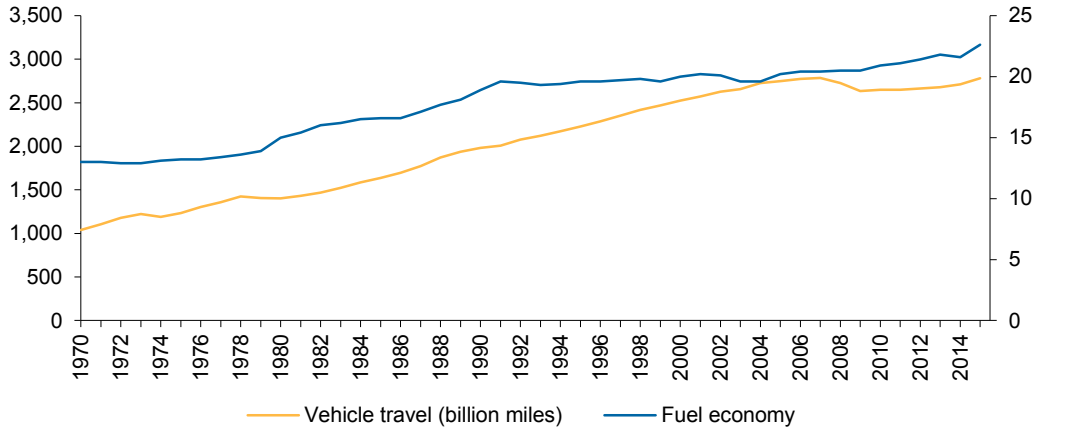
Fig 10 Emissions Profile of Vehicles Using Different Energy Sources



Source: Transportation Data Book: Edition 36.2 – 2018

We note that while fuel economy for internal combustion engines continues to improve, the pace of emissions growth hasn’t fallen by the same magnitude, as shown in Figure 10. This is due the rising number of vehicle miles driven (40% increase from 1990 to 2015) due population growth, economic growth, and periods of low fuel prices. We believe this will help to drive the trend to electric and hybrid-electric vehicles.

Fig 11 U.S. Transportation Industry Vehicle Miles Travelled and Average Fuel Economy



Source: Transportation Data Book: Edition 36.2 – 2018

China. China’s industrialization has helped the country achieve unprecedented rates of economic growth, though at the same time made the country increasingly dependent on foreign oil due to China’s lack of domestic reserves. The central government has identified the nation’s foreign oil dependence as a key national security risk and has long sought to promote the adoption of vehicles powered by alternative fuels. More recently, air pollution has also become a key concern amongst the general public and has garnered greater support across the country for more ambitious EV goals to address vehicle emissions. Currently, the country is targeting 2020 and 2025 new EV sales of 2 million and 7 million, respectively, which represent significant steps up from its latest ~600K deliveries in 2017.

From a regulatory perspective, the government is implementing a New Energy Vehicle (“NEV”) credit policy set to begin in 2019, with the first settlement of NEV credits to occur in 2021. Such a program will require automakers to sell Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV) models or acquire credits from a competitor, with each BEV earning up to 5 credits per vehicle depending on their range (we estimate on average OEMs will earn ~3.2 credits per BEV sold) and each PHEV earning 2.0 credits per vehicle. By 2020, the Chinese government hopes to achieve NEV sales penetration of 7-10% and an even higher penetration rate of 40-50% by 2030, as shown in the below figure:

Fig 12 Chinese government’s NEV Sales Target for 2015-30

	2015	2020	2025	2030
NEV sales as % of total auto sales	1.5%	7-10%	15-20%	40-50%
Total NEV ownership (K units)	500	5,000	20,000	80,000
Number of charging stations (K units)	3.6	12.0	36.0	48.0
Number of charging piles (K units)	57	5,000	20,000	80,000

Note: Based on presentation by Mr. Wang Binggang, former Director of China Automotive Technology and Research Center, at Geely’s Dragon Bay Forum in May 2018

Source: CATARC, Macquarie Capital (USA), June 2018

Federal and local subsidy programs are also available to further promote NEV adoption. On the federal side, the Chinese government has released guidance for 2018, and we expect a 20% subsidy cut going into 2019 before subsidies completely expire at the end of 2020. Major cities across China generally all offer a local stipend as well for neighbourhood electric vehicles, though the size of such incentives is typically less than half of those offered at the federal level.

Fig 13 Chinese Federal NEV Subsidies

	NEV Subsidy (RMB K)			NEV Subsidy (RMB K)	
Travel range	2017	2018	YoY change	2019-20	YoY change
R<100km	0	0	0%	0	(20)%
100km≤R<150km	20	0	(100)%	0	(20)%
150km≤R<200km	36	15	(58)%	12	(20)%
200km≤R<250km	36	24	(33)%	19	(20)%
250km≤R<300km	44	34	(23)%	27	(20)%
300km≤R<400km	44	45	2%	36	(20)%
R≥400km	44	50	14%	40	(20)%
Plug-in hybrid EV	24	22	(8)%	18	(20)%

Note: Subsidy values as of 12 June (previously, 2018 subsidies were announced to be 70% of 2017 values)
Source: MIIT, Macquarie Capital (USA), June 2018

Europe. After the most recent Dieselgate cheating scandal, European governments have become increasingly motivated to cut the continent's dependence on internal combustion engine (ICE) vehicles. The EU's current long term emissions targets aim to achieve an industry wide 95g CO_2/km target by 2020/21 and a subsequent 15% and 30% reduction from 2021 levels in 2025 and 2030, respectively. Still, the European Parliament's environmental committee has most recently endorsed rules this past month for even more stringent emissions targets, seeking to set 2025 and 2030 reduction targets to 20% and 45% of 2021 levels.

Separately, a number of individual countries have announced that they will ban ICE vehicles entirely in future decades. Whether or not these jurisdictions actually follow through on these announcements, we view such public disclosures as indicative of the national sentiment of these individual countries, amongst which are three of the largest economies within the EU.

Fig 14 Select European Countries that have Announced ICE Phase Out Dates

Country	ICE Phase Out Date
Denmark	2030
Germany	2030
Netherlands	2030
France	2040
UK	2040
Norway	2025

Source: Macquarie Capital (USA), October 2018

As of September of this year, the EU has phased in its new Worldwide Harmonised Light Vehicle Test Procedures (WLTP) standard across all new passenger car sales within the region. While the impact of this standard varies for different vehicle models, individual nameplates are estimated to face a decrease in mileage per gallon and increase in emissions output label of ~20-30% versus the incumbent New European Driving Cycle ("NEDC") criterion. The adoption of WLTP is unlikely to have an effect on the EU's long term grams of CO_2 per km targets, though is likely to have an effect on individual countries' consumer automotive related taxes (vehicle taxes in many European countries are calculated based on a vehicle's engine specifications and emissions output).

A large number of European countries offer EV subsidies in the form of tax exemptions from automotive purchase/ownership taxes. With the adoption of WLTP standards, the value of such tax exemptions would further rise to help the continent progress towards its zero emissions targets.

Fig 15 EV Subsidy Programs for Select Major European Economies

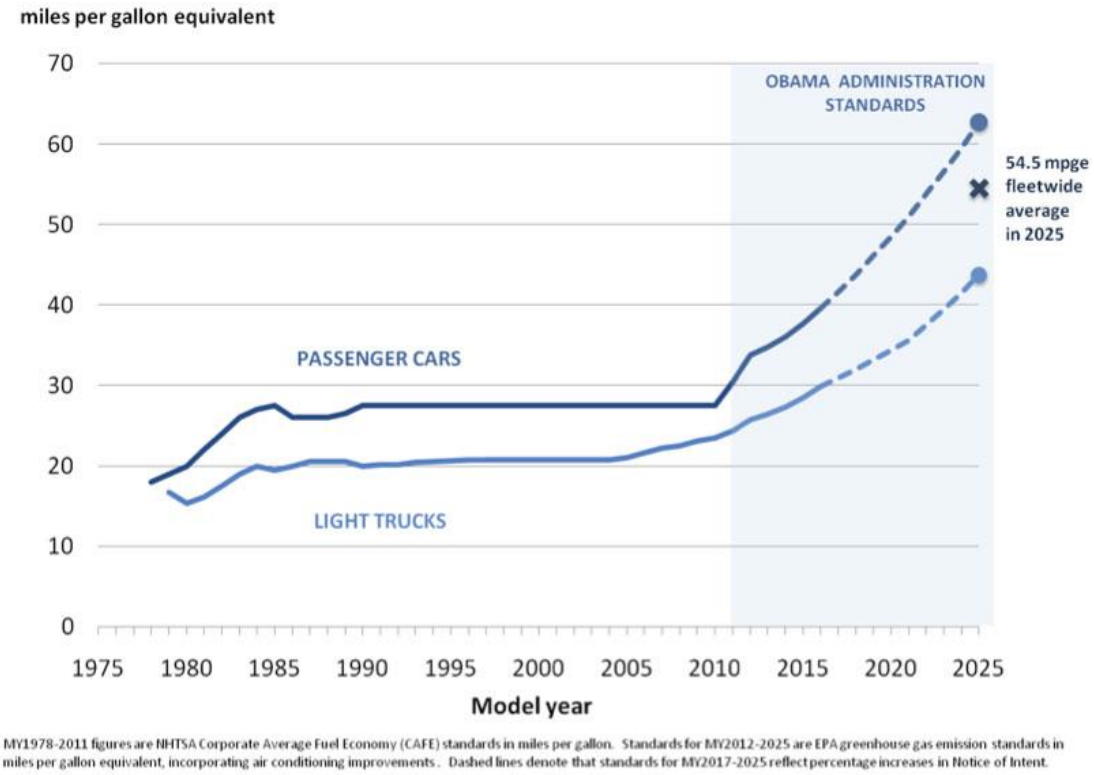
Austria	Electric vehicles are exempt from fuel consumption/pollution tax and ownership tax. In addition, a deduction of VAT is applicable for zero-CO2 emission (eg electric and hydrogen-powered cars).
Belgium	Electric vehicles pay the lowest rate of tax under the annual circulation tax in all three regions. In the Brussels-Capital region, financial incentives apply to electric, hybrid or fuel-cell vehicles. Electric and plug-in hybrid (until 31 December 2020) vehicles are exempt from registration tax in Flanders. Incentives (“Zero Emission Bonus”) for the purchase of battery electric and hydrogen-powered cars and vans are granted. The deductibility rate from corporate income of expenses related to the use of company cars is 120% for zero-emissions vehicles.
Czech Republic	Electric, hybrid and other alternative fuel vehicles are exempt from the road tax.
Denmark	Electric vehicles (BEVs) pay only 40% of the registration tax (in 2017). This percentage will be gradually increased to 65% in 2018, 90% in 2019 and 100% in 2020. Hydrogen and fuel cell-powered vehicles are exempt from registration tax until the end of 2020.
Finland	Pure electric vehicles always pay the minimum level of the CO2 based registration tax.
France	Regions have the option to provide an exemption from the registration tax (either total or 50%) for alternative fuel vehicles (ie electric, hybrids, CNG, LPG, and E85). Electric vehicles and vehicles emitting less than 60g CO2/km are not subject to the tax on company cars. Electric and hybrid electric vehicles emitting 20 g/km or less of CO 2 benefit from a premium of €6,000 under a bonus- malus scheme. An incentive scheme grants an extra €4,000 for switching an eleven year or more diesel vehicle for a new BEV (or €2,500 in case it’s a PHEV).
Germany	Electric vehicles are exempt from the annual circulation tax for a period of ten years from the date of their first registration. From July 2016, the government granted an environmental bonus of €4,000 for pure electric and fuel-cell vehicles and €3,000 for plug-in hybrid and range-extended electric vehicles.
Greece	Electric and hybrid vehicles are exempt from registration tax, luxury tax and luxury living tax. Electric and hybrid cars (with an engine capacity of up to 1,549cc and first registration date before 31 October 2010) are exempt from circulation tax.
Hungary	Electric cars and plug−in hybrids are exempt from registration tax, annual circulation tax and company car tax.
Ireland	Electric vehicles qualify for VRT (purchase tax) reliefs of €5,000 until 31 December 2021 (€2,500 for plug−in hybrids until 31 December 2018). In addition, electric vehicles and plug−in electric hybrids entitle the buyer to a grant of up to €5,000 on purchase until 31 December 2021 for electric vehicles and December 2018 for plug−in hybrid electric vehicles. Electric vehicles pay the minimum rate of the road tax (€120).
Italy	Electric vehicles are exempt from the annual circulation tax (ownership tax) for a period of five years from the date of the first registration. After this five-year period, they benefit from a 75% reduction of the tax rate applied to the equivalent petrol vehicles.
Luxembourg	Electric and fuel cell vehicles benefit from a tax allowance on the registration fees of €5,000. Electric vehicles also pay the minimum rate of the annual circulation tax. Pure electric and hydrogen cars pay the lowest tax on benefit in kind for private use of a company car.
Netherlands	Zero emission cars are exempt from paying registration tax. Passenger cars with zero CO2 emissions are exempt from motor vehicle tax up to and including 2020. Zero emission cars pay the lowest percentage (4%) of the income tax on the private use of a company car.
Poland	Electric and plug-in electric vehicles exempt from registration tax.
Portugal	VAT is deductible for electric vehicles (with acquisition cost <€62,000) and plug-in hybrids (with an acquisition cost <€50,000). Pure electric cars are exempt from the registration tax (Imposto Sobre Vehículos or ISV). Plug-in hybrid cars with all-electric mode up to 25km benefit from a 75% reduction of the tax.
Spain	Main city councils (eg Madrid, Barcelona, Zaragoza, Valencia etc) are reducing the annual circulation tax (ownership tax) for electric and fuel-efficient vehicles by 75%. Reductions are applied on company car taxation for pure electric and plug-in hybrid vehicles (30%), and for hybrids, LPG and CNG vehicles (20%).
Sweden	‘Climate bonus’ (Klimatbonus) is available for the purchase of new vehicles with CO2 emissions of maximum 60g/km. It ranges from SEK 60,000 for electric vehicles (BEV) with zero emission to plug-in hybrids (PHEV) with emission of 60g/km. Electric cars and plug-in hybrids are exempted from paying annual circulation tax for five years. 40% reduction is applied on company car taxation for electric cars and plug-in hybrids.
United Kingdom	From April 2018 until March 2021, cars that emit less than 50g/km qualify for 100% first year writing down allowances (FYAs). Zero emission vehicles attract a zero rate of vehicle excise duty (VED) Ultra-low emissions and electric vehicles pay reduced company car tax rates.

Source: ACEA, Macquarie Capital (USA), October 2018

The United States. The Obama administration and California Air Resources Board (CARB) had previously set ambitious emissions goals for automakers in the U.S., though the Trump administration's recent announcement in early August has put such regulatory targets in jeopardy. The current president's new initiatives are set to cap national Corporate Average Fuel Economy (CAFÉ) targets at 2020 levels that were originally supposed to step up through 2025, while at the same time revoke California's, and thereby CARB's, legal mandate to set its own emissions regulations.

Pre-existing Obama era emissions regulations set an aggressive 2025 CAFÉ target of 54.5 NHTSA-based mpg. For comparison purposes, the National Highway Traffic Safety Administration (NHTSA) NHTSA mpg ratings are more generous than EPA ratings, which are generally considered more realistic "real world" figures and are typically the values that appear on the window of new vehicles on display at U.S. retail dealer lots. The equivalent EPA-based mpg for 2025 Obama CAFÉ standards is approximately 40 mpg, while the U.S. automotive industry model year 2016's EPA-based mpg was 24.7.

Fig 16 Original Obama Administration Emissions Target for 2025

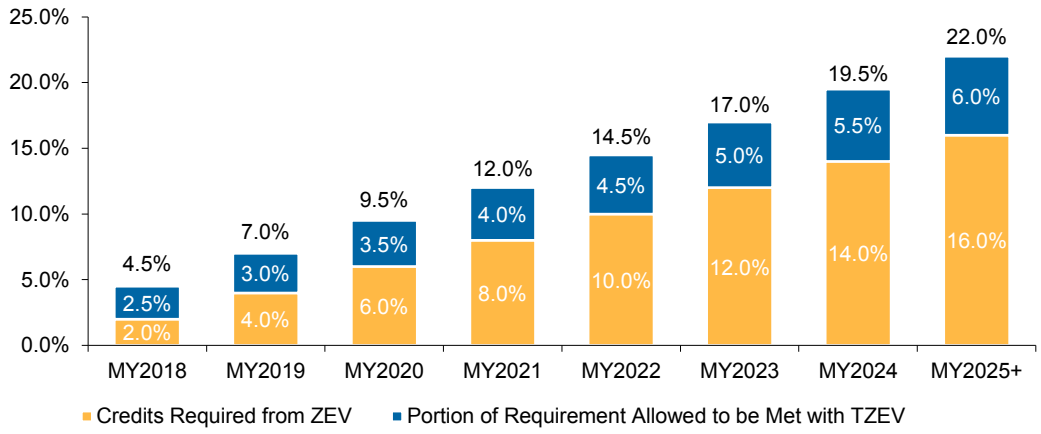


Source: U.S. Department of Transportation, July 2011

In addition to NHTSA and the EPA, CARB also sets its own vehicle emissions targets based on its low emission vehicle (LEV) and zero emission vehicle (ZEV) programs. In particular, the ZEV Credit Program was set to drive a dramatic increase in penetration of BEVs and PHEVs. Under the state's previous LEV program, conventional hybrid vehicles could earn emissions credits, though under the CARB's ZEV program, only BEV and PHEVs qualify for credits. With the ZEV Credit Program set to be implemented in model year 2018, the program was likely to serve as a key catalyst for higher sales penetration of EVs within the ten states that have chosen to adopt the state level program.

The ZEV Credit Program was originally set to go into effect in the 2018 model year and requires automakers to accrue ZEV credits equal to 4.5% of their total vehicle sales in participating jurisdictions for model year 2018. Credits are generally earned by selling BEVs and fuel cell electric vehicles (FCEVs) that can earn up to 4.0 credits per vehicle or PHEVs that can earn up to 1.1 credits per vehicle, both of which depend on the vehicle's all-electric-range. Credit requirements subsequently increase by 2.5 percentage points every model year (full details can be found in the appendix).

Fig 17 ZEV Credit Percentage Requirement By Model Year



Source: CARB, Macquarie Capital (USA), October 2018

In early August of this year, the Trump administration made a joint announcement with the EPA to roll back Obama-era emissions targets and cap OEM CAFÉ requirements at 2020 levels (i.e. approximately 37 NHTSA-based mpg or 27 EPA-based mpg) for future years. Such action would nearly eliminates any federal regulatory pressure on automakers to adopt lower emission technologies, since as of model year 2016, the U.S. automotive industry had achieved an EPA-based average mpg of 24.7.

Within the same announcement President Trump also disclosed his intention to revoke the legal waiver granted to California under the 1970 Clean Air Act to dictate its own emissions standards. The California Air Resources Board was originally established under this piece of federal legislation, and if the Trump administration is successful in disbanding CARB, there will be no regulatory framework within the U.S. that mandates the adoption of full BEVs and PHEVs.

One EV incentive program that the Trump administration has chosen to leave in place is the federal EV subsidy. The U.S. federal government offers a tax credit of $2,500 to $7,500 per new EV, with BEVs getting $7,500, and PHEVs receiving an intermediate value. The tax credit is available to the first 200,000 qualified EVs that an OEM manufactures, after which the credit begins to phase out (credit to drop to 50% over the following six months and then to 25% in the next six months before full phase out). In addition, EVs enjoy additional state level subsidies as well, which generally range in the low single digit thousands and are documented below:

Fig 18 State Level Tax Credit Subsidies for EVs

Arizona	Reduced Vehicle License Tax, Carpool lane access and reduced rates for electric vehicle charging
California	$2,500 rebate (based on income eligibility)
Connecticut	$3,000 rebate for new vehicles with a base price under $60,000
Colorado	$5,000 tax credit for purchase of a new vehicle $2,500 tax credit for lease of a new vehicle
Delaware	$1,000 rebate for new vehicles with a base price over $60,000 $3,500 rebate for new vehicles with a base price under $60,000
Hawaii	Carpool lane access and reduced rates for electric vehicle charging
Louisiana	$2,500 income tax credit
Maryland	$3,000 Excise Tax Credit for new vehicles with a total price under $60,000 $700 rebate on wall connectors and installation
Massachusetts	$1,000 rebate for new vehicles with a base price over $60,000 $2,500 rebate for new vehicles with a base price under $60,000
Nevada	Reduced rates for electric vehicle charging
New Jersey	Sales tax exempt
New York	$500 rebate for new vehicles with a base price over $60,000 $2,000 rebate for new vehicles with a base price under $60,000
Pennsylvania	$1,750 rebate for new vehicles with a base price under $50,000 (500 rebates available between January 1 and June 30, 2018)
Washington DC	Excise tax exempt

Source: Tesla website, October 2018

Electrification Architecturally Better Suited For Autonomous

Given the increasingly stringent regulatory environment regarding emissions, electric vehicles, in our opinion, will become more important, particularly as we get to autonomous.

But some autonomous driving companies use internal combustion engine vehicles – so why is electric needed? Many autonomous vehicles being used today are, notably, internal combustion engine vehicles or hybrids. For example, Waymo uses Chrysler Pacfica Hybrid minivans (though also uses Jaguar I-PACE), Uber uses Ford Fusion hybrids, and Lyft used BMW 5-series in Las Vegas. Autonomous technology, even in an internal combustion engine vehicle, is expected to lead to better fuel economy as computer algorithms are programmed to drive more smoothly through more sophisticated throttling and braking.

Fig 19 Vehicles Used by Select Autonomous Drive Programs

Company	Vehicle(s) Used
Baidu	Lincoln MKZ Hybrid
Delphi	Audi SQ5
Drive.ai	Lincoln MKZ Hybrid, Audi A4, Nissan NV200
GM Cruise	Chevrolet Bolt
Nissan	Nissan Leaf, Infiniti Q50
NVIDIA	Lincoln MKZ Hybrid
Waymo	Chrysler Pacifica, Jaguar I-Pace

Source: Company reports, Macquarie Capital (USA), October 2018

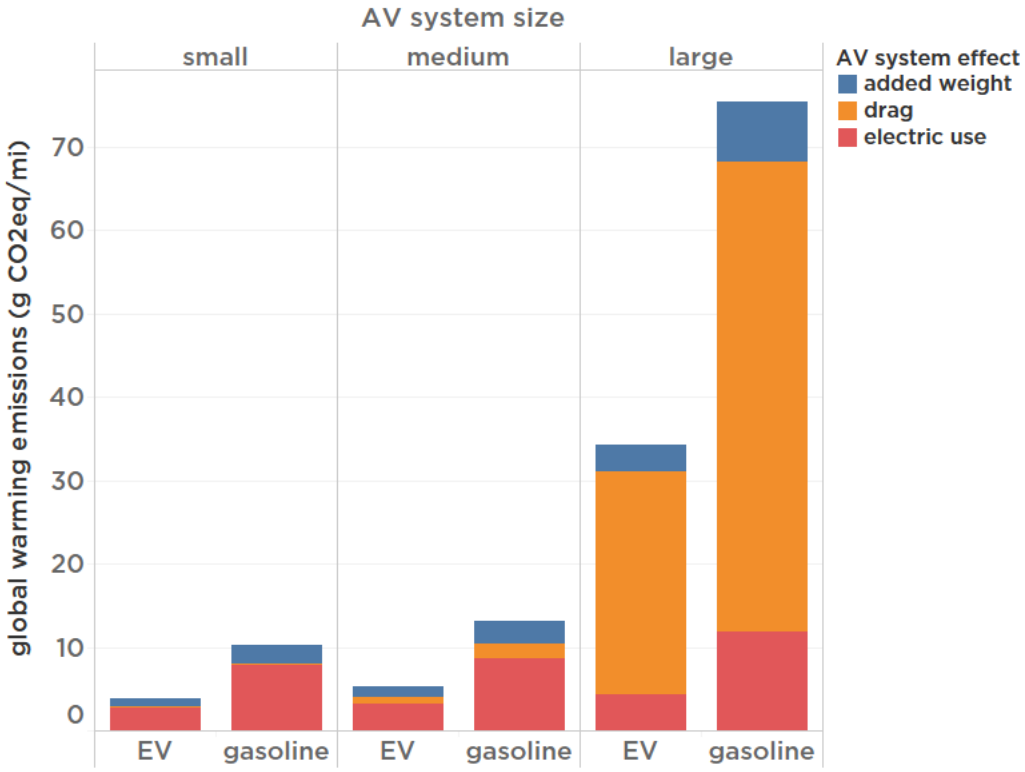
Power and fuel consumption can increase from the added weight in autonomous equipment

If internal combustion engine vehicles are proven to work as autonomous vehicles, why is electrification needed? When it comes to autonomous, we believe electric vehicles are architecturally better suited for two reasons, in particular:

1) **Higher power requirements** from the equipment (computer, cameras, LiDAR, etc.) and
2) **Lower vehicle emissions** as added weight of and drag from equipment directly impacts energy consumption in vehicles.

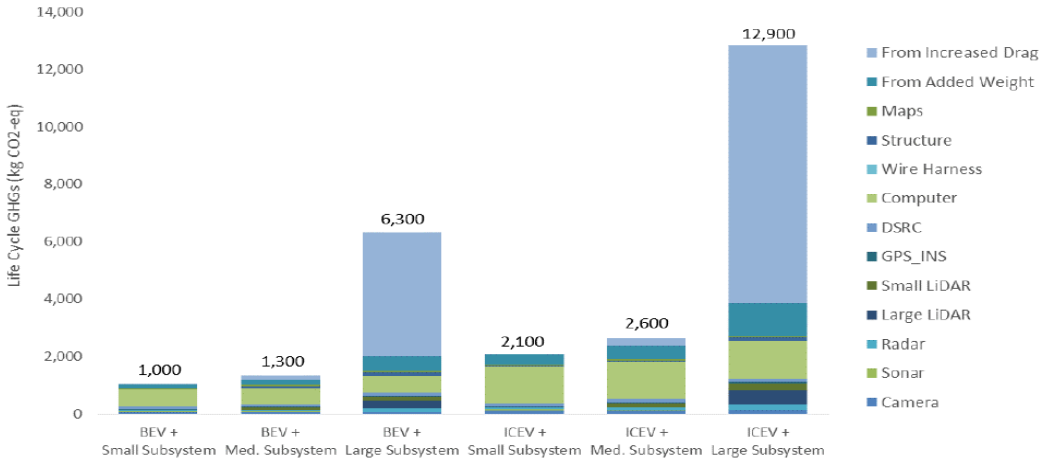
While an autonomous vehicle using an internal combustion engine is still expected to be more fuel efficient than a human-driven internal combustion engine vehicle, a study by the University of Michigan and Ford Motor Company published in February 2018 found that autonomous vehicles with electric powertrains produce 40% less lifetime greenhouse gas emissions than internal combustion engines.

Fig 20 Impact of AV Systems on GHG Emissions for Electric versus ICE Vehicles



Source: Union of Concerned Scientists, authored by David Reichmuth, adapted with permission from Gawron et al. Copyright (2018) American Chemical Society, May 2018

Fig 21 CAV Subsystem Life Cycle GHG Emissions



Source: Reprinted with permission from Gawron et al. Copyright (2018) American Chemical Society, May 2018

If autonomous vehicles generate higher greenhouse gas emissions than non-autonomous vehicles due to the additional weight, we could see emissions standards tightening unless ride-sharing reduces the number of vehicles on the road to offset the higher emissions.

Competition – Potentially the Most Important Driver

Since its invention in the 1800s, the internal combustion engine has undergone changes but the original concept remains unchanged – fuel and oxygen intake resulting in power output. In that sense, the basic internal combustion engine has not changed since its invention. However, the barrier to entry is high not only because of the advantage OEMs have in scale, distribution, and brand, but also because these automobiles have thousands of precisely engineered parts, which adds to the degrees of complexity. Thus, the top players have remained at the top as the barriers to entry have generally proven difficult to overcome.

Compare that to electric cars, which have much fewer parts – effectively basic motors and gearboxes. We believe this has lowered the barriers to entry and allowed new entrants. That said, Tesla’s manufacturing hiccups show that there are some levels of manufacturing experience that are necessary to get to volumes.

