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MCKINSEY CENTER FOR FUTURE MOBILITY

An automotive metamorphosis?
Adaptation, adoption and autonomy

Singapore | November 2018

www.mckinsey.com/mcfm

Key messages

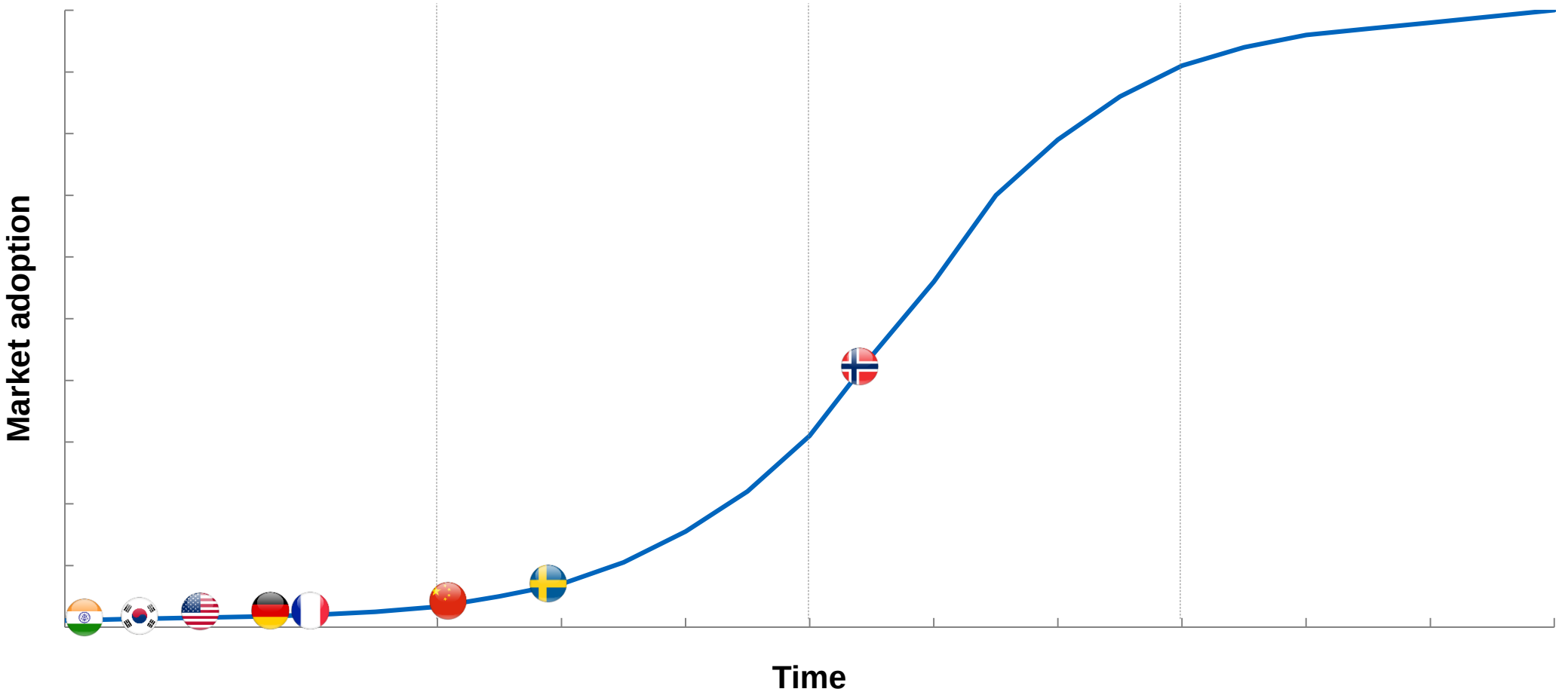
1. It is economic story, not environmental – markets in the money today enough to drive the S-curve
2. EVs are not a trend in isolation, they are in combination with AVs and Shared vehicles
3. Charging infrastructure is the main reason why people are not buying – “chicken and egg”.
4. The new business model – selling a “system” not a car, in the future selling mobility
5. Asia can lead the revolution – China, penetration in three wheelers etc. in developing countries