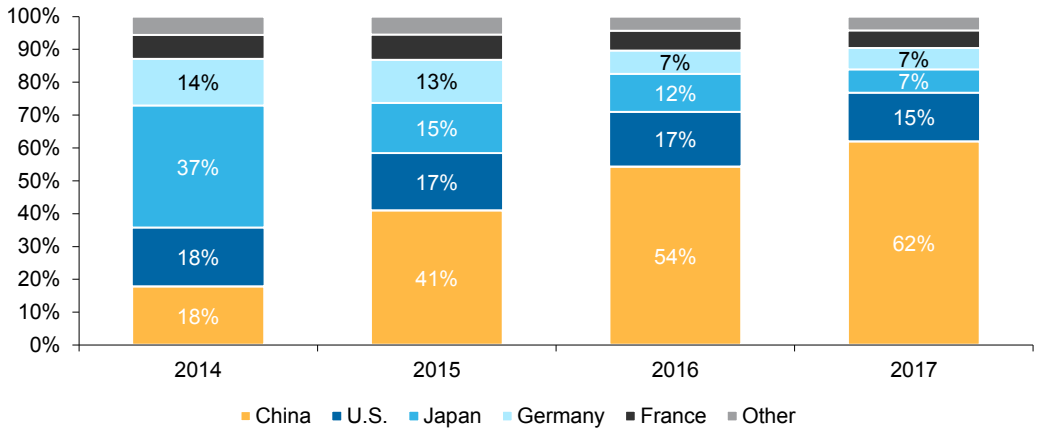
Nonetheless, electrification has opened the door to more investments by non-traditional companies, which we believe poses risk to traditional OEMs – from way out of left-field companies like home appliance company Dyson to the Chinese who can gain scale through electric vehicle growth in China. We believe the latter could prove to be a real risk.

Aside from competition, we believe electrification is a key stepping stone to autonomous, which we think should motivate OEMs to move to move quickly to adopt the technology.

Chinese pose the biggest risk. One of the advantages of the incumbent OEMs has been the level of scale achieved in manufacturing. However, we believe the China’s size provides an opportunity for Chinese OEMs to gain domestic scale in electric vehicles and use the potential profits from that scale to subsidize plans for global growth.

How real is the risk? The Chinese market already accounts for more than 62% of the world’s EV manufacturing, up from 54% in 2016, 41% in 2015 and just 18% in 2014.

Fig 22 Global Electric Vehicle Market Share By Vendor Nation

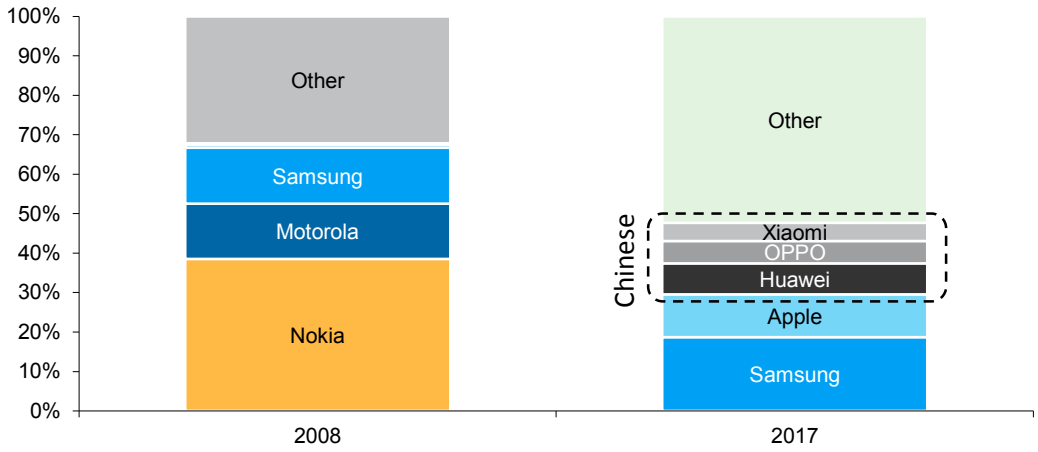


Source: LMC Automotive, Macquarie Capital (USA), October 2018

In fact, history has shown us that the Chinese are capable of gaining significant scale and using domestic strength to subsidize global growth.

For example, in 2007, Chinese OEMs accounted for a minimal percentage of the market, though by 2017, three Chinese OEMs accounted for nearly 20% of the market. This market was burdened by new entrants with new technologies, resulting in a complete shift in the top players over that decade.

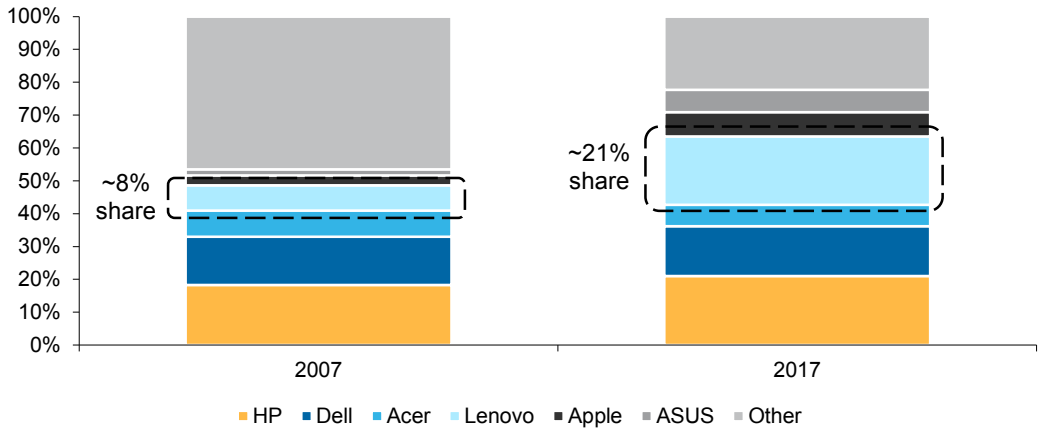
Fig 23 Handset/Smartphone Vendor Market Share in 2007 and 2017



Source: IDC, Bloomberg, Company Reports, Macquarie Capital (USA), October 2018

We saw a similar phenomenon in the PC industry as well. In 2007, Lenovo accounted for 7.7% of the market but by 2017, accounted for 21% of the market using a similar strategy of leveraging domestic scale and profits to subsidize global growth. However, unlike the smartphone market, existing large market players consolidated the market, leading to fewer OEMs with larger share. We believe this is largely because of the lack of disruptive technology from any new entrants.

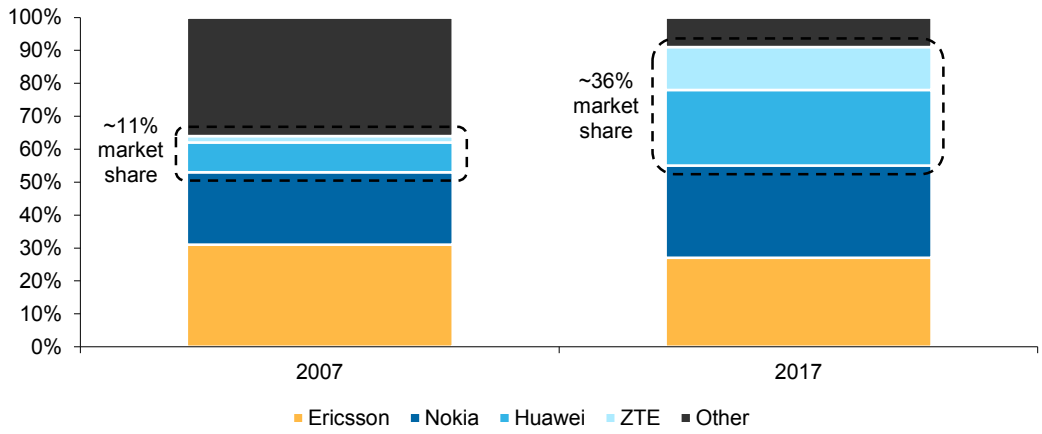
Fig 24 PC OEM Vendor Market Share in 2007 and 2017



Source: IDC, Gartner, Macquarie Capital (USA), October 2018

In the wireless infrastructure market, we saw yet another example of the Chinese leveraging domestic scale to compete globally. In 2007, Chinese OEMs accounted for ~11% of the market but by 2017, they accounted for 39% of the total market.

Fig 25 Wireless Infrastructure Vendor Market Share in 2007 and 2017



Source: IHS Markit, Macquarie Capital (USA), October 2018

Drivers To Push Consumers to Electric

While significant forces are compelling OEMs to increasingly adopt EV technology, a number of key trends are also influencing consumers to more seriously consider purchasing an EV. Currently, we see four key drivers for consumer adoption of EVs:

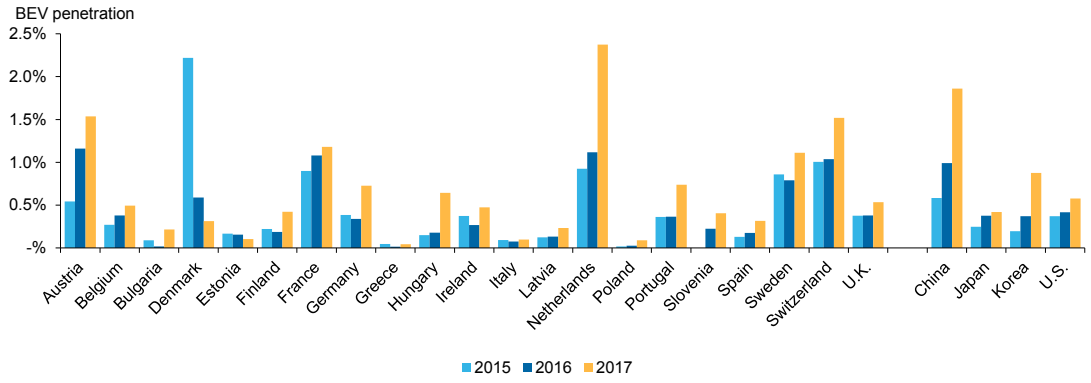
1) subsidies and incentives
2) improving charging infrastructure
3) improving battery range, and
4) lower maintenance costs.

Subsidies and Incentives

Government regulation and subsidies play an important role in the adoption of electric vehicles. We analysed government subsidy rates across a wide range of countries to more closely examine the impact of subsidies on electric vehicle penetration, taking note to consider incentives that come in monetary as well as other less tangible forms, both of which we believe are equally valuable in driving adoption

Of the countries we looked at, Norway was a clear leader in EV adoption with 20.8% EV penetration of new vehicles sold in 2017, up from 15.7% in 2016. The environment in Norway is a bit peculiar in itself, namely due to a variety of factors. The country imposes stiff taxes on vehicle purchases, including a registration tax of nearly $10,000/vehicle and an additional 25% VAT. These charges are both waived for EV purchases, thus helping to equalize the playing field for otherwise more expensive EV models. In addition, the road taxes (nearly $500/year), tollway fees (nearly $2,000/year), ferry crossing charges, and parking fees are all discounted or waived for EV drivers, and access to special and priority lanes in traffic afford additional advantages to owning an EV. For purposes of cross-country comparison, we thus exclude Norway due to the country’s excessively high EV adoption rate versus other nations given the country’s uniquely extensive EV adoption regime.

Fig 26 Electric Vehicle Penetration by Country



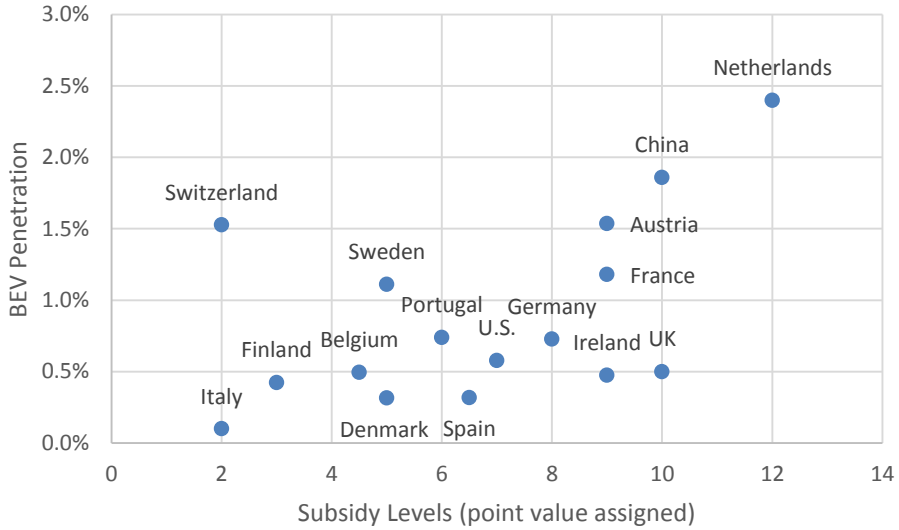
Source: ACEA, LMC, Macquarie Capital (USA), October 2018

Overall, all major countries we examined show increased adoption of EVs over the course of the last 3 years, with the glaring exception of Denmark, where EV subsidies have been cut over the last three years. In order to better analyse the effect of both financial and non-financial incentives offered by each country, we assigned point values based on the following approach:

1) Monetary – which included purchase grants, toll exemptions, and registration, ownership, income, fuel consumption, and value-added taxes. We assigned each grant amount one of five numerical scores—1 (€1- €500), 2.5 (€500- €2500), 4 (€2500- €5000), 5.5 (€5000- €7500), and 7 (€7500+).

2) Intangible – which included parking privileges, free charging, use of special driving lanes, etc. We assigned a numerical value for each intangible benefit provided by the country.

Fig 27 Effect of Subsidies on BEV Penetration



Source: ACEA, LMC, Macquarie Capital (USA), October 2018

The above figure generally shows a positive correlation between subsidies offered versus adoption of BEVs. Within this analysis, the U.S. and China are particularly noteworthy. While both countries offer generous financial subsidies for new BEV buyers, local jurisdictions in major cities within China offer significant non-financial incentives (special drive lanes, parking etc.) that help further promote EV adoption in the country. For those European countries we analysed, the below table further details how their subsidy programs differ.

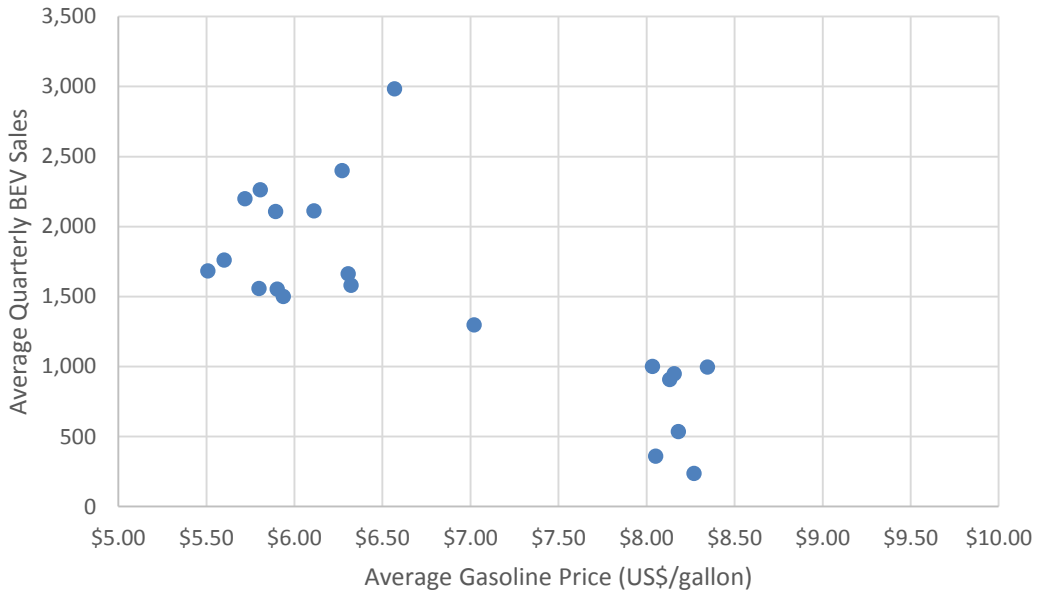
Fig 28 European EV Purchase Subsidies by Country

Countries	Purchase Subsidies	Registration Tax Benefits	Ownership Tax Benefits	Company Tax Benefits	VAT Benefits	Other Financial Benefits	Local Incentives	Infrastructure Incentives
Austria	✔	✔	✔	✔	✔		✔	
Belgium	✔	✔	✔	✔				
Bulgaria								
Croatia		✔						
Cyprus		✔	✔					
Czech Republic		✔	✔					
Denmark	✔	✔		✔			✔	✔
Estonia								
Finland		✔	✔					
France	✔	✔	✔	✔			✔	
Germany	✔		✔	✔		✔	✔	
Greece		✔	✔			✔		
Hungary		✔	✔	✔			✔	
Iceland		✔	✔		✔		✔	✔
Ireland	✔	✔	✔	✔			✔	✔
Italy	✔		✔					✔
Latvia		✔	✔				✔	
Liechtenstein	✔							
Lithuania		✔					✔	
Luxembourg	✔		✔	✔				
Malta	✔	✔	✔	✔			✔	✔
Netherlands		✔	✔	✔				
Norway		✔	✔	✔	✔	✔	✔	✔
Poland								
Portugal	✔	✔	✔	✔			✔	
Romania	✔	✔	✔					✔
Slovakia	✔	✔					✔	
Slovenia	✔	✔	✔					
Spain	✔	✔	✔			✔	✔	✔
Sweden	✔		✔	✔				
Switzerland			✔			✔		
Turkey					✔			
United Kingdom	✔	✔	✔	✔			✔	✔

Source: European Alternative Fuels Observatory, October 2018

One of the significant cost savings for EVs is the per mile cost advantage of electric power versus gasoline. Still, when we analysed European BEV sales versus rising and falling petrol prices over the last 5 years, we found limited correlation between the two variables.

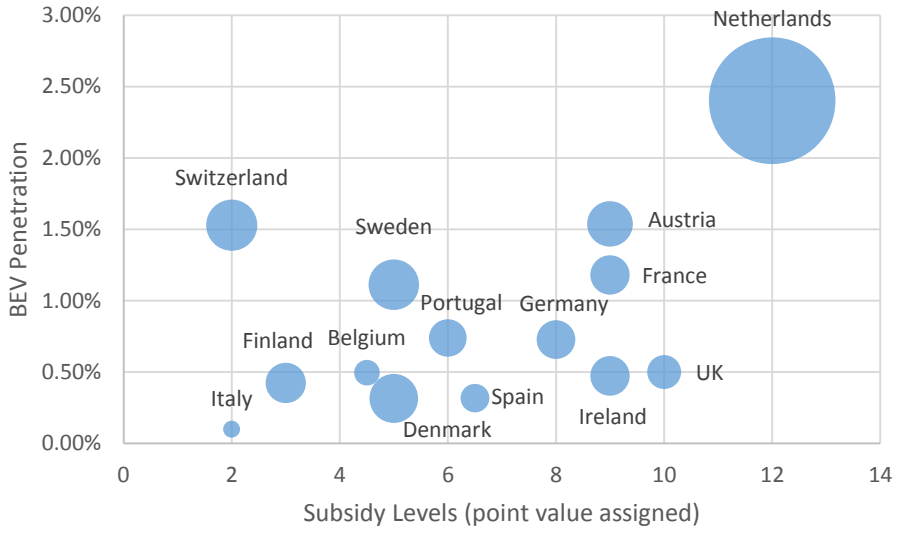
Fig 29 Quarterly Average BEV Sales for Varying Levels of Gasoline Prices (2013 – 2018)



Source: ACEA, Macquarie Capital (USA), October 2018

When analysing BEV penetration for different European countries in particular, it becomes noteworthy that greater EV charging stations per vehicle is often associated with countries with higher EV adoption rates. Thus, we further examine trends in EV charging infrastructure in the following section.

Fig 30 EV Charging Stations per Total Car Parc Versus BEV adoption and EV Subsidies

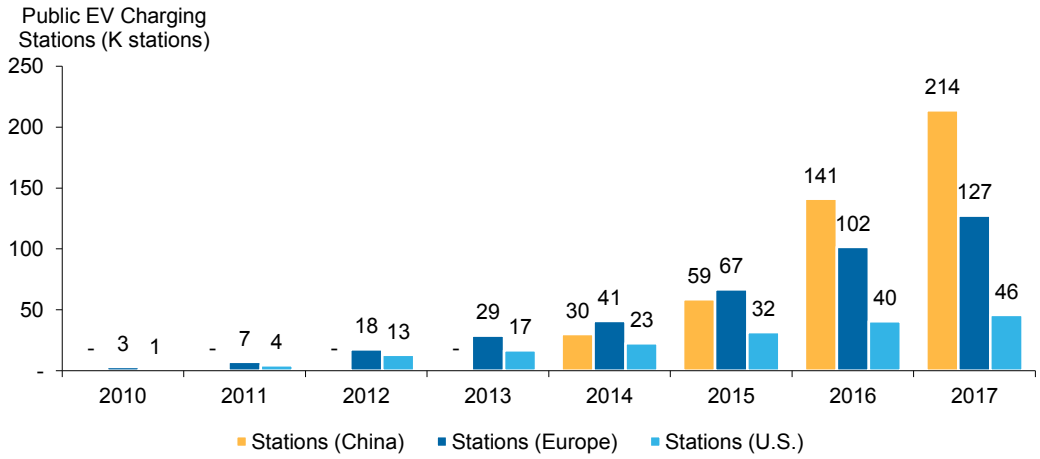


Source: ACEA, Macquarie Capital (USA), October 2018

Improving Charging Infrastructure

Industry reports generally agree that ~75% of EV charging is done at home, though EV charging infrastructure is still an important consideration for many prospective EV customers due to the pointed issue of range anxiety associated with BEVs. The total number of EV charging stations globally has significantly picked up in the last ~5 years, and we believe the rise in EV charging infrastructure has reached an inflection point that will significantly drive EV volumes on a global basis.

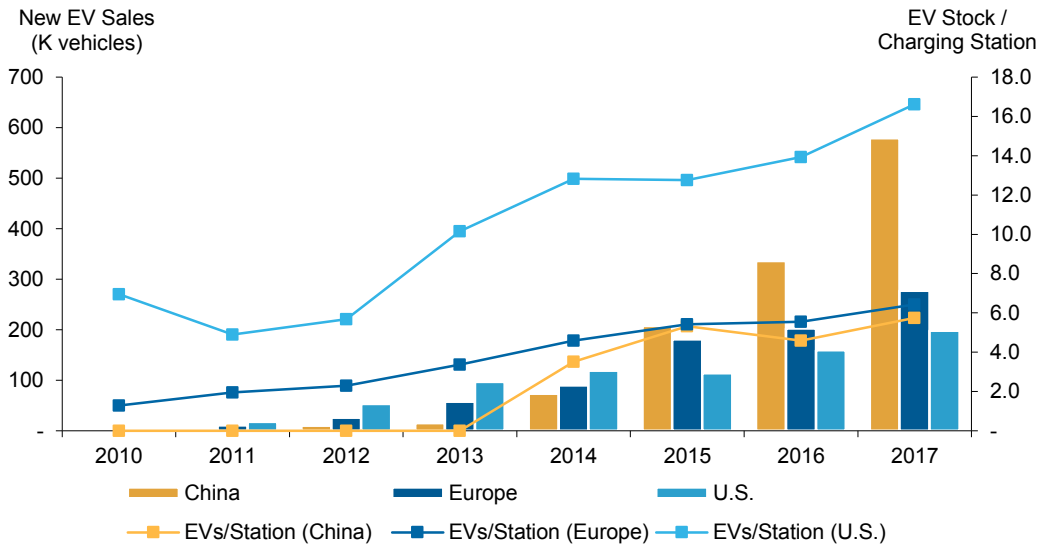
Fig 31 Global Number of EV Charging Stations



Source: OECD/IEA, Macquarie Capital (USA), October 2018

US EV sales led the world in the early part of this decade, though since 2015, the US has been overtaken by China and Europe. The US has always suffered from a high EV stock to charging station ratio relative to other parts of the world, and we believe that this disparity is helping China and Europe establish a higher rate of customer acceptance of EV models.

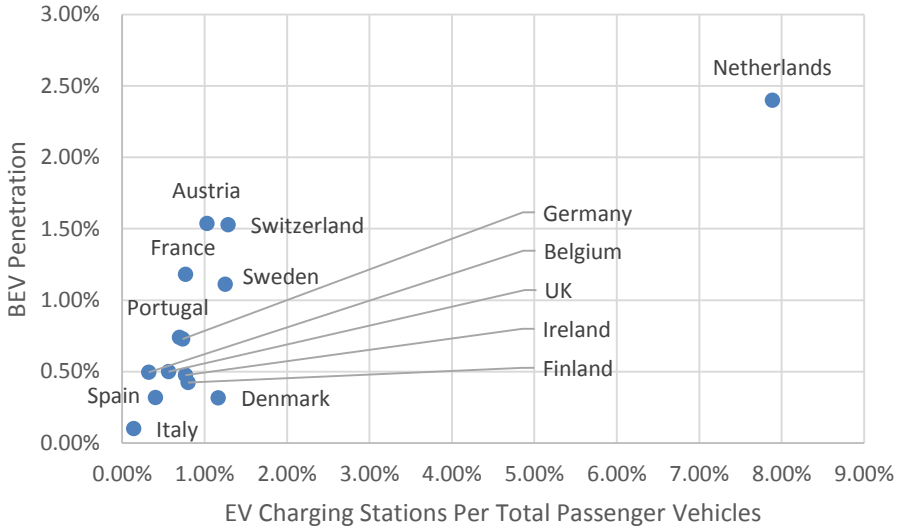
Fig 32 Global New EV Sales Versus Number of Outstanding EV Stock Per Charging Station



Source: OECD/IEA, Macquarie Capital (USA), October 2018

We analysed the direct impact that EV charging availability has on adoption of EVs in different countries across Europe and found a general trend that higher number of EV charging stations generally correlated with higher EV adoption rates. This helps to confirm the notion that retail customers meaningfully value access to public charging stations when considering whether to make the jump from a traditional ICE vehicle versus EV mode of transportation.

Fig 33 BEV Adoption Versus Number of EV Charging Stations per Total Passenger Vehicles



Source: ACEA, EAFO, Macquarie Capital (USA), October 2018

Several initiatives have been employed globally, which could dramatically increase the number of EV charging stations:

1) China: China’s central government has largely been responsible for the build out of the nation’s EV charging infrastructure and has targeted to construct 500,000 public charging stations by 2020. Different organizations are set to physically carry out this build out, with the State Grid Corporation of China (which has already built 56,000 charging stations through the first quarter of this year) planning to contribute 120,000 charging stations by 2020

2) Europe: The European Parliament passed a legislation earlier this year that mandates minimum EV charging infrastructure requirements for newly constructed residential and non-residential buildings as well as any significant building renovation projects. Individual countries have also announced their own plans to support charging infrastructure, with Germany and the UK having previously announced ~$350 million and ~$530 million funds for production and installation of EV charging stations, while France previously announced that it would aim for 7 million charging stations by 2030

3) U.S.: Government support in the U.S. for EV charging infrastructure is currently being spearheaded at the state level, with California is leading the pack with its $738 million investment program running over the next five years, while New York has pledged up to $250 million through 2025. Also, New Jersey utility company PSE&G has proposed a $300 million EV infrastructure program, while utility companies in Maryland have proposed ~$100 million to support this cause. On a national basis, the largest EV infrastructure initiative in place is Electrify America – a $2 billion investment program funded by Volkswagen (as part of its Dieselgate settlement terms) set to run through 2027.

In addition, we believe that other segments of the private sector will also invest to support the buildout of national EV charging infrastructure. In the U.S. in particular, retailers are utilizing a strategy employed by hypermarkets – stores such as Walmart, Costco, et al – that account for roughly 12% of

gas sold in the United States according to the National Association of Convenience Stores. The general concept is to lure consumers to stores to make higher margin purchases as for most gas stations, profit generation is not driven by gas but, rather, by convenience items sold in the store. Companies that have made announcements regarding installation or are currently installing EV charging stations at their stores within the U.S. include:

1) Walgreens currently offers EV charging at ~400 locations across the U.S., making the company the nation’s largest retail host.

2) Kroger was an early adopter of EV charging stations and previously announced a partnership with ECOtality in 2013 to add 225 charging stations at 125 store locations across California and Arizona (total station count to ~300, previously installed 74 stations in Washington, Oregon, and Texas).

3) Walmart recently teamed up with Electrify America to roll out EV charging stations at more than 100 store locations in 34 states by mid-2019. The company is also a big believer in all-electric trucks, having most recently increased its preorder of the Tesla Semis to 45 last month.

4) Target recently partnered with Tesla, ChargePoint and Electrify America to expand its current EV charging program (18 sites in 5 states) to cover more than 100 store locations across 20 states over the next two years.

5) Whole Foods is currently partnered with Blink Charging to further build out its current EV charging network, which currently already spans more than 100 of its store locations

6) Ikea has publicly committed to operate an all-electric fleet by 2030 and is targeting home delivery by electric vehicle in 5 major cities by 2020, although the company only has ~20 store locations with EV charging stations.

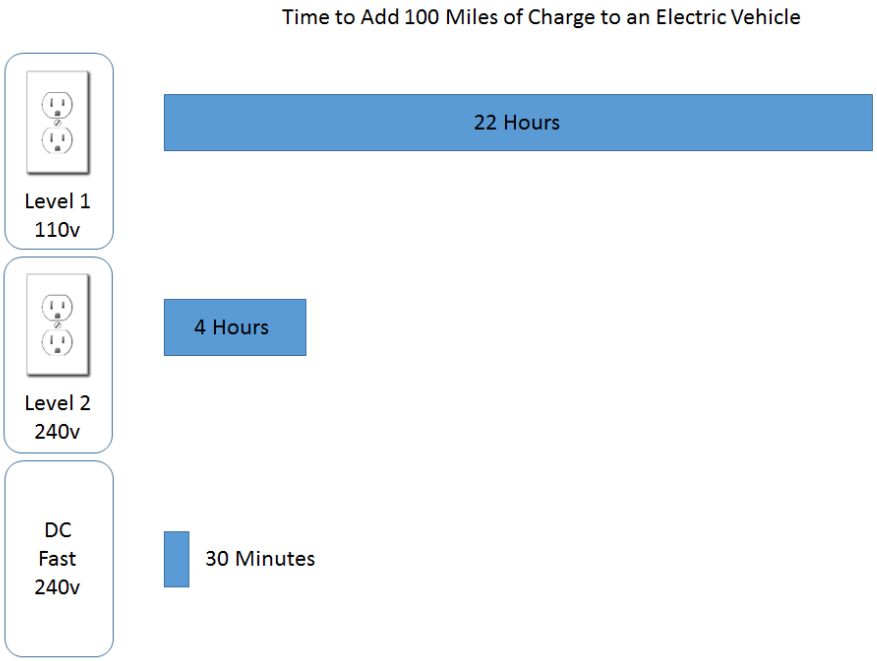
7) Kohl’s began installing EV chargers at its stores nearly a decade ago and currently operates 210 charging stations in 22 states.

8) Macy’s was also early to the game in offering EV charging at its stores and currently offers charging outlets at ~20 store locations, predominantly in California and has been working with Volta to build out a larger network of chargers.

Fully recognize charging time will have to continue to improve

We believe one area of improvement will have to be in the amount of time it takes to charge an electric vehicle. While charging times have improved somewhat, an average of 30 minutes to get 100 miles of charge still pales in comparison to a traditional gas pump. However, improvements in range should mitigate some of these concerns (though will still need to see improvement).

Fig 34 Time to refill 100 miles of charge to an EV



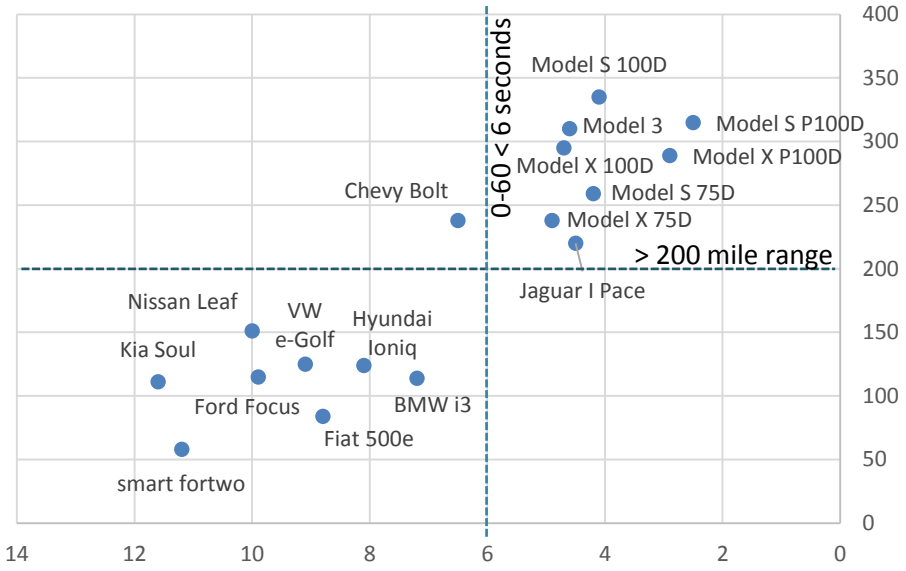
Source: Macquarie Capital (USA), October 2018

Of the DC fast-charge technologies currently available, Tesla’s Superchargers lead the way – logging peak 170 miles / 30 minutes recharge times. While current Supercharger technology is capped at 120kW for a single vehicle, Supercharger V3 is targeted at 200-250 kW (down from original Musk announced 350kW). Other automakers such as Audi and Porsche have advertised fast charging capabilities of 350kW, while GM has been cited to be working on a 400kW technology. Thus, we believe the path towards more consumer-acceptable charging rates meaningfully achievable over the medium term

Range Anxiety Still High But Technology Improving Significantly

Range anxiety is one of the biggest concerns consumers have around buying an electric vehicle. Major OEMs generally look at 200 miles as the minimum acceptable distance per charge for consumers, though based on current models, only three OEMs have models in production that achieve this: Tesla (all models), GM (Chevy Bolt), and Tata Motors (Jaguar I Pace). Designing and executing on a mass market EV that can meet range and acceleration performance levels acceptable to consumers is a difficult challenge, as the below figure illustrates

Fig 35 Battery Range Versus Performance (0-60 MPH in seconds)



Source: Automotive OEM websites, EPA, Macquarie Capital (USA), October 2018

Nearly all OEMs have announced plans for introducing BEV and PHEV models over the next 5 years, with ~100 new entries forecasted. While headline news of models such as the Mercedes EQC and Audi e-tron have promised ambitious performance features for these new models, it is likely that meaningful mishaps and delays are possible as companies progress through the design and manufacturing process for these frontline EV entries. Given the significantly different design characteristics associated with electric versus ICE vehicles, traditional automakers are likely to climb a difficult albeit different learning curve versus Tesla.

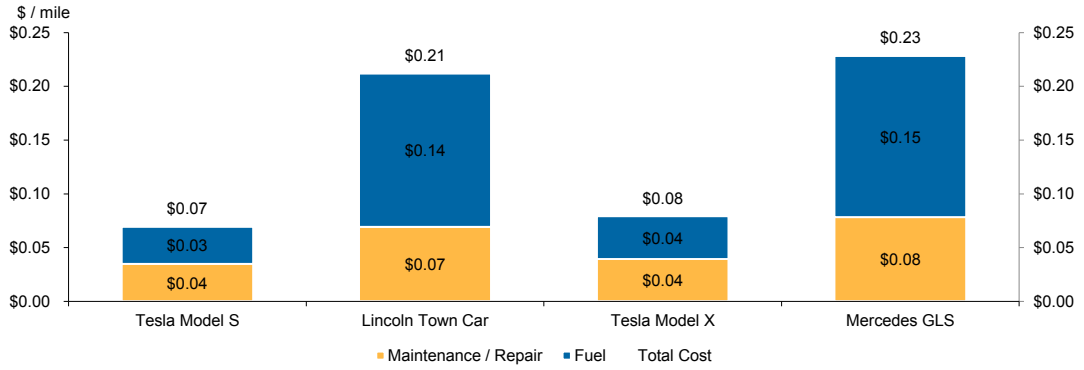
Cheaper to Maintain

We believe maintenance costs are an important element to ownership, particularly for ride sharing and other similar companies, as the costs should be materially lower than that of an internal combustion engine vehicle even when taking into account the lost wages due to higher charging times relative to pumping fuel.

In July 2018, Tesloop, a Tesla-only intercity shuttle for Southern California, announced that its Model S 90D surpassed the 400,000 mile mark. The Model S 90D, dubbed eHawk, was put into service in July 2015, reached 100,000 miles in February 2016, 200,000 miles in August 2016, and 300,000 miles in August 2017. Tesloop estimates that 90% of the miles driven were driven using Autopilot.

Since July 2015, Tesloop indicates it incurred a combined maintenance cost of approximately $19,000 or about $0.05/mile. $6,700 of the amount was for general repairs and $12,200 for regularly scheduled maintenance. By comparison, Tesloop estimates a Lincoln Town Car maintenance cost would be roughly $88,500 or $0.22/mile) and a Mercedes GLS roughly $98,900 ($0.25/mile) over 400,000 miles.

Fig 36 Maintenance Cost per Mile for Tesla EV models versus comparable ICE peer



Source: Tesloop, Macquarie Capital (USA), October 2018

eHawk had its battery replaced twice under warranty at 194,000 and 324,000 miles. The first replacement was due to a battery chemistry issue that the software was not calculating correctly. Tesloop notes that a firmware update was issued and had it been available at that time, a battery change would not have been necessary. At that time, battery degradation was roughly 6%. The second battery change was due to the high voltage battery assembly not working properly upon a diagnostic test. Battery degradation was roughly 22%. eHawk also had its front drive unit replaced at 36,000 miles under warranty.

By comparison, one of Tesloop's Models, the X 90D, hit 300,000 miles in June 2018 with its original battery and drive units. Battery degradation was roughly 10%.

Tesloop's experience is similar to the costs estimated by RethinkX, a leading independent think tank that analyses issues related to tech-driven disruption. While an electric vehicle may not be able to be on the road 24 hours a day due to recharging time, the savings on maintenance should more than outweigh the higher theoretical wages lost due to higher charge times (versus pumping fuel) when taking into account time off the road due to maintenance (oil changes, repairs, etc). This helps reinforce the notion that EVs may be better suited for commercial ride sharing applications.

Utilities: Doing Their Part to Drive Electric Vehicle Sales…

Consumers and businesses that use electric vehicles would have some obvious benefits to electric utilities that would supply the energy to charge these vehicles. In the United States, a number of electric utilities offer incentives to purchase electric vehicles and install Level 2 chargers. While some programs are an extension of governmental programs, some are not.

Fig 37 Rebates offered by various utilities for the use of EVs

Company	State	Rebate	Details
Burlington Electric Department	VT	$1,200	Rebate on purchase or lease of a new electric vehicle $50,000 or less
Alliant Energy	IA	$250	Consumer rebate on purchase of Level 2 home charging station
	IA	$1,500	Community/business rebate for Level 2 charger: $1,500 for dual-prong networked unit, $1,000 for dual-prong unit, $500 for single plug-in wall/pedestal unit
Redding Electric Utility	CA	$1,000	Rebate on purchase or lease of a new electric vehicle
		$500	Account credit for installation costs of Level 2 charger
JEA	FL	$1,000	Taxable rebate on purchase of a new electric vehicle w/ 15kWh battery or higher, $500 for smaller battery
Austin Energy	TX	$4,000	Rebate to install approved Level 2 charging stations or Level 1 outlets
		$10,000	Rebate to install DC Fast Charger
Rocky Mountain Power	CO	$3,500	Rebate for non-residential & multifamily multi-port Level 2 charger
		$42,000	Rebate for non-residential & multifamily multi-port DC fast charger
Georgia Power	GA	$500	Rebate for each new Level 2 workplace charger installed

Source: Macquarie Capital (USA), October 2018

… But Technology Disruption In the Form of Energy Storage Is Needed

According to the American Society of Civil Engineers, most electric transmission and distribution lines were built in the ‘50s and ‘60s with an expectation for a 50-year life span. More than 640,000+ miles of high voltage transmission lines in the lower continental US power grids are running at full capacity. Aging infrastructure will require, in our opinion, greater attention or risk more power interruptions and ultimately, the national economy. We believe there will be a growing disruption in energy production, delivery, and consumption with energy storage at the heart of the enablement.

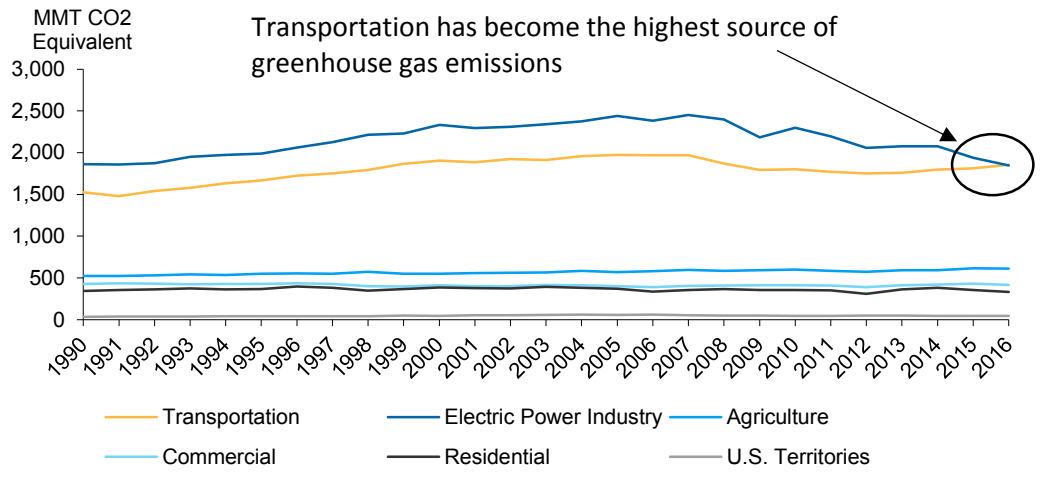
From a technology landscape perspective, we believe energy storage is similar to the structure of and need for content delivery networks. A content delivery network is a geographically distributed network of servers and data centers that store and deliver content to end users. For example, if a popular video went viral and it was stored on one server, the amount of traffic hitting that one server would result in the server going down (a black out). To alleviate these types of issues, content owners distribute their content across numerous servers across a geography in a content delivery network to distribute the demand and reduce the strain on one main server. Essentially, content is stored closer to the edge.

We believe electricity production and delivery will go through a disruption in much the same way. For example, on extremely hot days in the summer, the simultaneous demand for electricity from air conditioners puts a large load on power plants, which may lead to brown- or black-outs (server goes down from too much demand).To alleviate this problem, we believe electricity generation and storage can be distributed – meaning instead of homes drawing power from plants, it can generate its own electricity through sources such as solar and store them in batteries to be used later. Essentially, electricity is stored closer to the edge. While solar has been around for many years, the lack of reliable storage has been a deterrent as electricity usage when the sun is out is typically lower when most are at work or in school.

Every four years, the American Society of Civil Engineers issues the “American Society of Civil Engineers’ Report Card for America’s Infrastructure”. In 2017, it issued a D+ to the US energy system due to the aging infrastructure and resilience issues in severe weather events, which pose a threat to “public safety and the national economy”.

Additionally, electricity generation is the second highest source of greenhouse gas emissions in the US (having just been edged out by transportation), which is driving governments to continue to focus on clean and renewable energy sources, including solar. The State of California Energy Commission recently approved (unanimously) a measure that requires all new homes starting in 2020 to have solar power generation installed. New York State approved 26 large scale renewable energy projects, including 22 solar projects, a hydroelectric project and three wind farms.

Fig 38 Recent Trends in U.S. Greenhouse Gas Emissions and Sinks (MMT CO_2 Eq.)



Source: U.S. EPA, Macquarie Capital (USA), October 2018

Up until the more recent decade, we believe battery technology was not quite ready from both a cost and technology perspective. However, today, the technology has improved and we believe demand is strong. Our checks suggest there is pent up demand for Tesla’s Powerwall and Powerpack, which increasing capacity should start to address.

Countries such as Australia have built a 100MW power reserve using Tesla’s batteries to feed South Australia’s unstable power grid and data presented at Australian Energy Week in May indicate it reduced the cost of power outages by 90%. Energy is generated from wind.

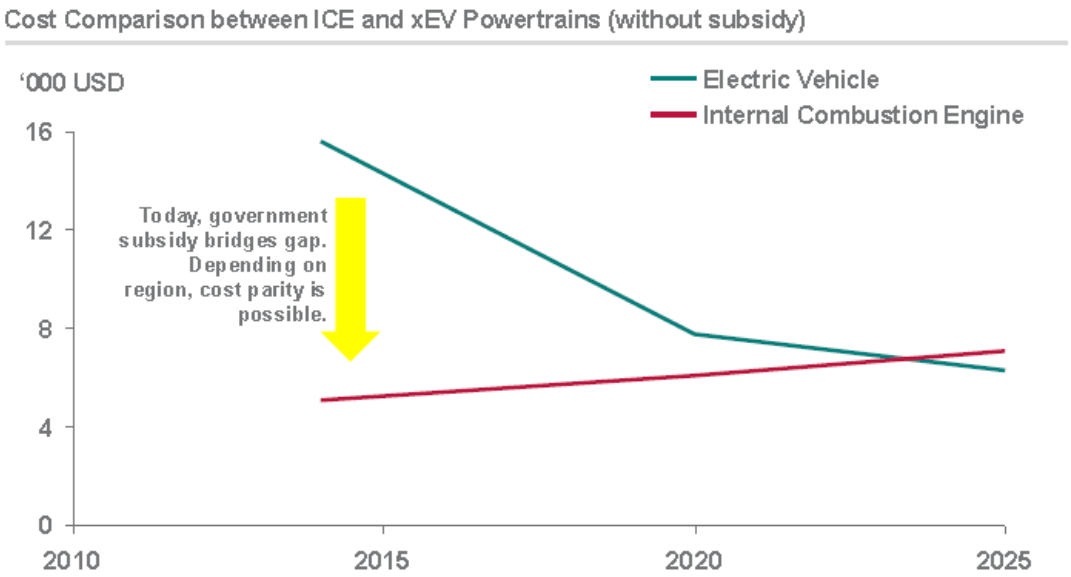
Southern California Edison formed a joint venture with Tesla on a battery storage facility in Mira Loma, CA to support grid operations during peak hours. Energy is generated from the sun as well as the electric grid during off-peak times.

Ultimately About Lowering Costs – Batteries Will Be Key

As we’ve shown, subsidies help to drive electric vehicle sales by lowering the overall cost of the vehicle. However, not all governments are offering these types of subsidies, making the cost less attractive to prospective buyers. We believe battery cost down will play a significant role in helping to drive down the cost of the electric vehicle. Batteries can account for upwards of 40% of the cost of an electrical vehicle and expectations are for battery costs to continue to decline, achieving a value of around 20% of the cost of the vehicle by the middle of the next decade.

Conventional ICE powertrains’ material costs generally run in the mid-to-high single thousands, while BEV equivalents generally run in the mid-to-high teens of thousands. The major difference here lies in cost of a battery pack (e.g. an 80kWh battery pack at $200/kWh costs around $16K). As technological improvements accumulate over the next 5-10 years, a nearly $10K improvement in material cost is possible into the mid 2020’s.

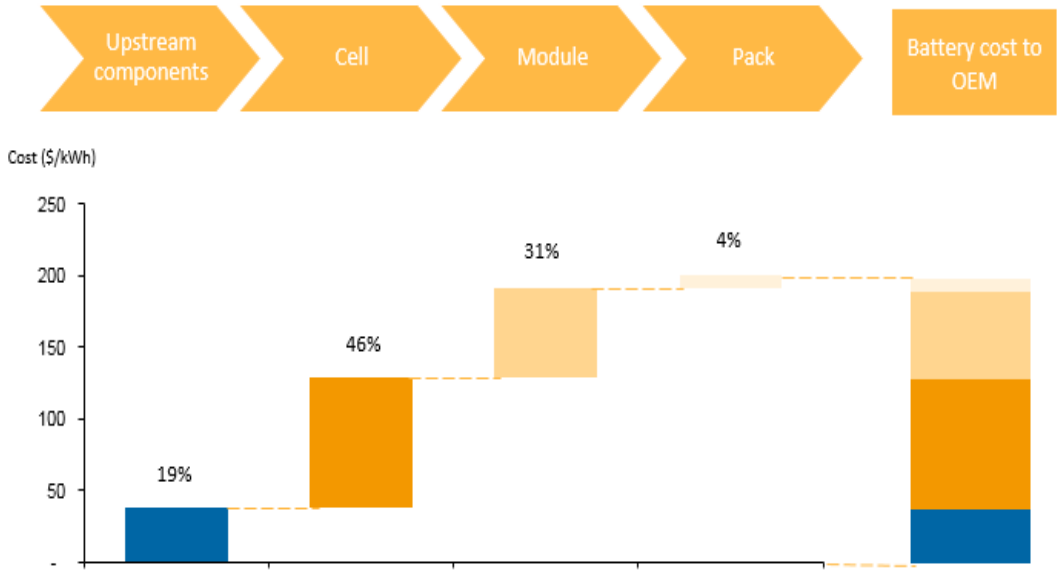
Fig 39 Powertrain Material Cost Comparison between Electric and ICE based Vehicles



Source: Vale, Macquarie Capital (USA), June 2018

Battery costs can generally be broken down into upstream components, cell and module/pack costs. We estimate that commodity input costs represent ~20% of the total cost of battery pack, the battery cell makes up ~50%, and the remainder is attributable to how cells are packed into module groupings that are encased in the overall outer battery pack.

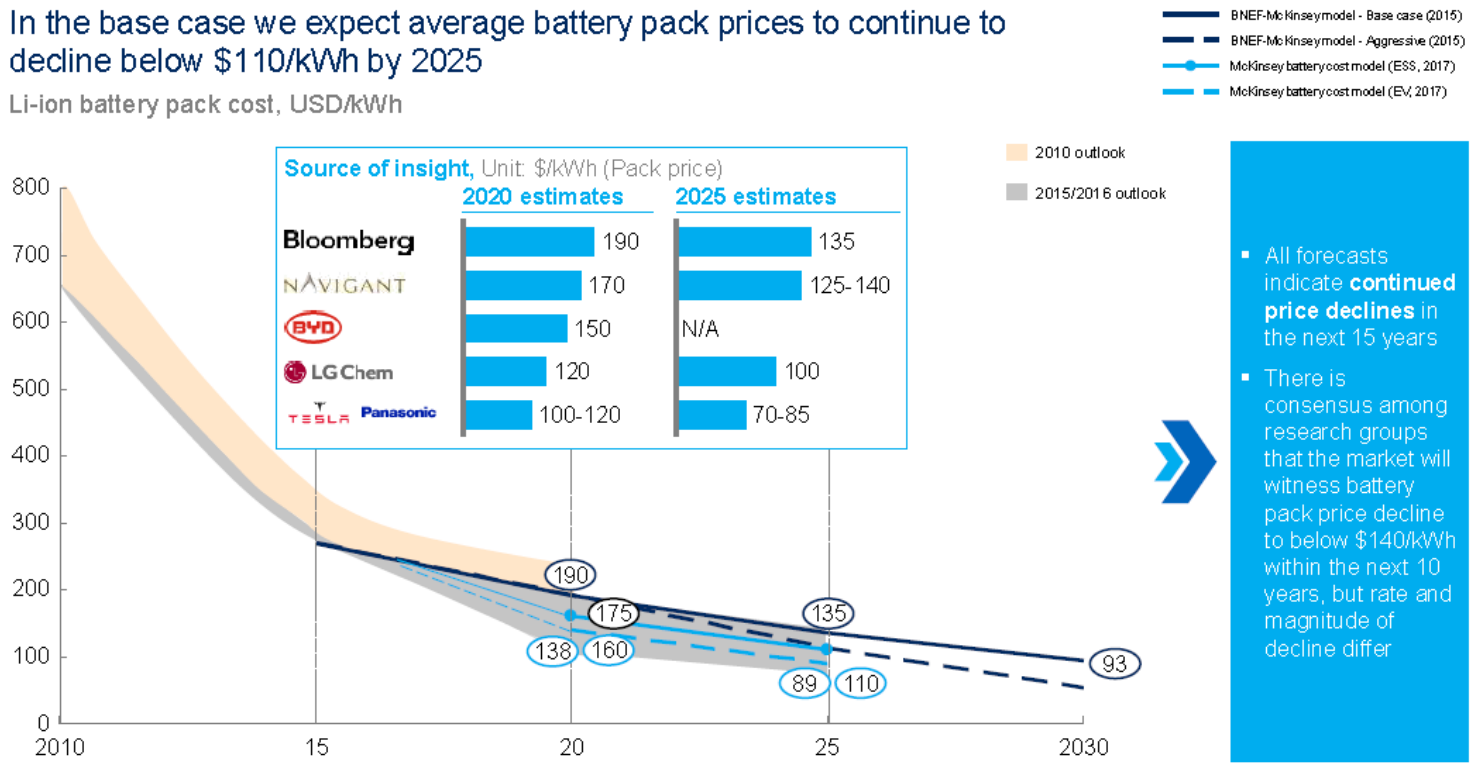
Fig 40 Battery Cost Breakdown by Input Costs



Source: Macquarie Capital (USA), June 2018

This cost structure subsequently supports the non-linear shape of the decline in battery costs over time, as really only ~80% of the total cost of a battery pack is available for technology driven cost improvements.

Fig 41 Battery Pack Costs are Expected to Continue to Decline with Improving Battery Cell and Manufacturing Technologies



Source: McKinsey, Macquarie Capital (USA), October 2018

Battery packs do hold a meaningful 20% input commodity cost exposure, though, this is heavily dependent on the chemistry adopted by different manufacturers. The majority of lithium battery makers have adopted the NMC (nickel-manganese-cobalt) chemistry, though TSLA and Panasonic utilize an NCA (nickel-cobalt-aluminium) design. A summary of the function of each individual metal is provided below:

1) Lithium: active agent that drives power storage and discharge. Global supply of lithium is moving towards a period of significant oversupply with LCE supply increasing 35% and 52% in 2018 and 2019, as new projects are opening in Australia, Chile, Argentina, and Canada. Global demand for lithium is now ~40% from batteries and set to continue to grow at a ~30% CAGR, though supply growth is set to outstrip demand growth over the medium term

2) Cobalt: used within the cathode end of a battery cell. Cobalt prices peaked in April (off now ~25%) and are likely set for further declines as we forecast supply to grow 12% in 2018 and nearly 30% in 2019 from new and restarting projects come online (versus our forecasted demand growth of 8-9%). EV battery manufacturers are currently moving towards lower cobalt and higher nickel content cells, though EV volume growth is set to meaningfully drive global cobalt demand, growing from ~10% currently to ~40% by 2022.

3) Manganese: used within the cathode end of a battery cell. Manganese prices have been trending upwards since the end of 2015, though the metal has sold off from its highs earlier in 2018 Q1 as we forecast global production this year to increase 10% versus low single digit growth in consumption. Multiple different geographies supply the manganese commodity market, and we forecast future supply growth to accommodate overall rising demand

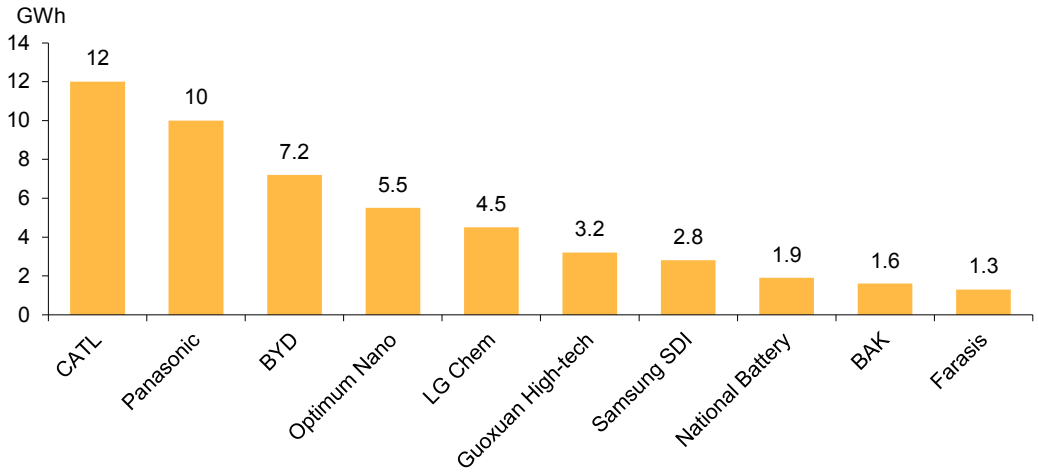
4) Nickel: used within the cathode end of a battery cell – results in higher energy density at the cost of less stability versus cobalt. Nickel is currently in a structural supply deficit and has risen more than 50% versus the start of 2017. The metal is primarily used in stainless steel applications, though nickel use in batteries is growing at a 30-40% YoY rate currently (~4% of nickel is currently used for batteries currently) as battery manufacturers increase capacity and battery cells are increasingly using higher nickel content to boost energy density

5) Aluminium: used within the cathode end of a battery cell in concert with nickel to improve stability though incrementally lowers power density. Overall, global aluminium prices are expected to continue to hold over the medium term as China's capacity reform sets in, while global demand remains stable. EV volumes will help drive demand growth for aluminium via its battery pack and lighter weight body frames over the longer term, though we believe the market is not supplied constrained and will not experience volatile price spikes

With each new iteration of NMC technology, nickel content is progressively increasing in order to increase energy density (i.e. increase EV drive range), while cobalt and manganese are correspondingly decreasing. TSLA and Panasonic have embarked on a similar trend with their NCA chemistry, as Tesla's latest Model 3's cathode composition is 80% nickel, 15% cobalt, and 5% aluminium.

While the EV battery supply chain is still in its early stages, given the large upcoming EV production ramp, a significant number of suppliers has already cropped up. The majority of these players is largely Chinese with the notable exception of Panasonic, LG, Samsung and Farasis, which is based in the Silicon Valley.

Fig 42 Major EV Battery Suppliers by Total Shipments in 2017



Source: GGI (高工锂电), Macquarie Capital (USA), June 2018

Autonomous the Key Enabler to New Business Models

We believe autonomous will usher in a new era for the automotive industry in much the same way smartphones and smartphone platforms ushered in new functionality and business models.

In many ways, the autonomous vehicle will become a living room on wheels, allowing the rider to consume content and increase productivity without the distraction of having to drive. But what will be the right strategy? Should OEMs become content aggregators and sell a service? On the contrary, we believe OEMs should veer from this strategy, as it strays from their respective core competencies and introduces unnecessary operational risks.

For example, an OEM that decides to enter the ridesharing business will have to understand complex transportation regulations in each region around the world, build back-end infrastructure, spend large amounts of money on marketing, manage a workforce of drivers, and numerous other issues around managing a business. This also doesn't take into consideration the tough competition against leaders in the market that already have the operational experience and scale today.

Similarly, we do not believe auto makers should try to deliver content by becoming content aggregators for a number of reasons. For starters, until the installed base of autonomous cars increases dramatically, the cost of purchasing content is likely to be prohibitive across a small number of subscribers. There may also be resistance to purchase yet another subscription on top of services such as Netflix. Additionally, auto OEMs do not have the expertise or experience in delivering content, exposing them to operational risk and further complexities (how will local sports events be blacked out in a vehicle that can move state to state?).

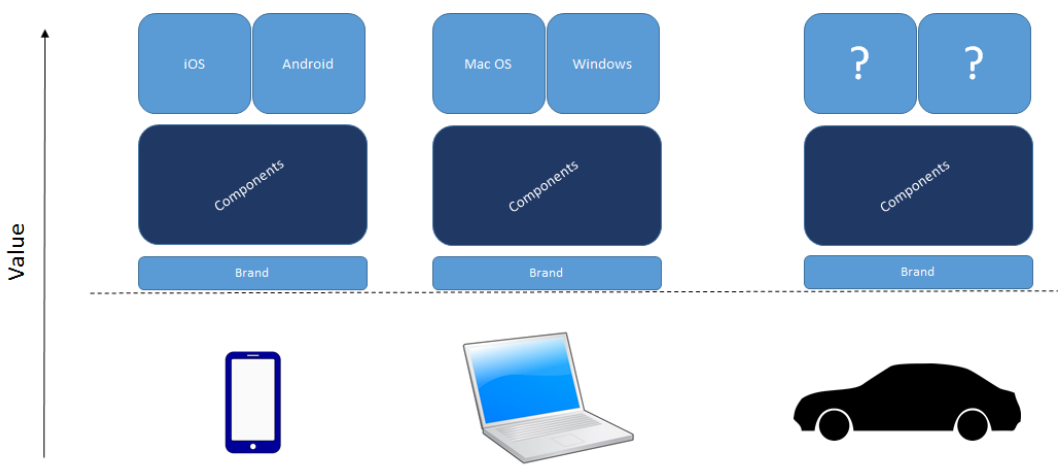
Auto Makers Should Pivot to Becoming a Platform Supplier In Autonomous

OEMs should focus on platforms and platform licensing revenue much like Apple & Google

We believe OEMs should focus on delivering platforms to enable the above mentioned businesses in much the same way smartphones enable other companies to deliver services on top of their platforms – a business model that revolves around platform license fees and revenue sharing. We believe Apple would never have been able to provide all the services its ecosystem provides today as adeptly as other companies that created them in its ecosystem. Nor do we believe that Apple would be able to adequately provide enough attention to each of the thousands of business models to provide the best service.

The big question, in our opinion, is whether auto OEMs can create their own ecosystems built on top of their own software or if the auto OEMs will have to bow down to the dominance of Apple and Google. Certainly Apple and Google would like to infiltrate the auto industry as it has the smartphone market though OEMs have to tread carefully in order not to repeat smartphone history.

Fig 43 The Digital Ecosystem – Autos To Enter in a Bigger Way



Source: Macquarie Capital (USA), October 2018

We believe a key platform difference from the likes of Apple or Google's platforms is the potential to create a commercial platform that will turn the vehicle into any number of applications – a ridesharing vehicle, a delivery vehicle, etc. We envision this, alongside a consumer-facing platform like Apple and Google, is the most logical path – one platform focused on commercial capabilities of the car and one focused on in-vehicle content delivery for passengers.

Companies can turn vehicles into a ridesharing or delivery vehicle by turning on that application

The commercial platform would enable companies to turn the vehicle into an application. For example, autonomous vehicles today are, by and large, regular vehicles that are retrofitted with sensors, cameras, computer systems, etc. If a ridesharing company wanted a fleet of autonomous vehicles, it would have to retrofit every vehicle and install a computer system that runs its ridesharing application and allows the vehicle to become a part of the ridesharing fleet.

A commercial platform would allow ridesharing companies, as one example, to write a ridesharing application directly onto the platform through application program interfaces (APIs) that interface directly with the vehicle, its wireless connectivity, and leverages the in-vehicle compute. The application would essentially program the vehicle to become a ridesharing vehicle, allowing it to understand where it needs to go, who to pick up, etc.

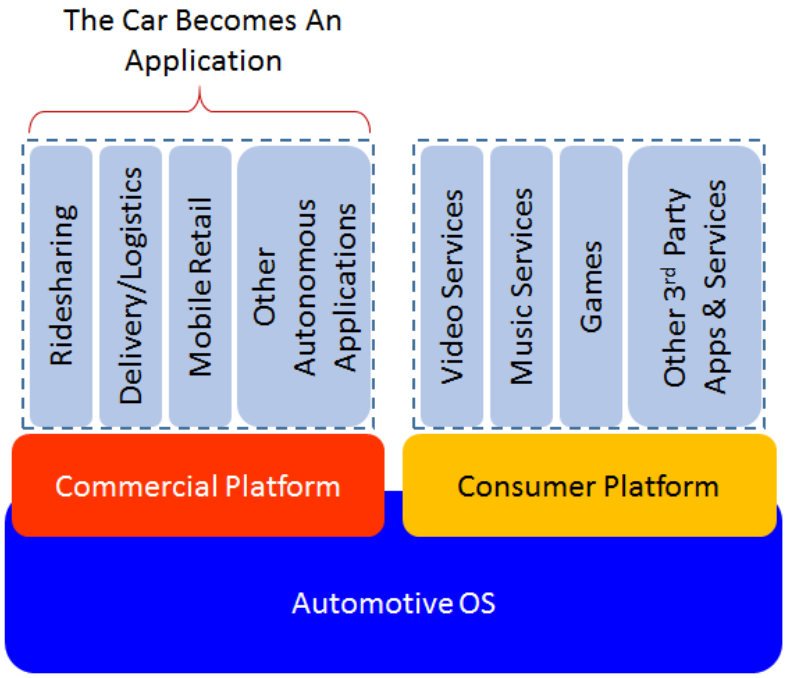
Similarly, a grocery store could write an application to program the vehicle to become a delivery vehicle or a garage company could write an application to return the car to the garage. The application would be able to communicate to the company's infrastructure through the vehicle's wireless connectivity.

Vehicle owners would also be able to turn their cars into ridesharing or delivery vehicles when not in use

Vehicle owners could also conceivably enable these various commercial applications and put their own vehicles into a ridesharing or delivery fleet when they're not using them to potentially make a little extra cash. This could help reduce capex for companies running these services as they wouldn't have to maintain every car in their fleet. Allowing the vehicle to become a Swiss Army Knife of applications may also drive greater adoption as smartphone adoption ramped when it became capable of doing more than just make phone calls and text messages.

We believe OEMs could charge a platform licensing fee or revenue share agreement for use of the platform.

Fig 44 Potential Applications for Autonomous Vehicle Operating System Platforms



Source: Macquarie Capital (USA), October 2018

What is more exciting is how these platforms will enable businesses we haven't even thought of yet. Every disruptive platform in recent history has brought with it new applications that, before the disruptive platform, were probably unfathomable and that disrupted major established industries. **We believe the automotive ecosystem platform will enable and disrupt** in much the same way.

Fig 45 Disruptive Technologies and Their Impacts

Disruptive Platform	New Application	Industry Disrupted
Internet	E-Commerce	Brick & Mortar
Smartphone Ecosystem	Ridesharing	Taxis
Cloud	As-A-Service	Applications & Servers
Automotive Ecosystem	???	???

Source: Macquarie Capital (USA), October 2018

The consumer platform would be similar to the platform ecosystems of Apple and Google where companies build applications and services to be served up in-vehicle on large screens. The business model would similarly be based on platform license fees. Utilizing this model would leave content and services in the hands of individual companies that have domain expertise in those industries and allowing OEMs to focus on their core competencies.

A survey by Ipsos/GenPop surveyed 130,000 car owners across nine countries to see what passengers would do in a vehicle if it were autonomous. Paying attention to the road was the chart topper, suggesting people may not fully trust autonomous technology at its start. Communicating with others came in second followed by sleep or watch content/play games. Online shopping also made the list, suggesting a wide variety of in-vehicle application opportunities.

There is one catch, however – OEMs must become software companies, something that has not traditionally been their strong point, aside, in our opinion, from Tesla.

When Will Autonomous Be Here? Technologists vs Pragmatists

The answer to this question depends on whom you ask. We've spoken to both sides and the answers are different. A technology company working on autonomous will tell you that it's sooner than you think. A US government official will tell you that it's farther away than you think.

One of the key debates is whether autonomous vehicles need to be able to communicate with road infrastructure. Most technology companies we spoke with are staunch believers that autonomous does not require the ability to communicate with infrastructure. However, a couple of government officials we spoke with believe it is critical and there are pilots underway to study this.

What the differing answers suggest is that the broad deployment of autonomous vehicles is not something likely to be counted on one hand, or even two. Governments will weigh in on how to regulate autonomous with most believing a federally mandated regulation as being more logical to create uniformity.

Ultimately, we believe autonomous will start in controlled areas where there are lower potential corner case issues that the car may not have seen and would not be able to handle. Farms are one example where autonomous is already happening. Campus vehicles or campus transportation is another example of a controlled area where we would expect to see autonomous vehicles.

Who Will Win? Other Disrupted Industries Give Hints

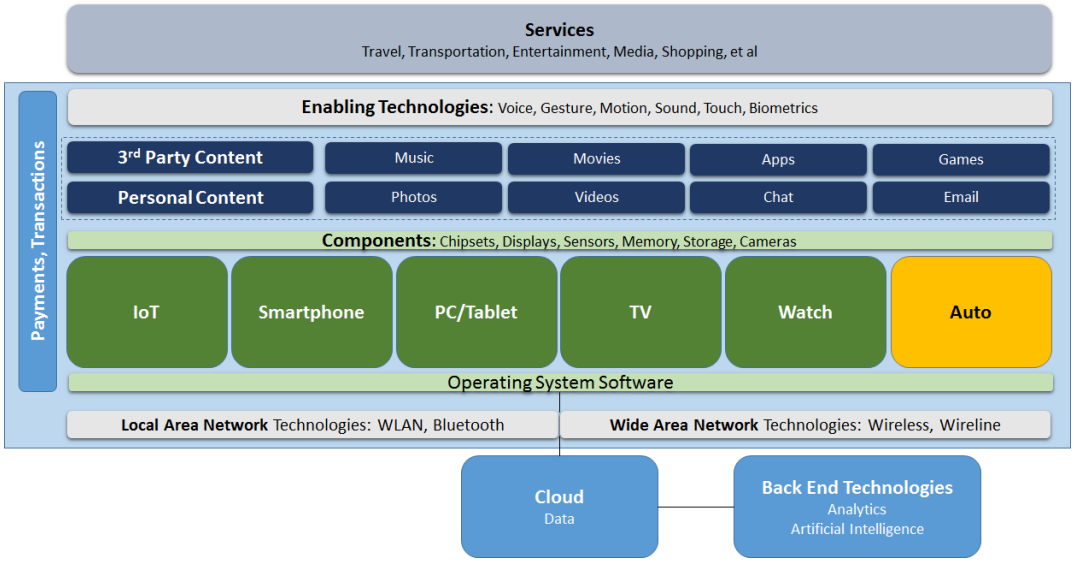
The automotive industry, in our opinion, has largely remained inside its own walled garden, closed off from the rest of the ecosystem. But we believe this is about to change. Figure 54 shows our view of how the automotive industry will fit into the ecosystem landscape. We believe the road to get there will require transformative change – complete architectural changes in electronics, centralized compute, greater expertise in the software domain, electrification of vehicles, building of platforms and increasing car connectivity.

We have seen transformative change across many of the domains listed in Figure 56. The nature of the disruptive technology had ripple effects that impacted legacy watch makers, cell phone OEMs and PC OEMs, and we believe the transformations in these industries can provide a decent guide as to the potential outcomes of the automotive industry. In particular, we examine the impacts in the smartphone and enterprise server markets for the potential pitfalls, strategies and outcomes for the auto market.

We see the potential for new entrants to take significant share, which we expect will drive consolidation in the market and force radical changes to existing businesses.

While we do not expect this to occur overnight, we believe we are seeing the sign posts signalling that the industry is headed in a similar direction. We believe incumbent OEMs should look to history and observe the opportunities and pitfalls in industries that have undergone transformational change. We believe the biggest challenge facing incumbent OEMs are: 1) the transition from traditional products, which generate the majority of the revenue, to newer products; 2) managing the shift in R&D; and, 3) integrating technology, like neural net – can they or are they doing it?

Fig 46 The Digital Ecosystem – Autos To Enter in a Bigger Way



Source: Macquarie Capital (USA), October 2018

Technology: What the Technology Sector Can Tell Us About the Road Ahead

The technology industry is one of rapid change with innovation forcing companies to move at breakneck pace. Disruptive technology has changed the landscape materially for a number of technology sectors, resulting in market share shifts, organic and inorganic consolidation, forced business transformations, and new business models. Given our view that the automotive market will experience similar types of disruption, we believe it is worth examining what happened in these industries to determine the strategy and direction the automotive industry should take or the pitfalls they should look to avoid.

We fully recognize that the auto industry has high barriers to entry that make it different from the smartphone industry and make it challenging for new entrants – manufacturing scale (in particular), the

required capital to achieve that scale, brand recognition, and distribution channel relationships, among others. Scale and production system innovations are what gave, and continue to give, companies like Ford, GM and Toyota their core production advantage.

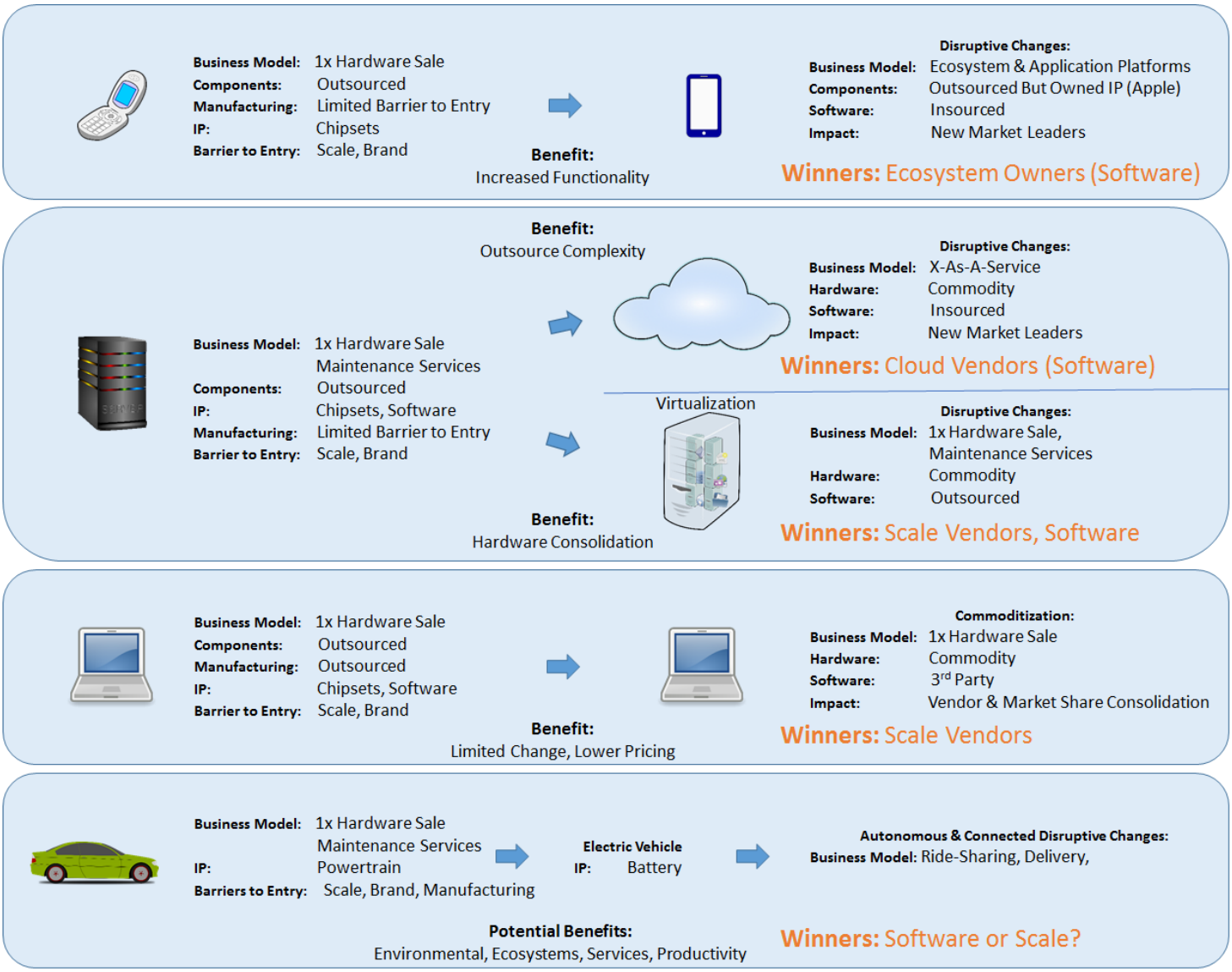
However, we believe the tides are shifting and, while the barriers to entry around manufacturing will continue to exist, we believe the mainstay of that advantage, which has primarily been around engineering excellence, will be more difficult to sustain as more of the value shifts in the electric vehicle supply chain away from the internal combustion engine, powertrain, and transmission, which are the key areas auto OEMs have focused.

The quick conclusion – software is the key, or scale in a commodity market. The winners in industries disrupted by technology tended to be those who created software IP – Apple, VMWare and SaaS vendors.

Interestingly, in the industries we examined, none of the incumbent vendors came out on the other end as the winners or those with the most valuable IP in the value chain. We believe this is, quite simply, because these were hardware companies at the core of their DNA and, in our opinion, were not able to culturally shift their strategy to one of software.

If OEMs miss the opportunity to create ecosystems or platforms via software, we expect the automotive market will commoditize. In this scenario, we see eventual consolidation with the winners being those with the greatest scale – a la Hewlett Packard in the PC and server industries.

Fig 47 The Impact of Disruptive Technology In Other Industries & The Key Winners



Source: Macquarie Capital (USA), October 2018

The Smartphone Path

We believe there are many similarities between what the auto industry is experiencing and what the mobile phone industry experienced in the early 2000’s (again, recognizing the higher barriers to entry in the automotive market) when the industry transitioned from one of brand and design to one beginning to be dominated by software and ecosystems enabled largely by improvements in technology.

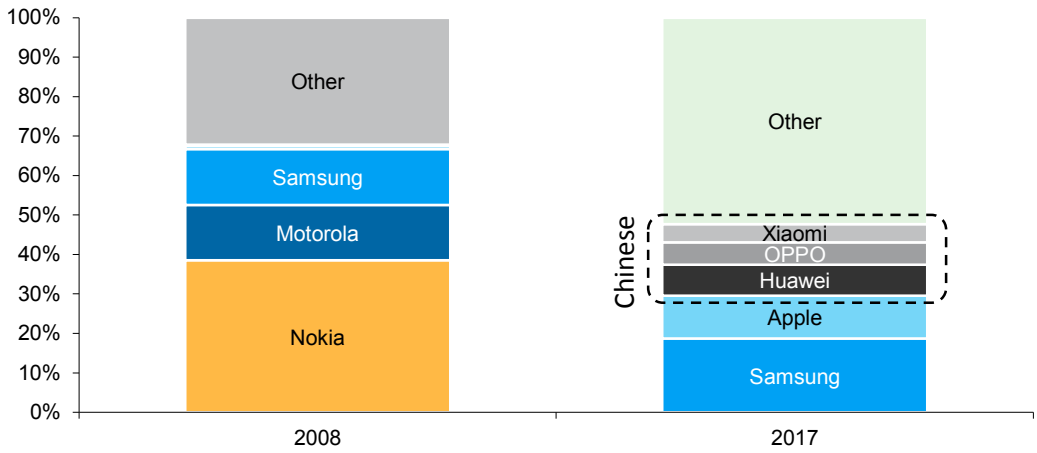
While automotive OEMs generate revenue from maintenance services and financing, we believe the Holy Grail is to generate revenue from ecosystem services that are more recurring in nature – similar to the way Apple pivoted from iPhone sales and maintenance to App Store revenue and now trying to pivot more toward subscription services.

Fig 48 The Digital Ecosystem – Autos To Enter in a Bigger Way

Source: Macquarie Capital (USA), October 2018

The automotive market, in our opinion, is reminiscent of the handset industry in 2007, prior to the real explosion of smartphones and when handsets were one-time hardware sales. During this time the handset market was dominated by Nokia, Motorola and Samsung, which, combined, accounted for more than 65% of the market. However, ten years later, Nokia and Motorola no longer make handsets as standalone entities and Apple and Samsung lead the market in share with more than 35% combined. More interestingly, in ten years, Chinese vendors have gone from less than 1% share to more than 25%.

Fig 49 Handset/Smartphone Market Share in 2007 & 2017



Source: IDC, Bloomberg, Company Reports, Macquarie Capital (USA), October 2018

Handsets were fashion and brand items; brand loyalty can change. Before the era of smartphones, handsets allowed phone calls, text messaging and some small varying degrees of applications. Decisions to purchase handsets were made largely on the back of brand or design. Nokia’s dominance was primarily driven by the strength of its brand and its user interface, which consumers became accustomed to, particularly in Europe. Worth noting as well is that Nokia’s model of manufacturing allowed the company to scale and be more efficient in manufacturing versus its competitors (not unlike the automotive OEMs).

While we do not discount the power of brand, we also note that this can change drastically, as the handset market has shown. In fact, in 2008, Nokia was the tenth most valuable brand in the world according to Brand Finance. By 2018, Nokia’s brand value dropped off and was no longer even in the top 100 (Nokia ranked 188) while Apple rocketed to being the second most valuable brand in the world.

Hence, while brand matters, we believe product matters even more and those that are in industries being disrupted by technology must shift quickly in order to maintain their dominance.

Fig 50 Most Valuable Brands, 2008 versus 2018

	2008	2018
1	Walmart	Amazon
2	Coca-Cola	Apple
3	Microsoft	Google
4	IBM	Samsung
5	Google	Facebook
6	GE	AT&T
7	HSBC	Microsoft
8	Hewlett-Packard	Verizon
9	Vodafone	Walmart
10	Nokia	ICBC
11	Bank of America	China Construction Bank
12	Marlboro	Alibaba
13	Pepsi	China Mobile
14	Gilette	Wells Fargo
15	Citi	Mercedes-Benz
16	McDonald's	Toyota
17	Intel	BMW
18	AT&T	Bank of China
19	Verizon	New State Grid
20	Toyota	NTT Group
21	Apple	Tencent
22	L'Oreal	T (Deutsche Telekom)
23	Santander	Shell
24	Budweiser	Chase
25	Dell	Huawei

Source: Brand Finance, Macquarie Capital (USA), October 2018

Motorola’s resurgence, on the other hand, was driven largely by its iconic design with the launch of the Motorola StarTAC and later with the Motorola RAZR – the first to market with an ultra-thin clamshell design. TV advertisements focused on two aspects of the phone – thin and clamshell – while trying to portray an air of coolness and lifestyle. Its advertisements didn’t focus much on the functionality. Motorola banked its success on being an iconic fashion item and, in fact, investors at that time, likened Motorola to more of a luxury goods company that might warrant a higher multiple. However, that quickly changed when the phone suddenly became more about the software and the multitude of application functionality rather than the hardware exclusively.

We believe it is noteworthy that automotive OEMs also focus their advertisements on design and lifestyle, which helps to build the brand. However, we believe OEMs must embrace the disruption that’s coming and make an early run at transforming their companies to embrace the changes that are coming due to technology. OEMs that continue to rely on brand over product transformation run the risk of facing similar fates to cellphone vendors. We believe it’s still early enough to make these transformations though the big hurdle these companies will face is not only product, but culture.

What Strategies Did Handset Manufacturers Employ? And What Went Wrong?

Hardware companies have customer and supplier relationships, not internal collaborative relationships that are needed to drive ecosystems

With the handset industry being turned on its head, a fire had been lit under handset manufacturers to compete against new entrants. The challenge that most handset vendors faced was that their core business of hardware revolved around customer and supplier relationships. But the technological disruption was now being driven by software. This was not only the integration of software into hardware but also building relationships and applications around the ecosystem. Apple was advantaged in this regard because of its relationships with content producers (music and movies), which it had already had on its iPods, as well as its own applications it created (email & calendar app, for example). Thus, Apple was well on its way to building its ecosystem long before it even ever released its first iPhone.

Samsung. The most successful company, in our opinion, to make this shift was Samsung Electronics. We believe Samsung's benefit was in its vertical integration – the company manufactured many of the major components in a smartphone and became a large supplier to Apple. In fact, Samsung entered the smartphone market because it was looking for someone to use its Super AMOLED display, which it ultimately did in its own Samsung Galaxy brand phone.

The vertical integration allowed Samsung to be nimble and react quickly. For example, Samsung was able to come out with multiple Galaxy models with different display sizes to see which sold best – an expensive proposition but one Samsung could do because it manufactured the displays (as well as the memory, processors, and other components). However, the one area where it was not vertically integrated was in the operating systems, where it used Google's Android software. Nonetheless, vertical integration, in our opinion became a key advantage.

Nokia. Nokia's strength was largely as a tiered platform company playing in the low-end, mid-range and high-end markets. Nokia had strong brand recognition, scale, and manufacturing prowess, which allowed it to maintain its leadership for years.

With more than 40% market share at its peak, Nokia was the dominant handset vendor in the market. In 2007, more than half its profits were coming from mobile phones (and NOT of the smartphone variety). While a benefit to cash flow, this was also an anchor for Nokia as it was difficult to admit that the core market for half its business would be obliterated – at least in the relatively short time horizon that it happened. We believe Nokia overestimated the staying power of its brand and its market position.

However, Nokia had, in fact, seen the writing on the wall when it shifted its operating system strategy to Symbian – an operating system that was originally created for use in personal digital assistants (PDA). Here, also, it tiered its strategy to low-end (Series 40 – though this wasn't a Symbian operating system) and higher-end (Series 60, 80, 90). And Nokia was also not new to touchscreens, having launched the 7710 in 2004 (to no avail due to the strange shape and lack of keyboard). With a smartphone OS and touchscreen experience, it appeared as though Nokia, with its powerful brand, could find some way to survive.

However, the major issue, in our opinion, was that Nokia, at its core, was a hardware company. Though it may have appeared to have the software strategy correct with Symbian, it, in fact, had to tweak the Symbian operating system for virtually every handset, resulting, by some accounts, in 57 different and incompatible versions by 2009, which often led to delays. Software also had to be tweaked for different telecom operators. These issues limited the scale benefit of having a single operating system. We believe this lack of software expertise and the hardware culture that was ingrained in Nokia made it challenging for the company to pivot to the new realities of the market.

Motorola. Motorola's success with the RAZR may have been its ultimate downfall as we believe the company relied on the laurels of the RAZR for too long and was late to the smartphone game. That, coupled with the late adoption of the then-new 3G technology, resulted in significant share loss. In 2008, Motorola brought in Sanjay Jha, who was, at that time, the head of Qualcomm's chipset division, to be co-CEO. Mr. Jha switched the company's software strategy exclusively to Android. In 2008, the company released a couple of Android-based smartphones – most importantly the Droid, which was launched with Verizon (Verizon's first Android smartphone). While the Droid found some success, it still trailed behind Apple and Samsung and struggled to find footing outside of Verizon.

In 2011, Motorola Mobility was acquired by Google. While many viewed the acquisition to be for the patents, the acquisition also allowed for tighter integration of hardware and software. In 2014, the business was sold to Lenovo.

Joint Ventures: Sony & Ericsson, Alcatel & TCL. To be fair, these joint ventures were not caused by the advent of the smartphone but rather, were formed to face the heightened competition in the handset market. Nonetheless, we believe these are interesting to look at in the context of the partnerships and joint ventures between some of the auto makers.

Ericsson, the number three player in the handset market, was struggling with large losses and, in 2001, announced a merger with Sony, which was a marginal player at that time. Sony later bought out Ericsson’s portion of the JV.

Alcatel and TCL partnered up in 2004 though TCL bought out Alcatel’s share roughly a year later. The rationale at the time was that the partnership would create a platform to grow TCL’s international business and the two companies would be able to realize significant synergies while leveraging its respective distribution and IP.

In both examples, the view was that the companies were stronger together amid heightened competition in the market. However, these JVs faced challenges in terms of commitment from the varying parties, which ultimately led to the buyout by one party. We believe JVs are also challenged by being less nimble in the ability to make quick decisions or to come to an agreement on strategy when there are differing ideas.

What went wrong?

While it’s easy to blame the demise of Nokia and Motorola (and others) on Apple, Google and Samsung, an equal part of the blame goes to the companies themselves in the lack of execution in turning the ship. Companies that were once small, nimble companies turned into mature, successful companies that rested more on their laurels, erring on the side of conservatism rather than taking risk in new innovation. Part of this was also due to cultural reasons where embracing change was not accepted (in this case, where the hardware people were in charge of the software people when it should have been the other way around) and differing opinions on strategies slowed the companies.

Companies that have been able to survive technology disruptions in other industries have been able to do so by being nimble and reinventing themselves over and over (ironically Nokia originally started as pulp mill, then expanded in electricity generation, was known for its rubber business, and also made respirators at one point in time). Ultimately, the inability to transform from a hardware-centric company to an integrated software company, in our opinion, led to the downfall of the legacy leaders. Simply having the hardware and the software wasn’t enough.

We believe automotive OEMs will also have to embrace transformative change and do what may be uncomfortable and that which might stray from the path of comfort. Auto OEMs, like most of the handset vendors, tend to outsource most of the vehicle while keeping the IP in-house (engine). However, with value shifting away from the internal combustion engine in electric vehicles, companies will have to change their strategies.

Server/Storage Industry – Managed On-Premise Shifts to As-A-Service Off-Premise

The server and storage industries also went through tremendous transformative change driven by the advent of cloud, which was encroaching on parts of the server business. Cloud disrupted the traditional technology architecture by offering a low-cost, off-premise solution to storing data and running applications. Cloud computing also enabled As-A-Service business models, allowing companies to shift CapEx spend to OpEx spend, driving new subscription business models.

In this market, incumbents acquired competitors, rationalized businesses to the size of the market, divested non-core businesses, and split into smaller companies to be more nimble and allow for greater risk taking.

While it took time for the cloud impact to be felt, after a number of years, cloud started having a real business impact. Companies had to scramble to adjust their strategies to the disruptive technology. The challenge was managing existing product portfolios and R&D while investing in newer cloud technologies – it was difficult to do both without impacting profits. This led to portfolio rationalization and asset divestitures, not too dissimilar to, for example, Ford’s decision to stop making sedans in the North American market, freeing up dollars to invest in other more critical areas.

Ultimately, HPQ separated into two companies, Dell acquired EMC, NTAP went through a period of margin pressure as it reinvested. While the areas it invested in were seeing tremendous growth (flash, converged infrastructure), the overall market was not growing as sales of new products came at the expense of legacy. New incumbents also came in and started taking share, which put further pressure on incumbents. This forced incumbents to acquire in fast growing segments like all flash. Again, not to dissimilar to the acquisition strategies of the auto OEMs. However, this didn't always work, sometimes due to cultural issues that clashed between the two companies, resulting in many of the talented engineers leaving.

PC Industry – Consolidation to Drive Scale

The PC market model is generally a one-time product sale that is generally outsourced for manufacturing with limited differentiation. The highest barrier to entry tends to be brand, scale, and distribution, which is similar to the automotive market. Where the two markets differ, however, is that the automotive OEMs generally tend to have their own powertrain intellectual property and have their own manufacturing.

In 2007, 11 vendors accounted for more than 65% market share. By 2017, the top four accounted for nearly the same amount of share – a result driven primarily by market consolidation. With the biggest intellectual property coming from the chip makers such as Intel and software makers such as Microsoft, the PC OEMs were left to battle partially on pricing to drive market share. However, these price battles for market share rarely resulted in sustained market share.

Over time, PC OEMs consolidated to drive greater scale, resulting in greater volume buying power and channel strength. Smaller PC OEMs with limited differentiation continued to see contracting share while those with more specialized niche products were the few able to garner some profits.

If the automotive market trends more like the PC market, the key winners are likely to be those with scale (in a truly commoditized market, those within niche markets, those with technology intellectual property in electric (batteries, etc), or those focused on software/ecosystems. In the commodity scenario, we expect to see significant consolidation to drive scale in order to leverage manufacturing and distribution. Conversely, we believe those that succeed in creating their own software can differentiate themselves whether through ecosystem platform or in autonomous technology.

Ten Trends to Play in Electric & Autonomous

We believe the road to electric and autonomous will be a multi-year, if not multi-decade, journey, and that there will be a number of key themes and stocks that we believe are investable around these trends. These themes include:

- OEMs leading in electric / autonomous
- Rising vehicle content driven by electrification, including:
  - ⇒ Passive component content increase
  - ⇒ PCB content increase
  - ⇒ Connector content increase
- Batteries and battery materials
- Centralized compute
- Autonomous Driving
- Lightweighting
- Power semiconductors
- Charging
- Thermal management
- Connected Car

1) OEMs leading in electric / autonomous

Fig 51 Investment Opportunities within Automotive OEMs

OEM	Tesla	TSLA (US)	Maynard Um	Outperform	Target Price: 430.00	10/4/18 Close: 281.83
	Toyota	7203 (JP)	Janet Lewis	Outperform	Target Price: 8,650	10/4/18 Close: 7,005
	BYD	1211 (HK)	Allen Yuan	Underperform	Target Price: 25.80	10/4/18 Close: 51.95
	NIO	NIO (US)				10/4/18 Close: 6.25

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Government regulation, AV technology and Chinese competition are all driving automakers towards increased investment in electric powertrain technologies. The future economic potential of establishing a software ecosystem centered around the vehicle is massive. Automotive OEMs with leading electrification technology and advanced software development capabilities will hold a competitive advantage going forward in competing in the retail passenger vehicle market.

Tesla – TSLA (US), Maynard Um – Outperform. We view Tesla as a disruptive technology growth company with differentiated products and strong brand presence in the secularly growing and equally disruptive markets of electric vehicles, energy storage, and energy generation. Our rating is predicated on the following five reasons: 1) accelerating vehicle unit growth driven by industry acceleration for electric vehicles over the next two decades, 2) unique potential among OEMs to lead in in-vehicle ecosystem platforms, 3) technology differentiation, 4) continued traction in the energy storage market, and 5) optionality to be a leader in autonomous driving given its tremendous and growing installed base.

Toyota Motor – 7203 (JP), Janet Lewis – Outperform. As the most profitable automaker in the world, Toyota has extensive resources to invest in new technologies. CEO Akio Toyoda has established a sense of crisis in the company, highlighting that current changes in automotive technology poses the biggest challenge in a century. Toyota is the industry pioneer in electrification, having launched the Prius, the first hybrid car, more than two decades ago. It has sold more than 12m hybrid vehicles since then. It has been reluctant to launch BEV products as it considers the current technology inferior. It is working with Panasonic to mass produce solid state batteries, which it believes will greatly improve the performance of BEV batteries, with an expected launch in the middle of the 2020s. It will launch electric versions of the C-HR and Izoa compact SUVs in China by 2020 to meet local requirements but it would prefer to hold off on launching other BEVs until it believes the technology meets its quality requirements. It has also set up a JV including Mazda and Denso, and more recently Suzuki and Subaru have joined to collaborate on EV technology development. Similarly it is working with group company Denso to develop ADAS technology. We expect Toyota to leverage its group relationships with companies like Denso to increase the diffusion of its internally developed technology and increase its royalty income. It is working with this group of companies on Connected Car technology. First and foremost the focus is on making cars as safe as possible. It is the first automaker to make its ADAS features – Toyota Safety Sense – standard on all cars it sells. It is also working with telecom companies like Verizon to deliver content and infotainment to its cars. Overall we are confident that Toyota will be a leader in the next generation of automotive technologies.

BYD – 1211 (HK), Allen Yuan – Underperform. While we have factored in the positives from BYD’s improved model cycle, we believe it is hard for BYD to benefit from this in light of the negatives from subsidy cuts for NEVs, rising power battery materials costs and heightened competition. The lack of a well-diversified client base for its power battery business, further subsidy cut in 2019/2020, elevated financing cost and slower-than-expected expansion of the SkyRail business also weigh on the profitability outlook of the company. Longer-term we doubt BYD has the scale or quality of product to prosper in passenger vehicles. The existing oversupply in the power battery industry and the fact that competition is intensifying as more brands launch NEV models should put pressure on its valuation multiple.

2) Rising Vehicle Content Driven by Electrification Content Increase as Bill of Materials Changes

The vastly different powertrains on electric vehicles versus internal combustion engine vehicles requires a different level of expertise and value-add. We believe the changing bill of materials (BOM) provides both opportunity and risk for various OEMs and suppliers.

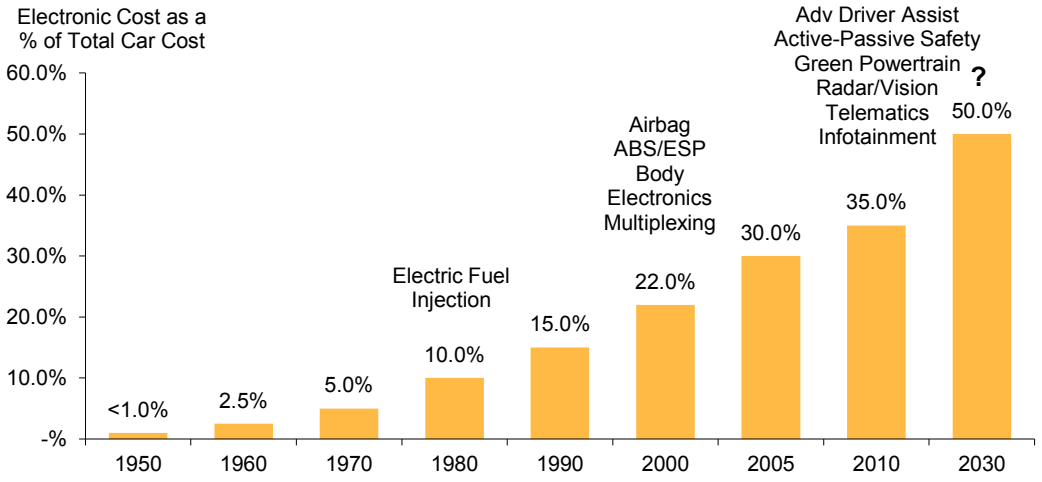
Fig 52 Bill of Materials Change with ICE to EV Transition

Components to be replaced / significantly modified	Components to largely remain the same
Powertrain	
o Engine motor / battery pack / engine cooling / transmission: adoption of electric versus internal combustion motor o Steering / drive shaft / differentials / axles / suspension / braking: built to accommodate single speed transmission, regenerative braking, etc. o Fuel system: EV charging versus gasoline/diesel fuel refill and motor oil systems o Exhaust system: no emissions system required for EVs	o Wheels / tires
Electronics	
o ECU ecosystem: largely to become consolidated under a single CPU (engine, infotainment, etc.) o Software OS: largely to become consolidated / implementation of hypervisor layer o Electronic hardware: content per vehicle to increase significantly to support greater data processing capability / functionality	o Minor auxiliary peripheral ECUs: may be retained on a select basis
Exteriors	
o Structural frame: significant light weighting and wind tunnel testing to maximize drive range	o Lights o Side mirrors o Body glass / panels
Interiors	
o HVAC: electric compressor / heat pumps	o Seats o Restraints and fasteners o Body / structural

Source: Macquarie Capital (USA), October 2018

We expect suppliers more geared toward newer components related to electric vehicles to see stronger secular growth versus more traditional OEMs and suppliers that will need to make up for declines in their incumbent internal combustion engine and diesel components businesses. Within the above figure, we view automotive parts categories that are largely remaining the same as commodity goods. For those component categories that will be significantly disrupted, electronic hardware content per vehicle will increase significantly for the powertrain and electronics segments as demand for smarter and better connected vehicles grow. We believe this will open the door to more non-traditional vendors and offers an opportunity for more traditional technology companies.

Fig 53 Automotive Electronic Content Growth



Source: Freescale Semiconductor / IC Insights IC Market Drivers 2013

Multi-Layer Ceramic Capacitors (MLCC)

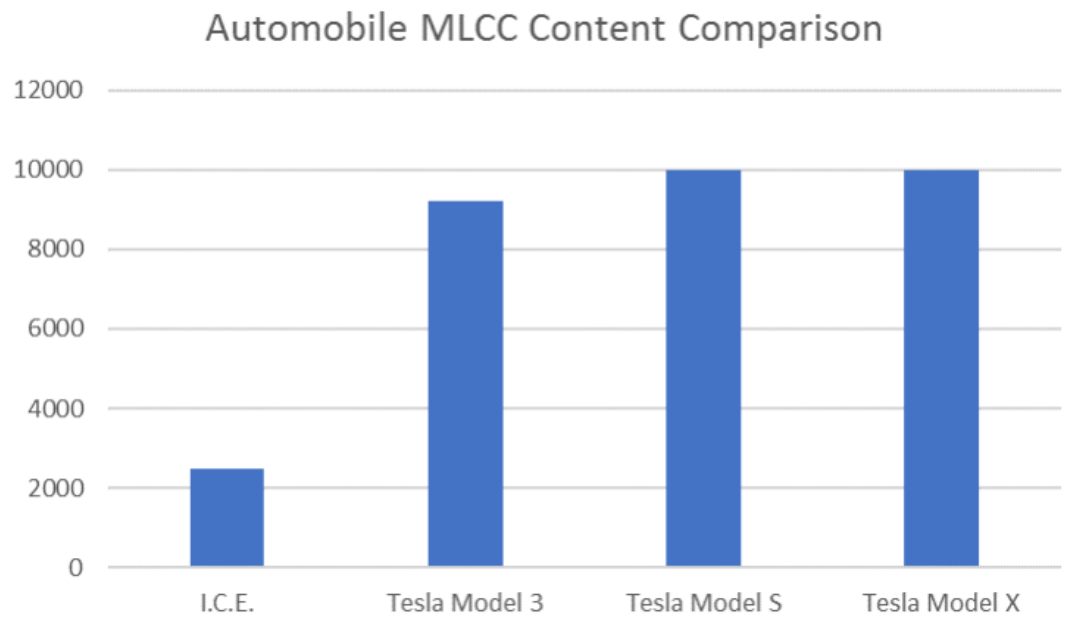
Fig 54 Investment Opportunities within Automotive Electronics Hardware

Passive Component Content Increase	KEMET	KEM (US)	Maynard Um	Outperform	Target Price: 25.00	10/4/18 Close: 18.70
	Murata	6981 (JP)	Damian Thong	Outperform	Target Price: 21,750	10/4/18 Close: 17,805
	Samsung Electro Mechanics	009150 (KS)	Daniel Kim	Outperform	Target Price: 235,000	10/4/18 Close: 138,500
	Taiyo Yuden	6976 (JP)	Damian Thong	Outperform	Target Price: 3,800	10/4/18 Close: 2,608
	TDK Corporation	6762 (JP)	Damian Thong	Outperform	Target Price: 14,400	10/4/18 Close: 11,890
	Samwha Capacitor	001820 (KS)				10/4/18 Close: 70,400
	Vishay	VSH (US)				10/4/18 Close: 19.55
	Yageo	2327 (TW)				10/4/18 Close: 446.00

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Electronics hardware can generally be categorized as active and passive – capacitors are considered passive electronic components. Demand for capacitors designed for automotive applications will grow as EV adoption progresses, as the average ICE vehicle will stock ~3,000 MLCCs per vehicle, while EVs require ~10,000 MLCCs per vehicle, with Tesla models averaging ~10,000 per vehicle

Fig 55 MLCC Piece Count In Vehicles



Source: Kemet company presentation, Macquarie Capital (USA), October 2018

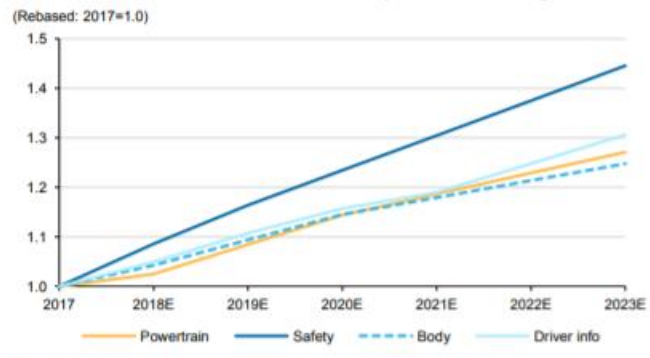
Electrification of all aspects of a vehicle will drive increased electronic hardware content per vehicle. The below figure lays out how past and current mechanical functions have turned electronic and how such a trend has given rise to MLCC demand from the automotive sector.

Fig 56 EV adoption to drive MLCC demand

Car becomes increasingly electronic

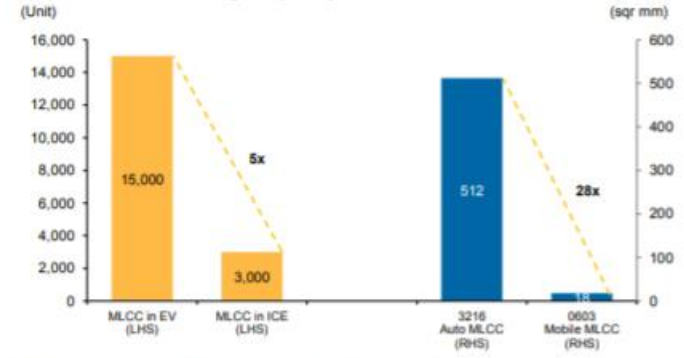
	Mechanical		Electronic
Handle	Manual steering	→	EPS (Electric Power Steering)
Brake / Hand brake	Oil brake / Manual hand brake	→	Regenerative brake / EPB (Electronic Parking Brake) & Auto hold
Lamp	Bulb lamp	→	LED lamp
Airbag	Airbag activated by physical impact	→	Smart Airbag
Window	Roll up/down	→	Power window
Display	Speedometer	→	LCD panel + Head up display
Key	Ignition key	→	Start/stop button
ADAS	n/a	→	LDWS (Lane Departure Warning System), LKAS (Lane Keep Assist System), FCWS (Forward Collision Warning System), SCC (Smart Cruise Control), Automatic Parking
Infortainment	Radio	→	Digital satellight radio, Navigator, Bluetooth, Telematics, Voice recognition, Blackbox,
Safety	n/a	→	ESP (Electronic Stability Program), Auto Cruise
Seat adjustment	Manual		Electronic, Memory-foam

Contents of Semiconductor and MLCC per car are rising



Source: Murata, Company data, Macquarie Research, June 2018

Auto MLCC to drain huge capacity



Source: Company data, Macquarie Research, June 2018

Source: Murata, Company Data, Macquarie Capital (USA), June 2018

Given the forecast increase in EV penetration as well as MLCC content per vehicle, we view the following companies as strong investment opportunities to play the long demand ramp of MLCCs from the automotive sector

KEMET – KEM (US), Maynard Um – Outperform. Our Outperform rating is predicated on the following five reasons: 1) industry supply/demand imbalance that we believe is unlikely to reach equilibrium until mid-2019 at the earliest, 2) potential revenue and earnings upside as Consensus appears to not be modelling either capacity growth or pricing increases, 3) favourable end-market dynamics driven by a number of megatrends to help mitigate historical cyclicality, 4) potential upside from debt refinancing, and 5) undemanding valuation.

Murata – 6981 (JP), Damian Thong – Outperform. Murata is the world's leading producer of multi-layer ceramic capacitors, with a ~40% share, and is the market share leader in MLCCs for automotive applications. The company is benefitting from increasing electronics content in cars, with MLCCs and other components playing a key role in signal quality and EMI suppression. Murata is also a leading supplier of communications modules, and is targeting growth in products for V2X. Car electronics accounted for 17% of revenues in 1Q FY3/19, up from 16% a year previously.

Samsung Electro Mechanics – 009150 (KS), Daniel Kim – Outperform. MLCC generates 43% of its revenues, but over 90% of its profits. Samsung Electro Mechanics (SEMCO) commands over 20% market share in MLCC, next to Murata (over 35%) in Japan. However, its presence in auto MLCC segment has been limited so far. SEMCO managed to get qualified on its MLCC by all the tier 1 auto part vendors in 2017 and its auto MLCC plant is ramping up from 3Q18. The company targets auto MLCC to become 10% of its MLCC revenues in 2019 and over 25% in 2020. MLCC contents are rapidly rising in conventional ICE (internal combustion engine) cars, while entry barriers to auto MLCC are very high. Moreover, EV (electric vehicle) requires 3-5 times MLCC than ICE cars. In this regard, SEMCO's strategy to focus on auto MLCC is more than sensible.

Taiyo Yuden – 6976 (JP), Damian Thong - Outperform. Taiyo Yuden is a major supplier of MLCCs. While automotive applications remains a small part of their mix (just 6% of revenues in FY3/17), this is the area where the company is targeting strong increase as a long-term driver of revenues and margin expansion. The company is aiming for an automotive revenue ratio of 15%, comprising devices such as large case size, high voltage and high reliability parts.

TDK Corporation – 6762 (JP), Damian Thong - Outperform. TDK is leading supplier of passive components, lithium ion batteries, ferrites and magnetic components. The company is the second largest supplier of MLCCs for automotive applications after Murata, and also a major supplier of inductors. With the acquisition of InvenSense, the company is now targeting sensors as a long-term growth driver.

Printer Circuit Boards (PCB)

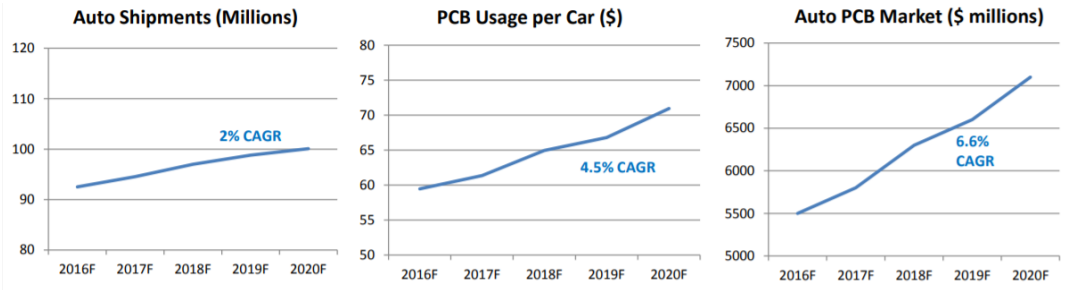
Fig 57 Investment Opportunities within Automotive Electronics Hardware

PCB Content Increase	TTM Technologies	TTMI (US)	Maynard Um	Outperform	Target Price: 20.00	10/4/18 Close: 15.31
	Chin-Poon Industrial	2355 (TW)				10/4/18 Close: 37.00
	CMK Corp	6958 (JP)				10/4/18 Close: 0,846
	Meiko Electronics	3787 (JP)				10/4/18 Close: 1,258

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

We see the auto PCB sector as one of the key beneficiaries from a number of key auto trends including electrification, autonomous, connected car, and vehicle safety. Applications such as LiDAR, radar, cameras, artificial intelligence, wireless communications, high resolution touch displays, inverters/converters, battery management, and charge modules will need some form of auto PCB. In addition to end market growth, PCB usage per car should continue to grow, providing a two-pronged growth opportunity.

Fig 58 Growth in the Automotive and Automotive PCB Markets



Source: NTI Digest, TTM Investor Day, December 2016

Given the projected rise in demand for PCB products from the automotive sector, we view the following stock as strong candidates for gaining exposure into this segment

TTM Technologies – TTMI (US), Maynard Um – Outperform. We are initiating coverage of TTMI, a leading global printed circuit board (PCB) manufacturer, with an Outperform rating predicated on 5 key reasons: 1) large end market growth potential driven by a number of megatrends, 2) the potential for revenue acceleration driven by increasing electronics and RF content, 3) scope for more material margin expansion, 4) potential deleveraging benefits to out-year earnings, and 5) undemanding valuation.

Connectors

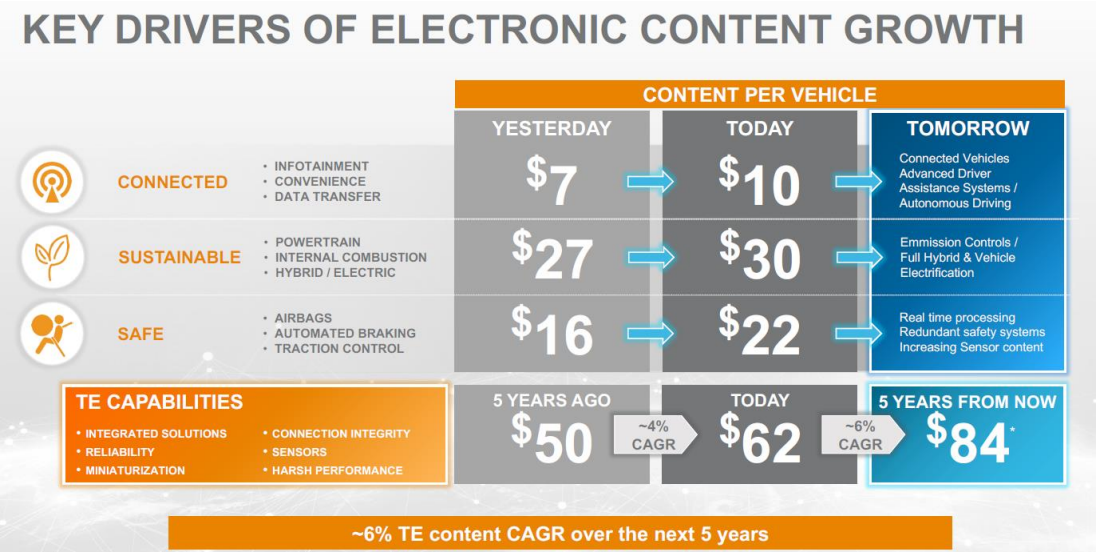
Fig 59 Investment Opportunities within Automotive Electronics Hardware

Connector Content Increase	TE Connectivity	TEL (US)	Maynard Um	Outperform	Target Price: 105.00	10/4/18 Close: 86.16
	Hirose Electric	6806 (JP)	Damian Thong	Neutral	Target Price: 12,500	10/4/18 Close: 12,320
	IRISO Electronics	6908 (JP)				10/4/18 Close: 6,010

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Connected vehicles, electrification, advanced driver assistance systems, an increasing number of sensors, and real time processing requirements should all drive the vehicle architecture more toward that of a datacenter, which we believe will require an increasing amount of connector content. Connectors should benefit from the increase in data content, need for lower latency and higher speeds, and the need for reliability. We believe the content increase in an electric vehicle can be 2x that of a comparable internal combustion engine vehicle while a hybrid up to 1.5x higher. According to TE Connectivity’s recent investor presentation, the company forecasts its connector content per vehicle will grow at a 50% higher CAGR in the next 5 years versus the last 5 years.

Fig 60 TE Connectivity Connector Per Vehicle Growth Forecast



Source: TE Connectivity company report, Macquarie Capital (USA), December 2017

Connectors are a crucial electrical hardware component that enables software platforms to direct data flow to disparate controllers within a vehicle. We believe this sub-segment will enjoy long term secular tailwinds as passenger cars become increasing electrified, with the following companies offering meaningful exposure to the automotive connectors space

TE Connectivity – TEL (US), Maynard Um – Outperform. We are initiating coverage of TEL, a leading connectivity and sensor solution technology company, with an Outperform rating with PT of $105 predicated on 5 key reasons: 1) large end market growth potential driven by a number of megatrends, 2) the high potential for revenue acceleration driven by content growth, 3) scope for continued margin expansion, 4) solid free cash flow generation capability, and 5) a track record of excellent execution.TEL has been on a decade long journey transforming its portfolio through the divestitures of less strategic assets and acquisitions of assets and platforms addressing markets seeing secular growth. We believe the company is in the earlier stages of the benefits from this transformation and growth in its end markets.

3) Battery and Battery Materials

Fig 61 Investment Opportunities within Batteries

Battery	LG Chem	051910 (KS)	Anna Park	Outperform	Target Price: 475,000	10/4/18 Close: 329,500
	Panasonic	6752 (JP)	Damian Thong	Outperform	Target Price: 1,685	10/4/18 Close: 1,357
	Samsung SDI	006400 (KS)	Daniel Kim	Outperform	Target Price: 340,000	10/4/18 Close: 244,000
	SK Innovation	096770 (KS)	Anna Park	Outperform	Target Price: 270,000	10/4/18 Close: 223,000
	BYD	1211 (HK)	Allen Yuan	Underperform	Target Price: 25.80	10/4/18 Close: 51.95
	CBAK Energy Technology	CBAK (US)				10/4/18 Close: 0.67

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

The battery pack is the single most expensive component of an electric vehicle and also is a key determinant of all-electric range. Bringing battery costs down will play a key role in helping electric vehicles become more affordable to the average middle class consumer, as batteries currently account for upwards of 40% of the cost of an electrical vehicle and expectations are for battery costs to continue to decline, achieving a value of around 20% of the cost of the vehicle by the middle of the next decade.

Battery costs can generally be broken down into upstream components, cell and module/pack costs. We estimate that commodity input costs represent ~20% of the total cost of battery pack, the battery cell makes up ~50%, and the remainder is attributable to how cells are packed into module groupings that are encased in the overall outer battery pack. This cost structure subsequently supports the non-linear shape of the decline in battery costs over time to ~$100/kWh by 2025, as really only ~80% of the total cost of a battery pack is available for technology driven cost improvements.

We believe that further technological advancements in battery chemistry technology as well as battery manufacturing technology will be necessary to achieve incremental cost improvements over time. The below figure documents different companies' forecast commitments to battery manufacturing capacity through 2020.

Fig 62 EV battery makers' capacity forecasts (unit MWh)

	Headquarters	Analyst	2015	2016	2017	2018E	2019E	2020E	2017-20 CAGR
CATL	Ningde, Fujian	Allen Chang	2,600	7,600	17,100	32,000	53,500	80,000	67%
Panasonic	Osaka	Damian Thong	8,500	9,500	13,500	28,500	36,300	48,000	53%
LG Chem	Seoul	Anna Park	6,000	11,000	18,000	31,000	50,000	70,000	57%
BYD	Shenzhen	Allen Yuan	7,500	10,000	16,000	20,000	23,000	26,000	18%
Samsung SDI	Yougin	Daniel Kim	2,000	4,000	7,000	14,000	22,000	27,000	57%

Source: Macquarie Capital (USA), October 2018

In addition to cars, we also believe that power utility applications will further stimulate demand for lithium ion batteries. As countries increasingly look to power their electricity and heating networks based on cleaner forms of energy, battery storage will be key to offsetting peak power generation versus usage cycles

Thus, we believe that the following list of battery manufacturers represent attractive opportunities to invest along this theme

LG Chem – 051910 (KS), Anna Park – Outperform. LG Chem is one of the leading EV battery makers, with order backlog rising to Won60tn. On top of that, the company recently decided to increase EV battery capacity to 90GWh in 2020 vs the current 18GWh. As the only materials company among battery makers, LG Chem has successfully increased its energy density based on its NCM cathode material technology, having led battery ASP drop and, hence, EV market growth. However, at our latest visit, the company's top mgmt. shared a change in EV battery strategy focusing on profitability. According to LG Chem, battery market size per model rose tenfold to over US$10bn for Gen 3 EVs relative to Gen 2. As such, auto OEMs are inclined to source batteries from multiple suppliers, while there are only limited number of reliable battery makers. We note leading players are now poised to get new orders without severe price competition. For the first time, we saw chances for EV battery OPM to approach double digits, after 2020. We estimate LG Chem's battery revenue could reach over Won13tn in 2020.

Panasonic – 6752 (JP), Damian Thong – Outperform. Panasonic is best known as the top supplier of automotive LiBs via its partnership with Tesla; the company's LiBs have been used in over 74 car models. Panasonic is also the leading supplier of infotainment systems, with customers including Toyota and Ford. The company is working to harness this position into digital cockpit and ADAS design-wins. Panasonic is also a leading Tier-2 automotive components supplier, and is a market leader in automotive relays, film capacitors, connectors, cameras and audio components. The company is targeting annual automotive revenues of JPY2.5tr (>US$20bn) by FY3/22 from JPY1.3tr in FY3/17 and a position as a top-ten automotive parts supplier.

Samsung SDI – 006400 (KS), Daniel Kim – Outperform. SDI is considered a pure play on LiB (lithium-ion battery), since 70% of its sales are from LiB. SDI has been the largest player in small-size LiB market for several years. SDI has been expanding its auto OEM client list from BMW to VW and Jaguar LandRover. Its order balance on auto LiB keeps rising and the company plans to increase its large-size LiB capacity from 7GWh in 2017-end to over 30GWh by 2020-end. Global auto OEMs are hurriedly reaching out to sign EV battery contracts with proven battery cell makers such as Samsung SDI. Accordingly, SDI seems to be enjoying stronger bargaining power and favourable supply contracts with auto OEMs.

SK Innovation – 096770 (KS), Anna Park – Outperform. As Asia's leading energy company, SK Innovation is growing its EV battery business. Our in-depth study of the EV battery-making process shows SK's film technology provides a grounding for battery production. Further, the company's double-coated separator film raises batteries' safety. It is less distorted despite high energy density, preventing the anode and cathode from being mixed and, hence, controlling unwanted chemical reactions (explosions). As per our conversation with the company, in 2019 Daimler will launch EVs for all classes of Mercedes Benz by using SK Innovation's batteries. In this context, SK Innovation confirmed commercial production of batteries with higher energy density (NCM 811 cathode material), which promises an unprecedented 400km from one full charge from 3Q18. The company is set to quadruple EV battery production in 2018 and reach a breakeven point by 2020 with a target revenue of Won1.5tn.

BYD – 1211 (HK), Allen Yuan – Underperform. While we have factored in the positives from BYD's improved model cycle, we believe it is hard for BYD to benefit from this in light of the negatives from subsidy cuts for NEVs, rising power battery materials costs and heightened competition. The lack of a well-diversified client base for its power battery business, further subsidy cut in 2019/2020, elevated financing cost and slower-than-expected expansion of the SkyRail business also weigh on the profitability outlook of the company. Longer-term we doubt BYD has the scale or quality of product to prosper in passenger vehicles. The existing oversupply in the power battery industry and the fact that competition is intensifying as more brands launch NEV models should put pressure on its valuation multiple.

Battery Materials

Fig 63 Investment Opportunities within Battery Materials

Battery Materials	Albemarle Corporation	ALB (US)	Cooley May	Outperform	Target Price: 140.00	10/4/18 Close: 104.22
	Bacanora Lithium	BCN (LN)	Grant Sporre	Outperform	Target Price: 0.70	10/4/18 Close: 0.30
	Clean TeQ Holdings	CLQ (AU)	Hayden Bairstow	Outperform	Target Price: 1.20	10/4/18 Close: 0.57
	Galaxy Resources	GXY (AU)	Ben Crowley	Outperform	Target Price: 4.00	10/4/18 Close: 2.80
	Glencore	GLEN (LN)	Grant Sporre	Outperform	Target Price: 4.40	10/4/18 Close: 3.33
	Neo Lithium	NLC (CA)	Grant Sporre	Outperform	Target Price: 1.70	10/4/18 Close: 1.07
	Orocobre	ORE (AU)	Andrew Hodge	Outperform	Target Price: 4.40	10/4/18 Close: 4.60
	Pilbara Minerals	PLS (AU)	Ben Crowley	Outperform	Target Price: 1.20	10/4/18 Close: 0.86
	Syrah Resources	SYR (AU)	Ben Crowley	Outperform	Target Price: 3.80	10/4/18 Close: 2.16
	Western Areas	WSA (AU)	Hayden Bairstow	Outperform	Target Price: 3.40	10/4/18 Close: 2.82
	Altura Mining	AJM (AU)	Ben Crowley	Underperform	Target Price: 0.22	10/4/18 Close: 0.26
	Independence Group	IGO (AU)	Hayden Bairstow	Underperform	Target Price: 4.20	10/4/18 Close: 4.85

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Battery packs costs do hold a meaningful 20% input commodity cost exposure, which is generally dependent on the chemistry adopted by different manufacturers. The majority of lithium battery makers have adopted the NMC (nickel-manganese-cobalt) chemistry, though TSLA and Panasonic utilize an NCA (nickel-cobalt-aluminium) design. A summary of the function of each individual metal is provided below:

1) Lithium: active agent that drives power storage and discharge
2) Cobalt: used within the cathode end of a battery cell
3) Manganese: used within the cathode end of a battery cell
4) Nickel: used within the cathode end of a battery cell – results in higher energy density at the cost of less stability versus cobalt
5) Aluminium: used within the cathode end of a battery cell in concert with nickel to improve stability though incrementally lowers power density

A number of metals and mining companies have exposure to the above commodities in a meaningful way. The below list documents certain key companies we view as critical to the future EV battery supply chain:

Albemarle Corporation – ALB (US), Cooley May – Outperform. Albemarle is not only one of the world’s largest lithium producers but is also one of world’s lowest-cost producers. In a lithium market recently suppressed by fears of oversupply, the company continues to differentiate itself on two fronts: in its recent push to develop specialized/more purified types of lithium & in its strategy to avoid spot market exposure by locking the majority of its lithium (LCE & LH) volume into medium-to-long-term contracts. We view this contract-based approach, where the company offers discounted pricing in order to secure a 20%+ ROI on its new expansions, as underappreciated. Given this strategy, we would not be surprised if ALB contract pricing increased in 2019 despite the rollover in China spot pricing & 2H18 market weakness as noted by SQM. We continue to be positive on the story as valuation currently sits ~10% below its weighted peer average.

Bacanora Lithium – BCN (LN), Grant Sporre – Outperform. Bacanora Lithium’s Sonora project in Mexico is a unique clay hosted sediment lithium project with the trade-off of “free dig” mining offset by more complex processing. The company has successfully run its pilot plant for over two years, but we acknowledge that some technical risks remain in the scale up of the plant. The company has recently failed in an attempt to fully fund the ~S$450m of capex which the project requires for funding. As a result the stock has sold off (down 80% YTD vs a more modest fall of 23% of LatAm peer SQM), to the point where we think the stock offers a decent long-term option on the longer term lithium demand growth theme.

Clean TeQ Holdings – CLQ (AU), Hayden Bairstow – Outperform. Clean TeQ is developing its Sunrise nickel/cobalt project in NSW, Australia. The project is expected to produce 20ktpa of nickel in sulphate and ~5ktpa of cobalt in sulphate. Construction is expected to commence in 2019 allowing first

production in 2021. The Sunrise project is targeting Lithium Ion battery and pre-cursor manufacturers. Its nickel and cobalt sulphate products are used in the manufacturing of nickel/cobalt/manganese batteries and represent one of the few sources of cobalt outside of the Democratic Republic of Congo. Securing the final offtake agreements for the Syerston project and solving the funding equation present key near-term catalysts for CLQ. We currently assume the US$1.5bn in capex is funded through a combination of debt and equity, however there is upside to our base case should CLQ be able to secure an investment partner at the project level or a nickel/cobalt streaming funding package.

Galaxy Resources – GXY (AU), Ben Crowley – Outperform. Galaxy Resources is currently producing around 200ktpa of lithium spodumene concentrate from its Mt Cattlin project in Western Australia. Mt Cattlin was the first new hard rock mine in Western Australia to commence production in recent years. The sale of the northern tenements at Sal de Vida to POSCO for US$280m has boosted the company’s cash reserves. The company offers significant leverage to the battery minerals thematic, through the development of the Sal de Vida lithium brine project in Argentina and the James Bay hard rock spodumene mine in Canada. Securing the remaining funding for Sal de Vida and advancing the James Bay project present key upcoming catalysts for Galaxy Resources.

Glencore – GLEN (LN), Grant Sporre – Outperform. Glencore is one of the global large cap diversified miners which is unique in that it is also one of the largest commodities traders globally. The company has two copper / cobalt mine complexes in the DRC; Mutanda and the Katanga complex. The DRC ore bodies are rich in cobalt; a by-product of copper mining. Glencore is ramping up the Katanga complex after a two year shut and re-development project. We forecast the group’s cobalt output to rise from ~23kt in 2015 to ~60kt in 2020E making it the largest cobalt miner globally. The overall contribution to the group is relatively small; 5 – 8% of group EBITDA. The company has had a series of challenges in the DRC, not least being the proposed mining code change imposing a 10% royalty (up from 3.5%) on cobalt as well as a “super profits” tax; this on top of a DoJ investigation into bribery claims in the country. Whilst Glencore has continued to ramp up operations, these issues highlight the challenges of security of supply in the DRC.

Neo Lithium – NLC (CA), Grante Sporre – Outperform. Neo Lithium’s Tres Quebradas project in Argentina is one of a handful of brine projects that offers good grades (600mg/L) with some of the lowest impurities (and, hence, first-decile costs of ~US$2,800/t) in the industry. The resource is good for 40 years of mine life with expansion potential at an incentive price of ~US$7,000/t LCE. We believe Neo Lithium will be one of the winners in a competitive sector as more greenfield supply is required in the medium term. The company’s next challenge is to find partners for offtake agreements and funding. There is no rush, and we believe the company is at an advantage starting off with a blank page despite more challenging market conditions.

Orocobre – ORE (AU), Andrew Hodge – Outperform. Orocobre is currently the largest lithium producer on the ASX with its Olaroz lithium brine project in Argentina expected to produce 8-10ktpa of lithium carbonate over the next two years. Olaroz boasts significant expansion optionality and Orocobre is planning to eventually double Lithium Carbonate production to 25ktpa. The company has recently suffered from the increase in export tariffs in Argentina, however we continue to see value in the stock. We believe Orocobre remains a potential acquisition target for some of the larger lithium producers in South America.

Pilbara Minerals – PLS (AU), Ben Crowley – Outperform. Pilbara Minerals has completed construction of its Pilgangoora hard rock lithium project in Western Australia. Pilgangoora is set to become a major supplier of lithium, with the mine forecast to produce ~850ktpa of spodumene. The mine is in the early stages of ramp up with the target production rate expected to be delivered within three years. General Lithium, one of four off-take partners, has already produced battery grade Lithium Carbonate from Pilgangoora spodumene concentrate. General Lithium is currently commissioning a 16ktpa Lithium Hydroxide plant and also expects to be able to utilise Pilgangoora concentrate. Pilbara Minerals remains our preferred pure play lithium stock and has the potential to grow production and move downstream, developing its own Lithium Hydroxide processing facilities.

Syrah Resources – SYR (AU), Ben Crowley – Outperform. Syrah Resources offers unique exposure to the natural graphite market, a key raw material for the lithium ion battery market. The company has recently commissioned its Balama graphite project in Mozambique, with production ramping up to ~200ktpa of graphite production. The company is also developing a downstream precursor

manufacturing and distribution business that will enable it to better service the battery market. The Balama project is one of the largest graphite projects globally and will see Syrah Resources dominate market share in a number of key graphite products.

Western Areas – WSA (AU), Hayden Bairstow – Outperform. Western Areas is one of the few globally listed pure play nickel miners. The company is producing ~20ktpa of nickel in concentrate from its Flying Fox and Spotted Quoll underground mines in Western Australia. WSA has a long operating history, having commenced production in 2007, with the current mine life expected to stretch into mid next decade. The company also has a major growth option with its Cosmos project. Development of Cosmos could underpin a 50% increase in nickel production, but requires higher nickel prices. WSA is also producing a high grade concentrate that is targeting battery manufacturers. Early acceptance of the product has been strong and could enable WSA to achieve increased payabilities.

Altura Mining – AJM (AU), Ben Crowley – Outperform. Altura Mining is developing its Pilgangoora project (adjacent to Pilbara Minerals' project of the same name) in Western Australia. Altura Mining's project is lower grade and smaller scale than Pilbara Minerals, expecting to produce ~230ktpa of lithium spodumene concentrate with a mine life in excess of ten years. The company has funded the development largely through debt, which increases the reliance on delivering on project ramp up schedules. We also see Altura Mining's project as lower quality in terms of reserves, however we note that the company has been able to produce to targeted product specifications during the ramp up period.

Independence Group – IGO (AU), Hayden Bairstow – Outperform. Independence Group owns and operates the Nova nickel mine in Western Australia. Nova produces ~28ktpa of nickel in concentrate, ~12kt of copper in concentrate and ~1ktpa of cobalt in concentrate and operates in the first quartile of the global nickel cost curve. Nova boasts a mine life of seven years. Nova is currently selling its nickel concentrate to Glencore and Nickel West, however the company is investigating the potential to add down-stream processing capacity to produce more refined products directly targeting battery and pre-cursor manufacturers. We do not currently include this in our forecasts and could deliver higher payabilities and revenue if achieved.

4) Centralized Computing

Fig 64 Investment Opportunities within Centralized Computing

Centralized Compute	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Intel Corp	INTC (US)	Srini Pajjuri	Outperform	Target Price: 60.00	10/4/18 Close: 48.13
	Renesas	6723 (JP)	Damian Thong	Outperform	Target Price: 1,265	10/4/18 Close: 0,742
	NVIDIA	NVDA (US)	Srini Pajjuri	Neutral	Target Price: 240.00	10/4/18 Close: 279.29
	Visteon Corp	VC (US)				10/4/18 Close: 92.01

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

A number of disparate computing domains currently exist within a traditional ICE vehicle (e.g. infotainment, engine operation, instrument cluster, etc.), though we believe that a centralized and consolidated computing platform will be the ultimate solution to streamlining all digital processes within a vehicle. Development of hypervisor and real time operating system technologies currently subsist at a more nascent level, though we believe that such technologies will be key to ultimately enabling individual companies to construct the software ecosystems that power future autonomous systems. The below public companies represent ways to gain exposure to the field of centralized vehicular computing

Aptiv – APTV (US), Maynard Um – Outperform. We believe the auto industry is on the precipice of a multi-decade long transformation driven by disruptive innovation and technology – the same dynamic forces that transformed many other technology industries. History suggests the biggest winners from technology disruption are those focused on software and ecosystem platforms. We believe APTV's strategy is aligned to this changing industry dynamic and believe the company is well positioned as it focuses on transitioning from being a pure Tier 1 auto supplier to one of a higher value-add, platform-based, technology solutions provider. While most of revenue is generated from traditional sales today, we believe the key milestone to watch for will be platform wins over the next 6-18 months. Our Outperform rating is based on four key reasons: 1) beneficiary of secular trends in electric, autonomous, and ecosystem platforms, 2) one of few companies with the ability to create end-to-end architecture systems through software, compute, sensors, and power/data distribution, 3) accretive diversification strategy, 4) cost structure flexibility, and 5) optionality from its turnkey autonomous driving and cloud platforms.

BlackBerry – BB (CA), Gus Papageorgiou – Outperform. BlackBerry offers software and services that securely connect millions of devices around the world. The Company's real-time operating system, QNX, has been installed in over 120m vehicles globally. The QNX product offering is evolving from offering specific applications within the automobile to acting as the underlying operating system of the connected car. We expect QNX penetration into the car to increase along with the ASPs per car.

Intel Corp – INTC (US), Srini Pajjuri – Outperform. Intel accelerated its Auto exposure with the purchase Mobileye in 2017. Intel's portfolio enables an end-to-end solution for autonomous driving: from server CPUs and memory in the data center, to network infrastructure and connectivity, to the processors and sensors in the vehicle. Intel has partnered with BMW, Waymo, Fiat Chrysler, and many tier 1 auto suppliers to jointly develop autonomous vehicles. While Intel's Auto revenues are still small, the company is also highly-levered to technologies enabling autonomous driving such as big data, 5G, and artificial intelligence, which will help DCG growth.

Renesas – 6723 (JP), Damian Thong – Outperform. Renesas is the world's third largest automotive semiconductors vendor with a ~10% share, and the leader in automotive microcontrollers with a >30% share. We expect a 9% revenue CAGR driven by growing sales of microcontrollers (~5% CAGR) and expanding SoC/processor sales (>10%). While Renesas' share in SoCs is currently low (~10%), we expect share gains and overall expansion in the deployment of computing power in the car (e.g. for image processing, cognitive processing) to drive growth. Renesas' SoCs have notably been chosen by Toyota as the basis of their autonomous driving system.

NVIDIA – NVDA (US), Srini Pajjuri – Neutral. NVidia has established itself as a leading compute/platform provider for AI-based autonomous driving with its NVDA DRIVE platform and Xavier

SoC. NVDA's approach leverages the company's DGX supercomputer to train deep neural networks and its DRIVE in-car platform to run inference on the trained neural nets and drive the car. While level 4/5 autonomous vehicles are still a couple years away, NVDA is well-positioned with 370+ automotive partners developing on its platform, including Toyota, Mercedes, Daimler, and VW.

5) Autonomous Drive

Fig 65 Investment Opportunities within Autonomous Drive

Autonomous Driving	Alphabet	GOOGL (US)	Ben Schachter	Outperform	Target Price: 1,250.00	10/4/18 Close: 1,177.07
	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	Apple	AAPL (US)	Ben Schachter	Outperform	Target Price: 235.00	10/4/18 Close: 227.99
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Nexteer	1316 (HK)	Janet Lewis	Outperform	Target Price: 16.60	10/4/18 Close: 11.72
	NVIDIA	NVDA (US)	Srini Pajjuri	Neutral	Target Price: 240.00	10/4/18 Close: 279.29
	Veoneer	VNE (US)	Maynard Um	Neutral	Target Price: 53.00	10/4/18 Close: 48.95
	General Motors	GM (US)				10/4/18 Close: 34.25

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Autonomous drive will be the ultimate destination for personal mobility, though achievement of full level 5 functionality may not reach commercial viability until the mid-2020’s. Below, we document key players within the market that we view as possible contenders to cracking the code to automated driving

Alphabet – GOOG (US), Ben Schachter – Outperform. Alphabet’s Waymo is one of the leading companies developing self-driving technology. The project began in 2009 as part of Google, and has since been elevated into its own company under Alphabet. Since its inception, Waymo has self-driven over 9 million miles. Waymo currently operates an Early Rider program in Phoenix Arizona, giving riders access to its fleet of fully autonomous Chrysler Pacifica mini-vans. Waymo has also struck a deal with Jaguar to create 20,000 self-driving versions of its electric I-PACE SUVs. Waymo has made significant progress with its self-driving technology as it moves towards a wider commercial application. However, at this point, Waymo’s eventual business model is still unclear though it has multiple viable options. Waymo currently builds its own self-driving hardware sensors and could scale that operation and sell the hardware to other car manufacturers, or once the technology has been finalized, Waymo could more simply license its tech and software to existing car makers. In its earlier stages it was thought that Waymo may create its own cars, but that avenue currently appears to be less likely. Other possible revenue streams for Waymo include owning/partnering for its own fleet of vehicles and offering a ride-sharing service to compete with Taxis and Uber, and also possibly autonomous package delivery. The bottom line is that GOOGs has many potential ways of eventually monetizing the progress that Waymo is making, but at this point which one or ones it will pursue are unclear.

Aptiv – APTV (US), Maynard Um – Outperform. We believe the auto industry is on the precipice of a multi-decade long transformation driven by disruptive innovation and technology – the same dynamic forces that transformed many other technology industries. History suggests the biggest winners from technology disruption are those focused on software and ecosystem platforms. We believe APTV’s strategy is aligned to this changing industry dynamic and believe the company is well positioned as it focuses on transitioning from being a pure Tier 1 auto supplier to one of a higher value-add, platform-based, technology solutions provider. While most of revenue is generated from traditional sales today, we believe the key milestone to watch for will be platform wins over the next 6-18 months. Our Outperform rating is based on four key reasons: 1) beneficiary of secular trends in electric, autonomous, and ecosystem platforms, 2) one of few companies with the ability to create end-to-end architecture systems through software, compute, sensors, and power/data distribution, 3) accretive diversification strategy, 4) cost structure flexibility, and 5) optionality from its turnkey autonomous driving and cloud platforms.

Apple – AAPL (US), Ben Schachter – Outperform. Apple currently offers its CarPlay operating system in over 50 car brands, including the overwhelming majority of the largest car manufacturers. CarPlay brings music & navigation apps into a car’s center console, as well as the ability to make calls and send/receive texts through Siri. Revenues, and certainly profits for APPL from CarPlay are likely limited, but autos is an additional avenue bolstering the overall iOS ecosystem in its competition with Android and other devices. Over the longer-term, it is an open secret that AAPL has been working on a self-driving auto solution known as “Project Titan”. AAPL has not officially stated its involvement in self-driving tech, but over the years there have been numerous reports detailing AAPL’s efforts. AAPL’s ultimate goal with Project Titan remains unclear as whether it will make its own car, or provide a

software solution to existing auto manufacturers, but AAPL certainly has ambitions for autos beyond CarPlay.

BlackBerry – BB (CA), Gus Papageorgiou – Outperform. BlackBerry offers software and services that securely connect millions of devices around the world. The Company’s real-time operating system, QNX, has been installed in over 120m vehicles globally. The QNX product offering is evolving from offering specific applications within the automobile to acting as the underlying operating system of the connected car. We expect QNX penetration into the car to increase along with the ASPs per car.

Nexteer – 1316 (HK), Janet Lewis – Outperform. Nexteer is a top-three company in steering. It was spun off from Delphi and is listed in Hong Kong, though GM remains its top customer with 42% share of its backlog. It was recognized by GM for its contribution to GM’s first Level 5 ADAS vehicle. Nexteer has expanded its business on the back of electric power steering (EPS) and is now pioneering steer by wire, leveraging its strong software skills. To put it in perspective, steer by wire includes 13.5m lines of code vs 4.3m lines in an EPS system. By eliminating the steering column, it can significantly help to reduce the weight of a vehicle as well. Nexteer currently has 12 programs in development with leading OEMs for Levels 3-5 ADAS steering systems. Among the technologies for Level 3 and above are stowable columns, Quiet Wheel Steering™ (steering wheel remains still in automated driving mode) and Steering on Demand™ systems, which provide a smooth transition between manual and automated driving.

NVIDIA – NVDA (US), Srini Pajjuri – Neutral. Nvidia has established itself as a leading compute/platform provider for AI-based autonomous driving with its NVDA DRIVE platform and Xavier SoC. NVDA's approach leverages the company's DGX supercomputer to train deep neural networks and its DRIVE in-car platform to run inference on the trained neural nets and drive the car. While level 4/5 autonomous vehicles are still a couple years away, NVDA is well-positioned with 370+ automotive partners developing on its platform, including Toyota, Mercedes, Daimler, and VW.

Veoneer – VNE (US), Maynard Um – Neutral. We are initiating coverage of VNE with a Neutral rating and $53 target price. We believe VNE is well positioned to take advantage of the secular growth trends as a near pure-play in the active safety and autonomous markets with regulatory tailwinds and strong order intake that should drive revenue heading toward the end of 2019 and into 2020. However, our Neutral rating is based on three key reasons: 1) our view that near-term investments for future growth, while the right strategy, will limit earnings upside, 2) our view that the variance in Consensus estimates needs to tighten to reflect this sound investment strategy, which we think may take at least a couple of quarters, and 3) our preference to see the bottoming of organic revenue in the restraint control and brake systems businesses.

6) Lightweighting

Fig 66 Investment Opportunities within Lightweighting

Lightweighting	Minth Group	425 (HK)	Janet Lewis	Outperform	Target Price: 44.20	10/4/18 Close: 29.25
	Nexteer	1316 (HK)	Janet Lewis	Outperform	Target Price: 16.60	10/4/18 Close: 11.72
	Gestamp Automocion	GEST (MCE)				10/4/18 Close: 6.22
	Shiloh Industries	SHLO (US)				10/4/18 Close: 9.33

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Minimizing the weight of a vehicle is a key factor to designing a BEV with a maximum number all electric range. Current trends in this segment include hot stamping as well as increased use of aluminium casting and welding techniques. Select public companies with exposure to vehicular lightweighting include the following

Minth Group – 425 (HK), Janet Lewis – Outperform. Minth is a global leader in metal trim, decorative and body structural parts, roof racks and seat systems for autos. It has about 10% global market share for its products. It has leveraged its strong performance in China to achieve an increasing number of global programs for leading automakers including BMW, Honda, Toyota, GM and many others. It has been working with automakers to reduce the weight of vehicles, which has been a driver for the high-margin aluminium business, which is now 35% of its order backlog. Two key areas are aluminium door frames and plastic tailgates. It is also focused on developing products for NEVs such as casing for battery packs, as well as for ADAS features, such as parts that incorporate camera modules for around-view monitoring and ACC emblems.

Nexteer – 1316 (HK), Janet Lewis – Outperform. Nexteer is a top-three company in steering. It was spun off from Delphi and is listed in Hong Kong, though GM remains its top customer with 42% share of its backlog. It was recognized by GM for its contribution to GM’s first Level 5 ADAS vehicle. Nexteer has expanded its business on the back of electric power steering (EPS) and is now pioneering steer by wire, leveraging its strong software skills. To put it in perspective, steer by wire includes 13.5m lines of code vs 4.3m lines in an EPS system. By eliminating the steering column, it can significantly help to reduce the weight of a vehicle as well. Nexteer currently has 12 programs in development with leading OEMs for Levels 3-5 ADAS steering systems. Among the technologies for Level 3 and above are stowable columns, Quiet Wheel Steering™ (steering wheel remains still in automated driving mode) and Steering on Demand™ systems, which provide a smooth transition between manual and automated driving.

7) Power Semiconductors

Fig 67 Investment Opportunities within Power Semiconductors

Power Semiconductors	Rohm	6963 (JP)	Damian Thong	Outperform	Target Price: 12,100	10/4/18 Close: 8,210
	Fuji Electric	6504 (JP)	Damian Thong	Neutral	Target Price: 4,785	10/4/18 Close: 4,585
	Mitsubishi Electric	6503 (JP)	Damian Thong	Neutral	Target Price: 1,480	10/4/18 Close: 1,552
	Cree	CREE (US)				10/4/18 Close: 36.75
	Infineon	IFX (DE)				10/4/18 Close: 20.15

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Power semiconductors are switch-like devices that, unlike low power semiconductors, can handle high voltages and large currents and can be used to control and convert electrical power in electronic circuits such as in changing DC to AC and AC to DC. They are important, for example, in driving motors from low to high speeds. There are several types of power semiconductor devices including power diodes, metal oxide semiconductor field-effect transistors (MOSFET), thyristors, and insulated gate bipolar transistors (IGBT). IGBTs are frequently used in electric vehicles.

Infineon has indicated that the power semiconductors' value in the vehicle powertrain rises sharply from US$17 in the case of an internal combustion engine (ICE) vehicle to US$265 in the case of a HEV, PHEV or BEV. IGBT modules are key components for on-board battery chargers and inverters/motor drive systems, and demand will see a strong boost from vehicle electrification. In addition, an increasing part of the market will be captured by silicon carbide (SiC) based power modules.

We believe Power Semiconductors will be a key beneficiary of electric vehicle growth.

Rohm – ticker (JP), Damian Thong – Outperform. Rohm is aiming to be the leading Japanese player in discrete semiconductors, including power devices like power MOSFETs and power diodes. While the company has a low share in IGBTs, they are targeting 30% share in IGBT devices. Since the acquisition of SiCrystal, the company is vertically integrated from SiC wafer to modules, and has secured automotive design-ins to underpin growth.

Fuji Electric – ticker (JP), Damian Thong – Neutral. Fuji Electric is a leading Japanese mid-size power electronics firm – with notable strengths in inverters, transformers, circuit breakers and switchgear. It is also the world's third largest supplier of IGBT power modules after Infineon, with a 10-15% market share. The company has secured significant design wins at Chinese automotive firms, and is now boosting capacity to meet demand. Fuji Electric has an active development program in SiC modules, but does not see demand taking off till the 2020s.

Mitsubishi Electric – ticker (JP), Damian Thong – Neutral. Mitsubishi Electric is Japan's largest supplier of factory automation components, including PLCs, inverters and servomotors, one of Japan's top air conditioner firms, and also the country's top defense/aerospace electronics supplier. It is also the world's second largest supplier of IGBT power modules after Infineon, with notable presence in appliance and industrial applications. The company is now adding capacity and products to win share in the automotive market. The company has a program in SiC modules, and has already sold into railway equipment and air conditioner applications.

8) Charging

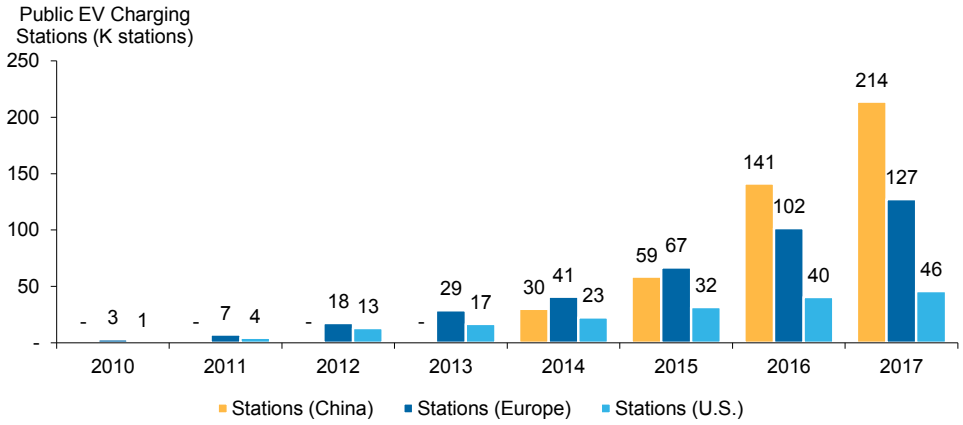
Fig 68 Investment Opportunities within Charging

Charging	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	Tesla	TSLA (US)	Maynard Um	Outperform	Target Price: 430.00	10/4/18 Close: 281.83
	Blink Charging	BLNK (US)				10/4/18 Close: 2.30
	Envision Solar International	EVSI (US)				10/4/18 Close: 0.19
	KS Terminals	3003 (TW)				10/4/18 Close: 47.40

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

The availability of EV charging infrastructure plays a key role in consumer adoption of electric vehicles, though EV charging stations have only begun to meaningfully climb in numbers in the past 5 years.

Fig 69 Global Number of EV Charging Stations



Source: OECD/IEA, Macquarie Capital (USA), October 2018

From a public policy perspective, government agencies understand the importance of establishing a pervasive and reliable charging network. Currently, several initiatives exist within China, Europe, and the U.S. that will dramatically increase the number of EV charging stations on a global basis. We provide a select list of public companies levered to this growing subsector below

Aptiv – APTV (US), Maynard Um – Outperform. We believe the auto industry is on the precipice of a multi-decade long transformation driven by disruptive innovation and technology – the same dynamic forces that transformed many other technology industries. History suggests the biggest winners from technology disruption are those focused on software and ecosystem platforms. We believe APTV's strategy is aligned to this changing industry dynamic and believe the company is well positioned as it focuses on transitioning from being a pure Tier 1 auto supplier to one of a higher value-add, platform-based, technology solutions provider. While most of revenue is generated from traditional sales today, we believe the key milestone to watch for will be platform wins over the next 6-18 months. Our Outperform rating is based on four key reasons: 1) beneficiary of secular trends in electric, autonomous, and ecosystem platforms, 2) one of few companies with the ability to create end-to-end architecture systems through software, compute, sensors, and power/data distribution, 3) accretive diversification strategy, 4) cost structure flexibility, and 5) optionality from its turnkey autonomous driving and cloud platforms.

Tesla – TSLA (US), Maynard Um – Outperform. We view Tesla as a disruptive technology growth company with differentiated products and strong brand presence in the secularly growing and equally disruptive markets of electric vehicles, energy storage, and energy generation. Our rating is predicated on the following five reasons: 1) accelerating vehicle unit growth driven by industry acceleration for electric vehicles over the next two decades, 2) unique potential among OEMs to lead in in-vehicle ecosystem platforms, 3) technology differentiation, 4) continued traction in the energy storage market, and 5) optionality to be a leader in autonomous driving given its tremendous and growing installed base.

9) Thermal Management

Fig 70 Investment Opportunities within Thermal Management

Thermal Management	Hanon Systems	018880 (KS)	James Hong	Outperform	Target Price: 17,000	10/4/18 Close: 12,650
	Dana Incorporated	DAN (US)				10/4/18 Close: 18.50
	Denso	6902 (JP)				10/4/18 Close: 5,745
	Gentherm Incorporated	THRM (US)				10/4/18 Close: 43.50
	Mahle-Metal Leve S.A.	LEVE3 (BR)				10/4/18 Close: 24.74
	Modine	MOD (US)				10/4/18 Close: 15.02
	Sanden	6444 (JP)				10/4/18 Close: 1,567
	Tecogen	TGEN (US)				10/4/18 Close: 3.05
	Toyota Industries	6201 (JP)				10/4/18 Close: 6,480
	Valeo SA	FR (FR)				10/4/18 Close: 32.50

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Thermal management for an electric vehicle is fundamentally different versus an internal combustion vehicle. A primary driver for this is the fact that ICE configurations give off much more heat and require large radiators to offset such peak temperatures. EV powertrains on the other hand operate at lower peak temperatures and must keep their battery power systems at a minimum temperature in cold weather climate conditions. We document a select variety of public companies with exposure to EV thermal management systems

Hanon Systems – 018880 (KS), James Hong – Outperform. Hanon Systems is a leading e-compressor producer and thermal management supplier globally with diversified client base ranging from global OEMs like Hyundai/Kia, Ford, Volkswagen, Chrysler, BMW, PSA, Daimler, and General Motors, and EV producers like Tesla. Hanon is a sole vendor for therma management system in EVs of Hyundai/Kia, BMW, and Tesla (model S and X). Recently, the company announced the $1.2bn acquisition of Magna International’s global fluid pressure & controls business. Hanon has a wide range of product portfolio, covering HVAC, compressor, and fluid control. Its profitability in EV business should exceed ICE business from late 2019 on scale. Currently, the company generates slightly less than 10% of its revenue from EV.

10) Connected Car

Fig 71 Investment Opportunities within Connected Car

Connected Car	Amazon	AMZN (US)	Ben Schachter	Outperform	Target Price: 2,200.00	10/4/18 Close: 1,909.42
	Aptiv	APTV (US)	Maynard Um	Outperform	Target Price: 103.00	10/4/18 Close: 82.83
	AT&T	T (US)	Amy Yong	Outperform	Target Price: 35.00	10/4/18 Close: 34.12
	BT Group	BT/A (LN)	Guy Peddy	Outperform	Target Price: 3.55	10/4/18 Close: 2.28
	BlackBerry	BB (CA)	Gus Papageorgiou	Outperform	Target Price: 19.35	10/4/18 Close: 13.27
	Intel Corp	INTC (US)	Srini Pajjuri	Outperform	Target Price: 60.00	10/4/18 Close: 48.13
	Orange	ORA (FP)	Guy Peddy	Outperform	Target Price: 16.30	10/4/18 Close: 13.73
	Panasonic	6752 (JP)	Damian Thong	Outperform	Target Price: 1,685	10/4/18 Close: 1,357
	Qualcomm	QCOM (US)	Srini Pajjuri	Outperform	Target Price: 84.00	10/4/18 Close: 72.38
	Renesas	6723 (JP)	Damian Thong	Outperform	Target Price: 1,265	10/4/18 Close: 0,742
	Sony	6758 (JP)	Damian Thong	Outperform	Target Price: 7,650	10/4/18 Close: 6,613
	Maxim	MXIM (US)	Srini Pajjuri	Neutral	Target Price: 60.00	10/4/18 Close: 55.71
	Sierra Wireless	SWIR (US)	Gus Papageorgiou	Neutral	Target Price: 24.00	10/4/18 Close: 19.37
	Texas Instruments	TXN (US)	Srini Pajjuri	Neutral	Target Price: 110.00	10/4/18 Close: 105.87
	Verizon	VZ (US)	Amy Yong	Neutral	Target Price: 55.00	10/4/18 Close: 55.02

Source: Factset, Macquarie Capital (USA), October 2018; priced as of 04 October 2018

Current ICE and EV models already feature connected car functionality, though we view this subsector as only in its very early stages. The final stage of this evolution will result in a small number of vehicle ecosystem platforms that are interconnected by V2X technologies to maximize data flow to enable maximize passenger safety, vehicle functionality, and overall user experience. 5G connectivity will be the first catalyst for this industry trend, as we believe the below stocks stand to benefit from the future further development of connect car technologies

Amazon – AMZN (US), Ben Schachter – Outperform. Amazon has been less overt with its auto ambitions, but its hardware, software, and AI/ML capabilities make AMZN an ever-present candidate to more seriously enter the autos space, particularly given the other tech giant’s existing involvement in autos. AMZN recently introduced the Echo Auto to expand the presence of its Alexa AI voice assistant ecosystem into the car. Echo Auto is an audio-only standalone device that connects to the car via Bluetooth or with an auxiliary cable, and is powered by a car charger (not a built-in solution like CarPlay or Android Auto). Echo Auto has the same Alexa functionality as the other Echo products, allowing users to get audio directions, play music from streaming services, control smart home devices, or any of the other existing Alexa skills. Additionally, AMZN’s AI/ML capabilities and AWS infrastructure, combined with its logistics network, provides the potential befits, and resources to more seriously compete in the development of self-driving technology. It is unclear if Amazon has any ambition to develop self-driving tech to compete directly with the likes of Google, Tesla, Uber, Nvidia, and Apple, but Amazon certainly has the resources to compete if it closes to do so.

Aptiv – APTV (US), Maynard Um – Outperform. We believe the auto industry is on the precipice of a multi-decade long transformation driven by disruptive innovation and technology – the same dynamic forces that transformed many other technology industries. History suggests the biggest winners from technology disruption are those focused on software and ecosystem platforms. We believe APTV’s strategy is aligned to this changing industry dynamic and believe the company is well positioned as it focuses on transitioning from being a pure Tier 1 auto supplier to one of a higher value-add, platform-based, technology solutions provider. While most of revenue is generated from traditional sales today, we believe the key milestone to watch for will be platform wins over the next 6-18 months. Our Outperform rating is based on four key reasons: 1) beneficiary of secular trends in electric, autonomous, and ecosystem platforms, 2) one of few companies with the ability to create end-to-end architecture systems through software, compute, sensors, and power/data distribution, 3) accretive diversification strategy, 4) cost structure flexibility, and 5) optionality from its turnkey autonomous driving and cloud platforms.

AT&T – T (US), Amy Yong – Outperform. IoT continues to be a major initiative among telcos, particularly AT&T and Verizon. The pair has been leading the way in establishing partnerships with the top global auto OEMs and view this as a US$1bn+ annual revenue opportunity. AT&T’s goal is to

collaborate with the top players in the industry to provide connected drivers with IoT applications that provide enhanced in-car experiences and safety applications, as historically, ~50%+ of embedded vehicles rolling out in the US had AT&T connectivity. AT&T counts 21m connected cars on its network; it has added 1m+ connected cars to its network for the past 13 consecutive quarters. Recent deals with Audi and GM vehicles involve AT&T equipping new models with its LTE capabilities. Additionally, AT&T has enabled its connected cars to be added onto its mobile share data plan for only US$10/month or US$20/month for unlimited. On average, ARPU for LTE connectivity is ~US$8/month including ~US$3-4/month for diagnostics and ~US$4-5 for additional usage per account or additional usage per account assuming a 20% take rate for consumer auto LTE service.

BT Group – BT/A (LN), Guy Peddy – Outperform; Orange – ORA (FP), Guy Peddy – Outperform. The automotive industry is a key part of EU operators M2M existing offer and plans for the future. But it’s currently only a small part of the overall revenue pot as most operators report total M2M revenue between 1-2% of group revenue. Vehicle connectivity has evolved from 2G to 4G but remains limited in its complexity. It can provide technical details on the functioning of the vehicle but is most active in providing traffic management systems. Operators like Vodafone offer global M2M platforms which appeal to the larger auto manufacturers. Looking forward, vehicle connectivity is part of operators’ moves into concierge-like services. Current autonomous vehicle concepts rely on cameras and CPUs within the car, but this limits the radius of information and increases the cost of the vehicle – the CPU is a substantial cost at the moment. Telecom operators aim to provide an overlay technology (part of the V2X platform) to provide data on nearby but out of vision events and with EDGE computing this can be done in the cloud such that the vehicle does not need its own processor. This of course relies on very low latency networks, especially those envisaged by 5G. Edge computing and distributed networks should also improve the capabilities of onward entertainment/infotainment in the vehicle, so there is a double use. Operators will be rolling out these networks in the coming years as part of the move to 5G and fibre, and as we believe most markets will only be able to support up to two small-cell 5G networks, we believe network consolidation and/or partnerships are the way forward. The other angle operators are looking to exploit is Data Analytics. BT, Orange and Vodafone are at the forefront of these initiatives, looking to combine mobility data with activity levels. Examples include providing data on driving styles or speed data at incidents to insurance companies, allowing for an even greater level of insurance personalisation. Additionally with the ability to track pedestrians, especially if app based, Data Analytics can feed data to connected vehicles on potential hazards. Certain operators, such as Orange are also looking to add insurance services to their consumer offers.

BlackBerry – BB (CA), Gus Papageorgiou – Outperform. BlackBerry offers software and services that securely connect millions of devices around the world. The Company’s real-time operating system, QNX, has been installed in over 120m vehicles globally. The QNX product offering is evolving from offering specific applications within the automobile to acting as the underlying operating system of the connected car. We expect QNX penetration into the car to increase along with the ASPs per car.

Intel Corp – INTC (US), Srini Pajjuri – Outperform. Intel accelerated its Auto exposure with the purchase Mobileye in 2017. Intel’s portfolio enables an end-to-end solution for autonomous driving: from server CPUs and memory in the data center, to network infrastructure and connectivity, to the processors and sensors in the vehicle. Intel has partnered with BMW, Waymo, Fiat Chrysler, and many tier 1 auto suppliers to jointly develop autonomous vehicles. While Intel’s Auto revenues are still small, the company is also highly-levered to technologies enabling autonomous driving such as big data, 5G, and artificial intelligence, which will help DCG growth.

Panasonic – 6752 (JP), Damian Thong – Outperform. Panasonic is best known as the top supplier of automotive LiBs via its partnership with Tesla; the company’s LiBs have been used in over 74 car models. Panasonic is also the leading supplier of infotainment systems, with customers including Toyota and Ford. The company is working to harness this position into digital cockpit and ADAS design-wins. Panasonic is also a leading Tier-2 automotive components supplier, and is a market leader in automotive relays, film capacitors, connectors, cameras and audio components. The company is targeting annual automotive revenues of JPY2.5tr (>US$20bn) by FY3/22 from JPY1.3tr in FY3/17 and a position as a top-ten automotive parts supplier.

Qualcomm – QCOM (US), Srini Pajjuri – Outperform. Qualcomm highlighted a $5b Auto backlog on their Jun-18Q earnings call. More than half of the opportunity is in infotainment, where we believe Qualcomm’s Snapdragon 602A and 820A platforms have been gaining share. Outside of infotainment,

Qualcomm has the leading cellular V2X telematics portfolio and is well-positioned for autonomous vehicle adoption over the next few years. LTE penetration is increasing at a rapid pace in Auto, and we see that trend accelerating with 5G. Overall, Auto is a key adjacent opportunity for QCOM and we expect the company to continue to gain share over the coming years.

Renesas – 6723 (JP), Damian Thong – Outperform. Renesas is the world’s third largest automotive semiconductors vendor with a ~10% share, and the leader in automotive microcontrollers with a >30% share. We expect a 9% revenue CAGR driven by growing sales of microcontrollers (~5% CAGR) and expanding SoC/processor sales (>10%). While Renesas’ share in SoCs is currently low (~10%), we expect share gains and overall expansion in the deployment of computing power in the car (e.g. for image processing, cognitive processing) to drive growth. Renesas’ SoCs have notably been chosen by Toyota as the basis of their autonomous driving system.

Sony – 6758 (JP), Damian Thong – Outperform. Sony is the global market share leader in image sensors with a ~40% share. Image sensor revenues are set to grow at a 9% CAGR, helped by growing contribution from automotive image sensors. Sony’s sensors have notably been chosen by Denso for its automotive camera systems, which are already being deployed for a new generation of active safety systems in Toyota and Lexus cars.

Maxim – MXIM (US), Srini Pajjuri – Neutral – Maxim supplies analog and power management solutions primarily into Infotainment, ADAS, and Battery Management (BMS) applications. Majority of revenues come from infotainment, where MXIM provides high-speed serial link, SerDes, and power management solutions. Key growth areas are hybrid electric vehicle adoption (particularly in China) and level 2+ ADAS, which requires increasingly high-speed serial links for data transmission from more advanced camera and sensor configurations. Overall, MXIM is well-positioned for sustained growth in Auto, helped by a partnership with NVDA on NVDA's level 4/5 DRIVE platforms.

Sierra Wireless – SWIR (US), Gus Papageorgiou – Neutral. Sierra Wireless is the leading supplier of embedded modules in the world and one of the dominant suppliers to the auto industry. As the number of cars with mobile connectivity increases Sierra Wireless is set to benefit as its market grows. Sierra is also attempting to build services to enhance its position with its automobile customers.

Texas Instruments – TXN (US), Srini Pajjuri - Neutral – Texas Instruments offers broad automotive product and customer exposure, and should continue to benefit from the increasing electrification of vehicles. TXN’s Auto portfolio includes embedded processors, analog/mixed signal, and connectivity solutions with diverse exposure across infotainment, ADAS, body electronics, and hybrid electric vehicle power train applications.

Verizon – VZ (US), Amy Yong – Neutral. IoT continues to be a major initiative among telcos, particularly AT&T and Verizon. The pair has been leading the way in establishing partnerships with the top global auto OEMs and view this as a US$1bn+ annual revenue opportunity. For Verizon, the Telogis and Fleetmatics deals have helped boost Verizon’s scale in Telematics, where it has a growing portfolio of solutions including automatic, insurance, and fleet management. Assuming the telematics opportunity grows to US$50bn+ by ’20, a ~10% market share gain would represent ~US$5bn+ in incremental annual revenues. Since buying Hughes Telematics for US$612m in ’12, the majority of Verizon’s auto revenue (~US$500m) has come from wholesale as opposed to its retail LTE connectivity. In this case, the Telogis acquisition adds to its enterprise telematics positioning while Fleetmatics improves its SMB offering. Its retail brand Verizon Vehicle was launched in Jan ’15 and rebranded to Hum in Aug ‘16. The service involves an OBD (on-board diagnostic) reader, a Bluetooth connected speaker, and a smartphone app, enabling older cars to become smart vehicles.

Appendices

The Hybrid Vehicle Market

Why do hybrid vehicles exist today?

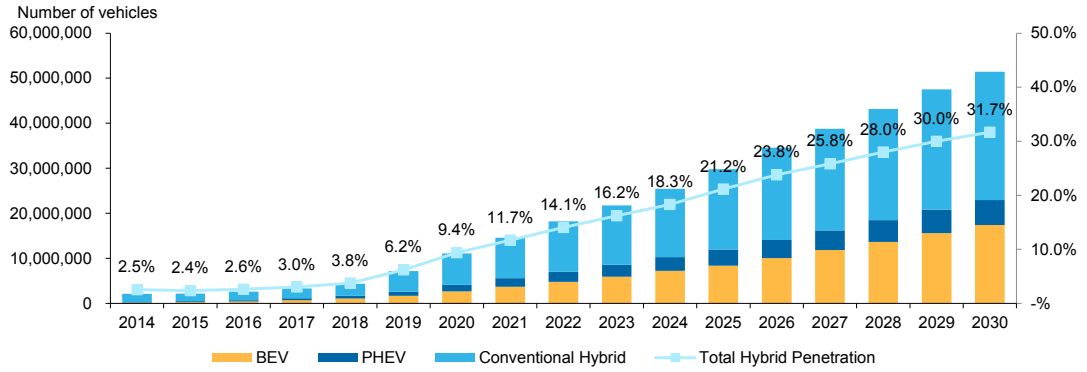
Hybrid powertrain technology has existed since the time of the first automobiles in the late 1800’s, though the key catalyst for their mainstream adoption today has been driven by a combination of volatile oil prices, impracticality of BEV technology, and growing public environmental concerns. In more recent history, soaring oil prices in the 1960s and 70s prompted Congress to pass the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976. Numerous automakers were testing electric powertrains at the time, though due to underdeveloped battery technology of the time, full BEVs topped out at speeds of ~50 mph and all electric ranges of less than 50 miles.

While battery technology failed to make meaningful progress in the decades following, public concerns related to greenhouse gas emissions in the 1980’s and into the 90’s resulted in passage of legislation such as the 1990 Clean Air Act Amendment and the adoption of the Low Emission Vehicle Standards by the California Air Resource Board (“CARB”). While numerous OEMs tested hybrid vehicle prototypes at the time, the industry generally recognizes the introduction of the Toyota Prius in 1997 (introduced in Japan in 1997 and the U.S. in 2000) as the key catalyst for mainstream adoption of hybrid vehicles.

Hybrid Vehicles to Become an Increasingly Important Component of the Global Automotive Market

While plug in hybrid (“PHEV”) and conventional hybrid vehicles still make up a relatively small portion of the overall global automotive market, the subsector continues to experience strong growth, with volumes having more than doubled over the last 3 years. Regulatory emissions initiatives from Europe and China are set to drive BEV and HEV (“hybrid electric vehicle”) volumes through 2030, as illustrated below:

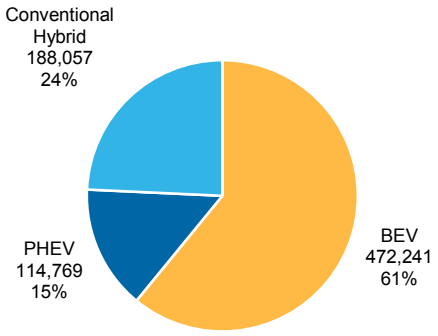
Fig 72 Global EV Sales Volumes and Penetration Rates



Source: LMC Automotive, Macquarie Capital (USA), October 2018

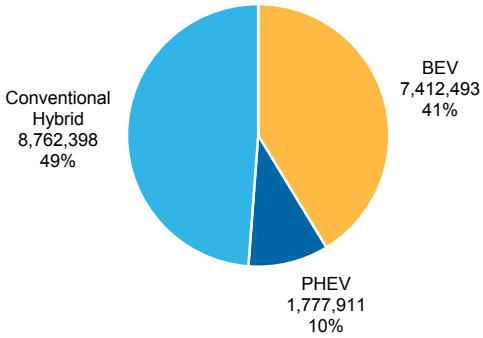
China is the world’s largest automotive market, with passenger vehicle sales totalling just shy of 28M in 2017 according to China’s Association of Automotive Manufacturers (CAAM). The EV market has mainly been driven by regulatory initiatives motivated by national security concerns regarding the country’s dependence on foreign oil. Historically, the Chinese government has directed more generous subsidies to BEVs versus hybrids, which has driven sales of BEVs. As BEV subsidies fall off though, hybrid sales are likely to become a larger portion of the overall Chinese EV market as domestic OEMs invest in hybrid powertrain technologies to meet increasingly stringent emissions standards.

Fig 73 China EV Sales Distribution - 2017



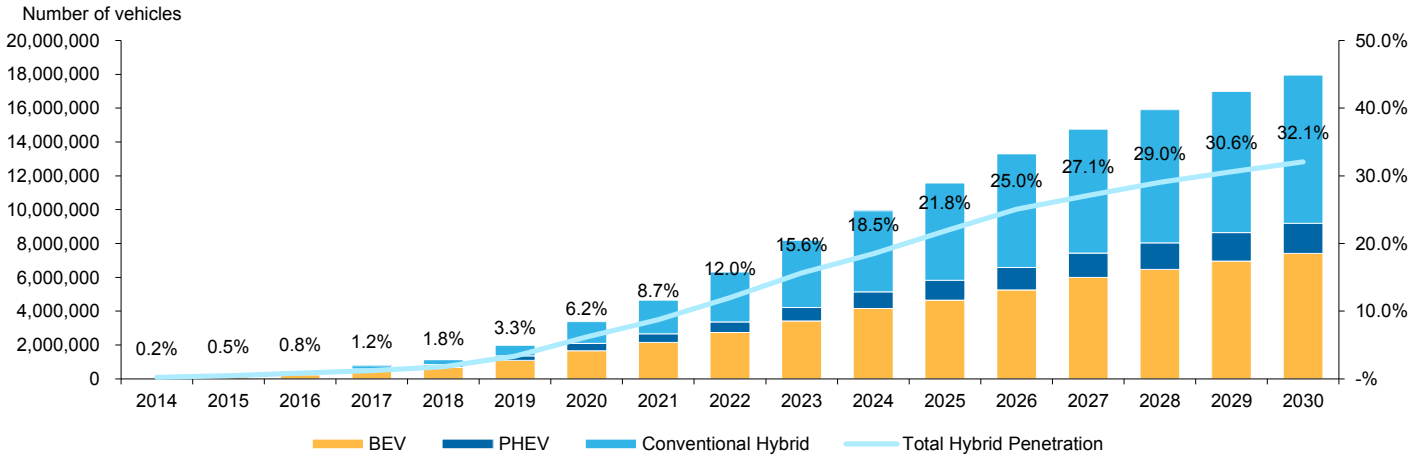
Source: LMC Automotive, Macquarie Capital (USA), October 2018

Fig 74 China EV Sales Distribution - 2030



Source: LMC Automotive, Macquarie Capital (USA), October 2018

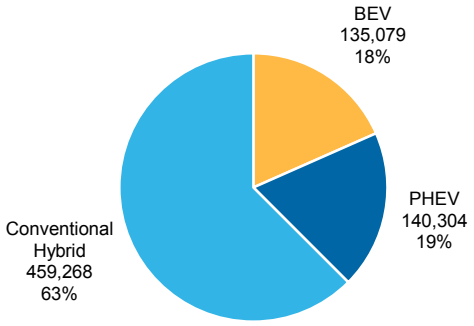
Fig 75 China EV Sales Volumes and Penetration Rates



Source: LMC Automotive, Macquarie Capital (USA), October 2018

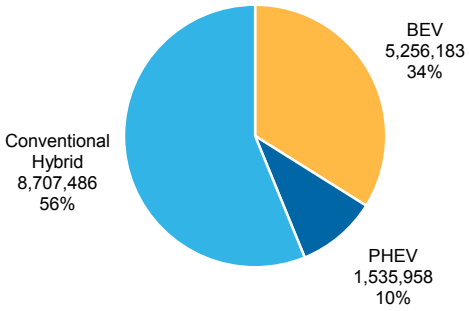
The European automotive market is the third largest in the world, with the EU27 registering 15M new vehicles in 2017. The region is highly mature from an automotive technology standpoint, though the most recent Dieselgate scandal is driving significant changes in powertrain mix for new vehicle sales. The EU boasts the most ambitious emissions targets of any other region, thereby driving the market towards a combined 70% penetration of BEV and HEV of total new passenger vehicle sales by 2030 according to LMC Automotive.

Fig 76 Europe EV Sales Distribution - 2017



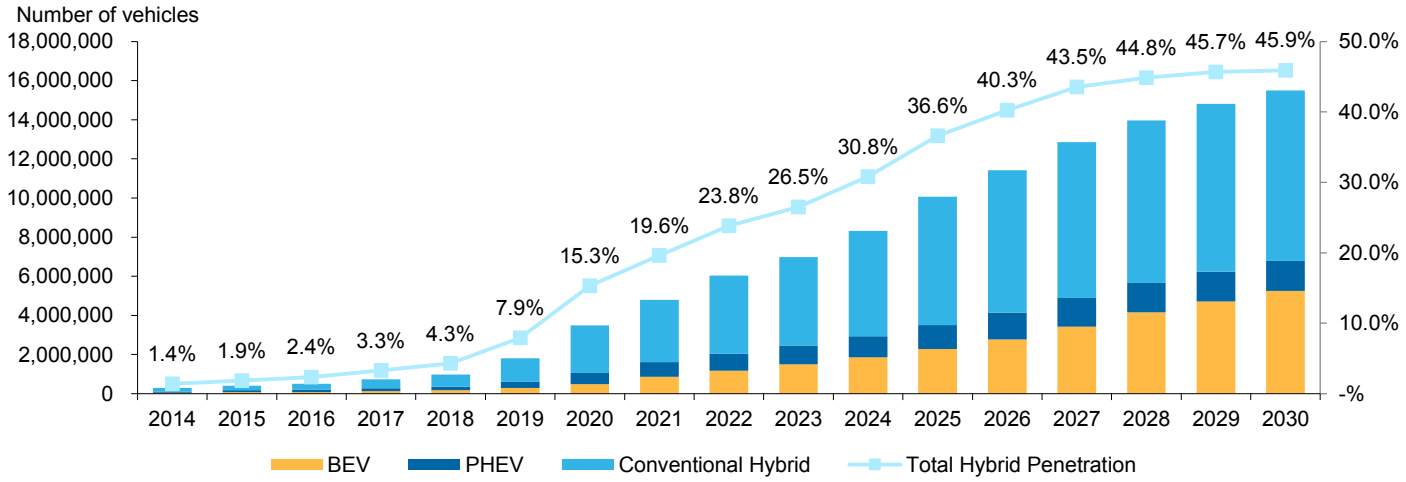
Source: LMC Automotive, Macquarie Capital (USA), October 2018

Fig 77 Europe EV Sales Distribution - 2030



Source: LMC Automotive, Macquarie Capital (USA), October 2018

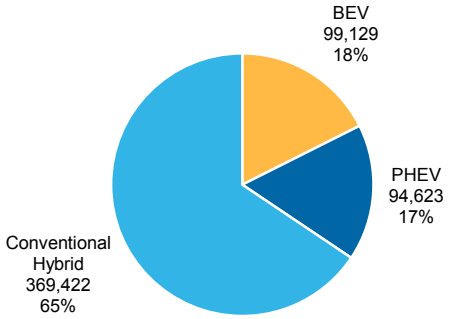
Fig 78 Europe EV Sales Volumes and Penetration Rates



Source: LMC Automotive, Macquarie Capital (USA), October 2018

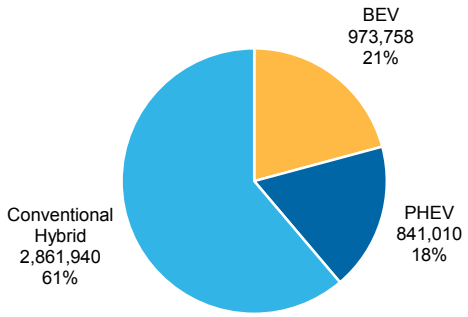
The US automotive industry is the second largest in the world, totalling just over 17M units in 2017. The sector is characterized by a similar distribution of hybrids versus BEVs as Europe given the maturity of powertrain technologies amongst OEMs that supply the market. With the most recently proposed rollback of Obama era emissions regulations by the Trump administration, EV volumes will likely be more driven by economics and consumer tastes versus regulatory targets by the federal and state governments. Thus, ICE powertrains will potentially make up a larger portion of the overall automotive market versus China and Europe.

Fig 79 U.S. EV Sales Distribution - 2017



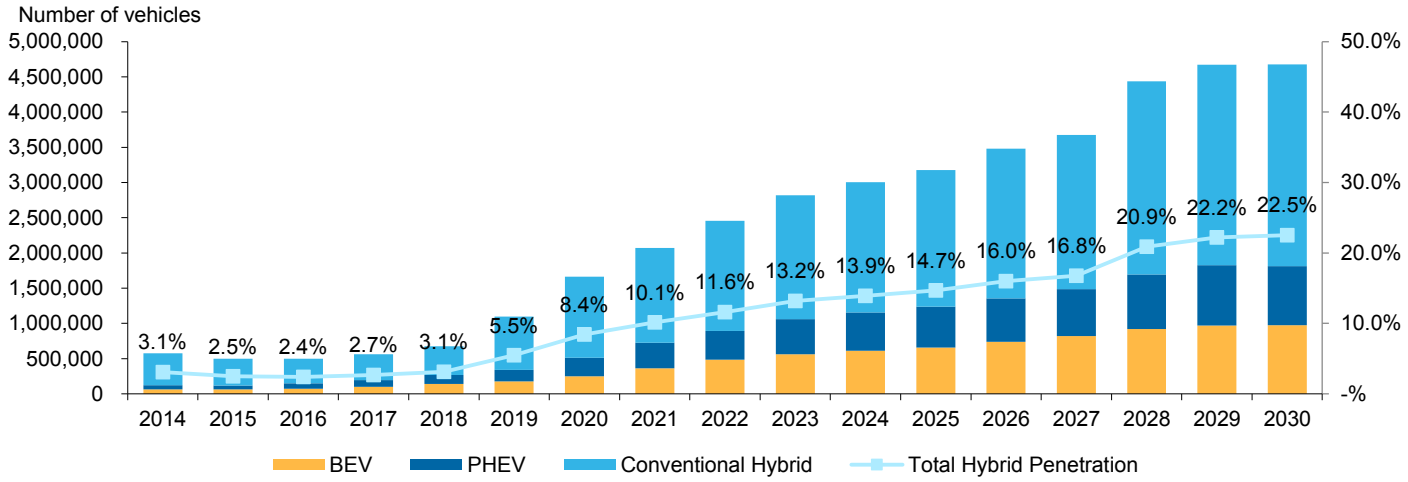
Source: LMC Automotive, Macquarie Capital (USA), October 2018

Fig 80 U.S. EV Sales Distribution - 2030



Source: LMC Automotive, Macquarie Capital (USA), October 2018

Fig 81 U.S. EV Sales Volumes and Penetration Rates



Source: LMC Automotive, Macquarie Capital (USA), October 2018

The Long Term Future for Hybrid Vehicles

While hybrids help to ameliorate total vehicle emissions over the medium term, we view the future automotive sector as entirely electric. The original thesis behind the rise of hybrids, i.e. oil prices (cost), emissions concerns, and underdeveloped battery tech, falls apart upon successful execution of an electric vehicle that fulfils the following key consumer specifications

- Total cost of ownership (MSRP plus cost of ownership)
  - ⇒ Battery packs are set to decrease in cost over the coming years, though currently remains the largest input cost for EVs
  - ⇒ Full EVs’ cost of ownership is already generally lower than that of ICE vehicles
- Sufficient range (e.g. >200 miles)
  - ⇒ Tesla and Chevy already produce models with 200+ mile range, while other OEMs have announced plans for new EV models to be introduced over the next 5 years with similar specifications

- Refuel time
  - ⇒ Fast charging for a Tesla still takes ~1 hour and continues to pose a meaningful barrier of adoption for mainstream consumers
  - ⇒ Future progress in battery recharge / refuelling technology is required

As these obstacles are ultimately overcome by advancements in technology and increased industry adoption of EV architectures, hybrid volumes are likely to broadly decline. Barring regulatory restrictions on production of full ICE models, the incremental emissions / fuel economy advantage of hybrids will become overshadowed by BEVs. Thus, conventional and PHEVs will play an important part in helping to minimize vehicle emissions and mitigate oil demand growth over the short to medium term, though the tall advantages of BEVs will likely minimize the future role of hybrid vehicles over the longer term.

Tesloop Maintenance Record Details

Fig 82 Tesla Model S "eHawk" Maintenance Record over 400k Miles

Maintenance Item	Mileage	Cost
Tire Replacement	51,000	$194
Wheel Alignment	74,469	$200
Tire Replacement	75,135	$513
Tire Replacement	95,242	$388
Tire Replacement	126,419	$389
Rear Bumper Repairs	N/A	$1,000
Tire Replacement	159,648	$389
12v Battery Replacement	194,237	$171
Replace - Front/Rear Brake Pads/Rotors	225,351	$1,759
Tire Replacement	231,546	$334
Wheel Alignment	231,570	$0
Replaced Headlights	251,252	$2,800
General Maintenance	274,610	$2,176
Replace AC TXV Valve Evaporator	278,732	$436
Tire Replacement	278,735	$666
Air Conditioning	290,263	$1,351
Tire Replacement	362,821	$362
Tire Replacement	N/A	$100
Tire Replacement	386,025	$781
	Total:	**$14,009**
	$/Mile over 400k Miles:	**$0.04**

Source: Tesloop Website, Macquarie Capital (USA), October 2018

Fig 83 Tesla Model X Maintenance Record over 300k Miles

Maintenance Item	Mileage	Cost
Tire Replacement	5,000	$112
Tire Replacement	9,725	$574
Tire Replacement	39,250	$423
Tire Replacement	68,000	$1,012
Air Conditioning	72,384	$987
Other - Towing	N/A	$660
Tire Replacement	77,235	$363
Parts - Windshield Wipers	91,168	$60
Tire Replacement	94,180	$702
Tire Replacement	115,368	$355
Wheel Alignment	119,038	$166
Tire Replacement	135,927	$372
Tire Replacement	151,970	$369
Towing	N/A	$255
12V Battery Replacement	158,114	$133
Parts - Axle, Brake Pads and Rotors	166,449	$2,394
Tire Replacement	167,402	$732
Tire Replacement	199,781	$370
Tire Replacement	227,318	$362
Windshield/Window Repair	N/A	$79
Tire Replacement	246,882	$374
Tire Replacement	272,487	$360
Parts - Axle Seal	302,477	$170
Tire Replacement	N/A	$128
Tire Replacement	307,808	$186
Towing	315,161	$128
	Total:	**$11,824**
	$/Mile over 300k Miles:	**$0.04**

Source: Tesloop Website, Macquarie Capital (USA), October 2018

Fig 84 Lincoln Town Car Prospective Maintenance Record over 400k Miles

Maintenance Item	Frequency (miles)	Unit Cost	Total Cost
Oil Change	6,250	$35	$2,240
Brake Shoe Replacement (Rear)	43,750	$225	$2,057
Fuel Filter Replacement	45,000	$100	$889
Replace coolant for main circuit	45,000	$130	$863
Brake Pad Replacement	62,500	$300	$1,920
Brake Rotors/Discs Replacement	62,500	$400	$2,560
Radiator Hose Repair	75,000	$262	$1,395
Single Window Electrical Repair	75,000	$320	$1,278
Serpentine/Drive Belt Replacement	90,000	$104	$460
Drive Belt Tensioner Replacement	90,000	$157	$698
Transmission Fluid Flush	90,000	$150	$500
Differential/Gear Oil Replacement	120,000	$109	$363
Oil Pan Gasket Replacement	120,000	$399	$1,330
Oxygen Sensor Replacement	120,000	$173	$577
Timing Belt	120,000	$250	$833
Alternator Repair	125,000	$236	$754
CV Axle / Shaft Assembly Replacement	125,000	$337	$1,077
Wheel Bearings Replacement	150,000	$255	$680
Fuel Pump Replacement	150,000	$600	$1,600
Power Steering Pump Replacement	150,000	$190	$507
Power Steering Pressure Hose Replacement	150,000	$185	$493
Car AC Compressor Replacement	187,500	$692	$1,476
Car Starter Repair	187,500	$205	$436
Blower Motor and Regulator	225,000	$600	$800
Radiator Replacement	262,500	$600	$914
Ignition Coil Replacement / Spark Plugs	300,000	$350	$467
Ball Joint Replacement (Front/Rear)	300,000	$400	$533
		Total:	**$27,700**
	$/Mile over 400k Miles:		**$0.07**

Source: Tesloop Website, Macquarie Capital (USA), October 2018

Fig 85 Mercedes GLS Prospective Maintenance Record over 300k Miles

Maintenance Item	Frequency (miles)	Unit Cost	Total Cost
Oil Change	6,250	$35	$1,680
Brake Shoe Replacement (Rear)	43,750	$225	$1,543
Replace Engine Air Filter	45,000	$100	$667
Replace coolant for main circuit	45,000	$130	$863
Brake Pad Replacement	62,500	$300	$1,440
Brake Rotors/Discs Replacement	62,500	$400	$1,920
Replace radiator / hoses	75,000	$862	$3,446
Single Window Electrical Repair	75,000	$320	$1,278
Serpentine/Drive Belt Replacement	90,000	$104	$345
Starter Motor / New Battery	90,000	$243	$808
Drive Belt Tensioner Replacement	90,000	$157	$523
Transmission Fluid Flush	90,000	$150	$500
Differential/Gear Oil Replacement	120,000	$109	$273
Oil Pan Gasket Replacement	120,000	$399	$998
Oxygen Sensor Replacement	120,000	$173	$433
Timing Chains	120,000	$250	$625
CV Axle / Shaft Assembly Replacement	125,000	$337	$808
Replace Alternator	150,000	$236	$471
Wheel Bearings Replacement	150,000	$255	$510
Fuel Pump Replacement	150,000	$600	$1,200
Replace Spark Plugs	150,000	$153	$306
Power Steering Pump Replacement	150,000	$190	$380
Power Steering Pressure Hose Replacement	150,000	$185	$370
AC Compressor Replacement	225,000	$692	$923
Blower Motor and Regulator	225,000	$600	$800
Ball Joint Replacement (Front/Rear)	300,000	$400	$400
		Total:	**$23,508**
	$/Mile over 300k Miles:		**$0.08**

Source: Tesloop Website, Macquarie Capital (USA), October 2018

Changes to ZEV Regulations Could Help ZEV Demand

What are Zero Emission Vehicle (ZEV) credits?

In ten states, auto OEMs are required to accrue a certain number of ZEV credits as a percentage of their total sales of passenger cars and light duty trucks. ZEV credits are earned through the sale of various types of zero- or low-emission vehicles. Automakers may also buy or sell credits if they have excess credits or are short credits (the latter scenario carries a fine). Tesla generally tends to have excess credits as it only sells battery electric vehicles (the highest number of credits are given to all electric vehicles with ranges greater than 350 miles).

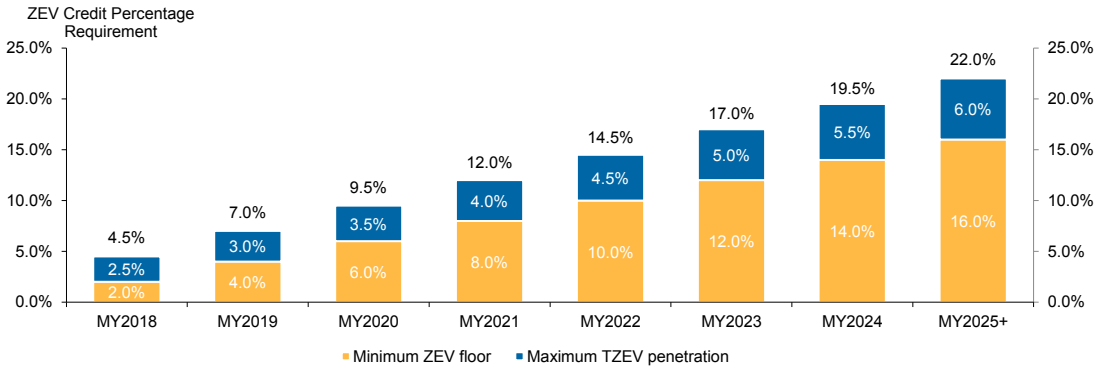
What’s Changing That Might Drive ZEV Credit Demand? Clean ICE and conventional hybrids no longer generate credits

Starting with 2018 car year models, the regulation around ZEV credits changes. Historically, there have been six types of vehicles an OEM could get ZEV credits for –

1) Zero Emission Vehicles (ZEV): these are battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV)
2) Transitional Zero Emission Vehicles (TZEV): these are plug-in hybrid electric vehicles (PHEV) and hydrogen internal combustion engine vehicles (HICE)
3) Partial Zero-Emission Vehicle (“PZEV”): principally composed of highly clean running internal combustion engine (ICE) vehicles
4) Advanced Technology PZEVs (“AT PZEVs”): principally composed of non-plug-in hybrid electric vehicles
5) 1.5x/IIx
6) Neighbourhood Electric Vehicles

Starting with the 2018 car year model, PZEV and AT PZEVs are not eligible to earn credits and the ZEV credit percentage required is 4.5% and increases 250 basis points until it reaches 22% for 2025 car year models. For large vehicle manufacturers (Fiat Chrysler, Ford, GM, Honda, Nissan, and Toyota), there is an additional requirement for a certain portion of the credit requirements to be fulfilled by zero emission vehicles (battery electric or fuel cell electric vehicles).

Fig 86 ZEV Credit Percentage Requirement By Model Year



Source: California Air Resource Board, Macquarie Capital (USA), October 2018

While OEMs appear to have been acquiring credits in anticipation of this increase, we nonetheless believe this could help to increase ZEV credit demand over time from some of the larger OEMs that have historically generated a large number of credits from these types of vehicles if they do not ramp sales of other zero emission vehicles (Honda has the largest balance of PZEV credits and Toyota of AT PZEV credits).

Background on ZEV Program

The Zero Emission Vehicle (“ZEV”) Program was first established by the California Air Resources Board (“CARB”) in 1990 as part of the Low Emission Vehicle Program in an effort to reduce extensive air pollution affecting major cities in the state (e.g. Los Angeles). Today, the ZEV Program extends across California and 13 other states plus the District of Columbia, though CARB still manages the program.

Under this system, automakers are classified as small (“SVM”), intermediate (“IVM”), and large volume manufacturers (“LVM”) based on latest trailing average annual sales volume – ZEV Program requirements are most stringent for LVMs and decline in rigidity for IVMs and SVMs. Automakers are rewarded credits based on the number of ZEV units it sells within participating states, though earn credits depending on the vehicle’s powertrain:

- BEVs and FCEVs: credits awarded based on All-Electric Range (“AER”)
  - ⇒ A vehicle’s EPA rated range is generally ~70% of the value of a vehicle’s AER value
  - ⇒ Zero credits for AER < 50 miles
  - ⇒ ZEV credits equals (0.01 x AER) + 0.50 for AER > 50 miles
  - ⇒ ZEV credits earned is capped at 4.00 per vehicle for AER > 350 miles
- Transitional Zero Emission Vehicles (“TZEV”) mainly include Plug-in Hybrid Electric Vehicles (“PHEVs”)
  - ⇒ Additional requirements:
    - Super Ultra-Low Emissions Vehicle (“SULEV”) emission standards and zero evaporative emissions
    - 15 year / 150,000 mile extended emissions warranty and 10 year / 150,000 mile warranty on energy storage device
  - ⇒ Zero credits for AER < 10 miles
  - ⇒ ZEV credits equals (0.01 x EAER) + 0.30 for AER > 10 miles
    - Equivalent All-Electric Range (“EAER”) is similar to AER, though with slightly different test procedures
    - ≥ 10 miles of AER on US06 test cycle adds additional 0.2 credits
  - ⇒ ZEV credits earned is capped at 1.10 per vehicle for AER > 80 miles
    - ≥ 10 miles of AER on US06 test cycle adds additional 0.2 credits

Automakers are required to accrue ZEV credits based on their total sales of passenger cars and light duty trucks (including ZEVs). This total volume figure is calculated using the average of the previously 2nd, 3rd, and 4th model years from the current model year (e.g. 2018 MY’s ZEV credit percentage is calculated as the average of 2014-16 MY sales). Model year 2018 is the first year for implementation of the new CARB ZEV standards, which we believe further supports ZEV pricing going forward for the following reasons:

ZEV credits market

The market for ZEV credits is dictated by supply and demand – namely automakers with high sales of ZEV vehicles and automakers with low to no sales of ZEV vehicles. Elon Musk has, in the past, mentioned that the $/credit TSLA had been realizing was roughly $2,500, which is consistent with our calculation based on the company’s latest ZEV revenue figures and state government data.

Public state records show that in the 12 months ending in August 2017, TSLA transferred approximately 83K credits. Unfortunately, this time horizon doesn’t correspond with TSLA’s quarterly reporting, which shows that the company accrued $120M in ZEV revenue in the 12 months ending September 2017 and $258M in ZEV revenue in the 12 months ending June 2017. This yields a range of values for $/credit of $1,500-$3,100, implying a midpoint of ~$2,300/credit.

Model year 2018 is the first year for implementation of the new CARB ZEV standards, which we believe further supports ZEV pricing going forward for the following reasons:

1) **Clean ICE and conventional hybrids no longer generate credits; existing credits to get a haircut:** CARB’s new ZEV program dictates that credits are only earned via ZEV (i.e. BEVs and FCEVs) and TZEV (i.e. PHEVs) vehicles and exclude Partial Zero-Emission Vehicle (“PZEV”) and Advanced Technology PZEVs (“AT PZEVs”), which are principally composed of highly clean running ICE vehicles and non-plug-in hybrid electric vehicles. Major automakers such as Toyota and Honda have historically depended on PZEV and AT PZEV volumes to meet California’s emissions requirements. In particular, the Prius and hybrid versions of the Camry, Avalon, RAV4, and Highlander have been key volume models for Toyota, while hybrid models of the Accord as well as the Insight and the Clarity have been important for Honda. Emissions credits carried over from prior years’ AT PZEV and PZEV volumes are set to take a 93.25% and 75% respective discount for LVMs (75% overall discount for IVMs) starting model year 2018 as well. Thus, the drop-off in PZEV and AT PZEV credit eligibility will significantly constrain the supply of emissions credits during this current model year cycle.

2) **Impending model year 2018 ZEV requirement that escalates rapidly each year:** The ZEV requirement for model year 2018 is 4.5%, of which 2.0% must be fulfilled with ZEVs, and steps up aggressively at 2.5% per year overall for ZEVs and TZEVs. Ever increasing ZEV requirements being implemented during the current 2018 model year will drive ever increasing demand for emissions credits

3) **Lack of ZEV models offered currently and uncertainty of future ZEV entries:** Of the LVMs operating in California currently, Ford currently does not offer a ZEV within its product portfolio, and Toyota only stocks the Mirai, which is dependent on access to nascent hydrogen fuel cell refuelling infrastructure. While all LVMs have introduced aggressive electrification plans over the next five years, consumer demand for such future nameplates remains uncertain, as even “successful” models such as the Leaf and Bolt have experienced year-on-year declines in volumes since their first introduction. The current lack of / poor performance of ZEV models (excluding TSLA’s) and the untested potential of future ZEV entries limits the supply of emissions credits

4) **Stiff penalties for non-compliance:** The penalty for non-compliance with required ZEV thresholds is $5K/credit and still requires the automaker to make up for the missed credit. LVMs must make up for their deficit the following year (IVMs can hold a deficit for up to 3 years in special cases) and must use ZEV, not TZEV credits to make up for missed credits (IVMs can use ZEV and TZEV credits). The significant financial cost of incurring ZEV penalties gives the program real teeth and reinforces demand for emissions credits.

Important disclosures:

Recommendation definitions

Macquarie - Australia/New Zealand
Outperform – return >3% in excess of benchmark return
Neutral – return within 3% of benchmark return
Underperform – return >3% below benchmark return

Benchmark return is determined by long term nominal GDP growth plus 12 month forward market dividend yield, which is currently around 9%.

Macquarie – Asia/Europe
Outperform – expected return >+10%
Neutral – expected return from -10% to +10%
Underperform – expected return <-10%

Mazi Macquarie – South Africa
Outperform – expected return >+10%
Neutral – expected return from -10% to +10%
Underperform – expected return <-10%

Macquarie - Canada
Outperform – return >5% in excess of benchmark return
Neutral – return within 5% of benchmark return
Underperform – return >5% below benchmark return

Macquarie - USA
Outperform (Buy) – return >5% in excess of Russell 3000 index return
Neutral (Hold) – return within 5% of Russell 3000 index return
Underperform (Sell)– return >5% below Russell 3000 index return

Volatility index definition*

This is calculated from the volatility of historical price movements.

Very high–highest risk – Stock should be expected to move up or down 60–100% in a year – investors should be aware this stock is highly speculative.

High – stock should be expected to move up or down at least 40–60% in a year – investors should be aware this stock could be speculative.

Medium – stock should be expected to move up or down at least 30–40% in a year.

Low–medium – stock should be expected to move up or down at least 25–30% in a year.

Low – stock should be expected to move up or down at least 15–25% in a year.
* Applicable to Asia/Australian/NZ/Canada stocks only

Recommendations – 12 months
Note: Quant recommendations may differ from Fundamental Analyst recommendations

Financial definitions

All "Adjusted" data items have had the following adjustments made:
Added back: goodwill amortisation, provision for catastrophe reserves, IFRS derivatives & hedging, IFRS impairments & IFRS interest expense
Excluded: non recurring items, asset revals, property revals, appraisal value uplift, preference dividends & minority interests

EPS = adjusted net profit / efpowa*
ROA = adjusted ebit / average total assets
ROA Banks/Insurance = adjusted net profit /average total assets
ROE = adjusted net profit / average shareholders funds
Gross cashflow = adjusted net profit + depreciation
*equivalent fully paid ordinary weighted average number of shares

All Reported numbers for Australian/NZ listed stocks are modelled under IFRS (International Financial Reporting Standards).

Recommendation proportions – For quarter ending 30 September 2018

	AU/NZ	Asia	RSA	USA	CA	EUR	
Outperform	51.56%	59.51%	45.05%	46.88%	67.86%	46.70%	(for global coverage by Macquarie, 3.70% of stocks followed are investment banking clients)
Neutral	33.20%	28.92%	37.36%	47.70%	25.00%	42.73%	(for global coverage by Macquarie, 2.04% of stocks followed are investment banking clients)
Underperform	15.23%	11.57%	17.58%	5.42%	7.14%	10.57%	(for global coverage by Macquarie, 0.47% of stocks followed are investment banking clients)

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