1 Electric vehicle sales are increasing at very different speeds around the world

ILLUSTRATIVE

The 4 stages of a disruptive trend – focus on EV market adoption

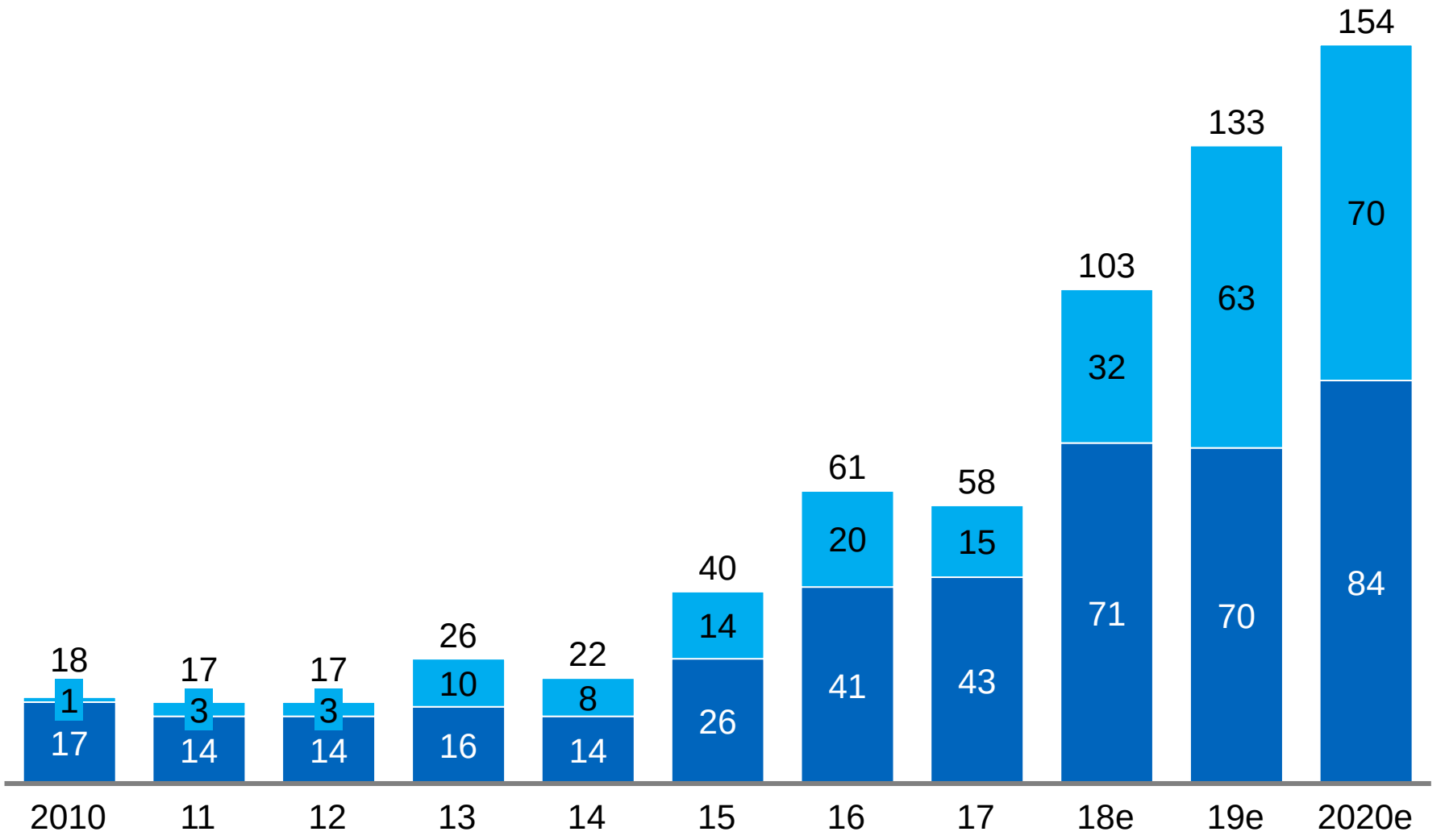
Disruption is…	Detectable	Clear	Inevitable	New normal
	Faint signals with lots of noise	Emergence of a validated model	Critical mass of adoption achieved	At scale and mature



SOURCE: Sven Smit - Strategy beyond the hockey stick (2018); McKinsey

1 Electric vehicle launches keep on increasing with almost 300 new models being introduced in the next two years worldwide

Number of new BEV and PHEV model launches worldwide



Implications

- Compared to the past few years, significantly more launches of electric vehicles are planned by various manufacturers
- Full-battery EV launches still outnumber plug-in hybrid EVs, though the latter are gaining importance
- Limitations on the supply side are likely to not be an issue anymore in the mid term

SOURCE: IHS Automotive (Jul 2018), McKinsey

1 Let's talk economics – although the average consumer does not yet have a TCO benefit from an EV…

EXAMPLE AUSTRALIA

Internal Combustion Engine (ICE)

2017 Toyota Corolla

- 650km range
- 7-9L/ 100km
- 173 Nm torque
- 103kW
- 0-100 in ~9s

Electric Vehicle (EV)

2017 Chevrolet Bolt

- 320km range
- 60kWhr battery
- 360 Nm torque
- 200 hp 150 kW
- 0-100 in <7s

Purchase price[1], $000's

- **EV $20k higher price**

Average annual operating cost[2], $000's

- **EV $2k cheaper /year**

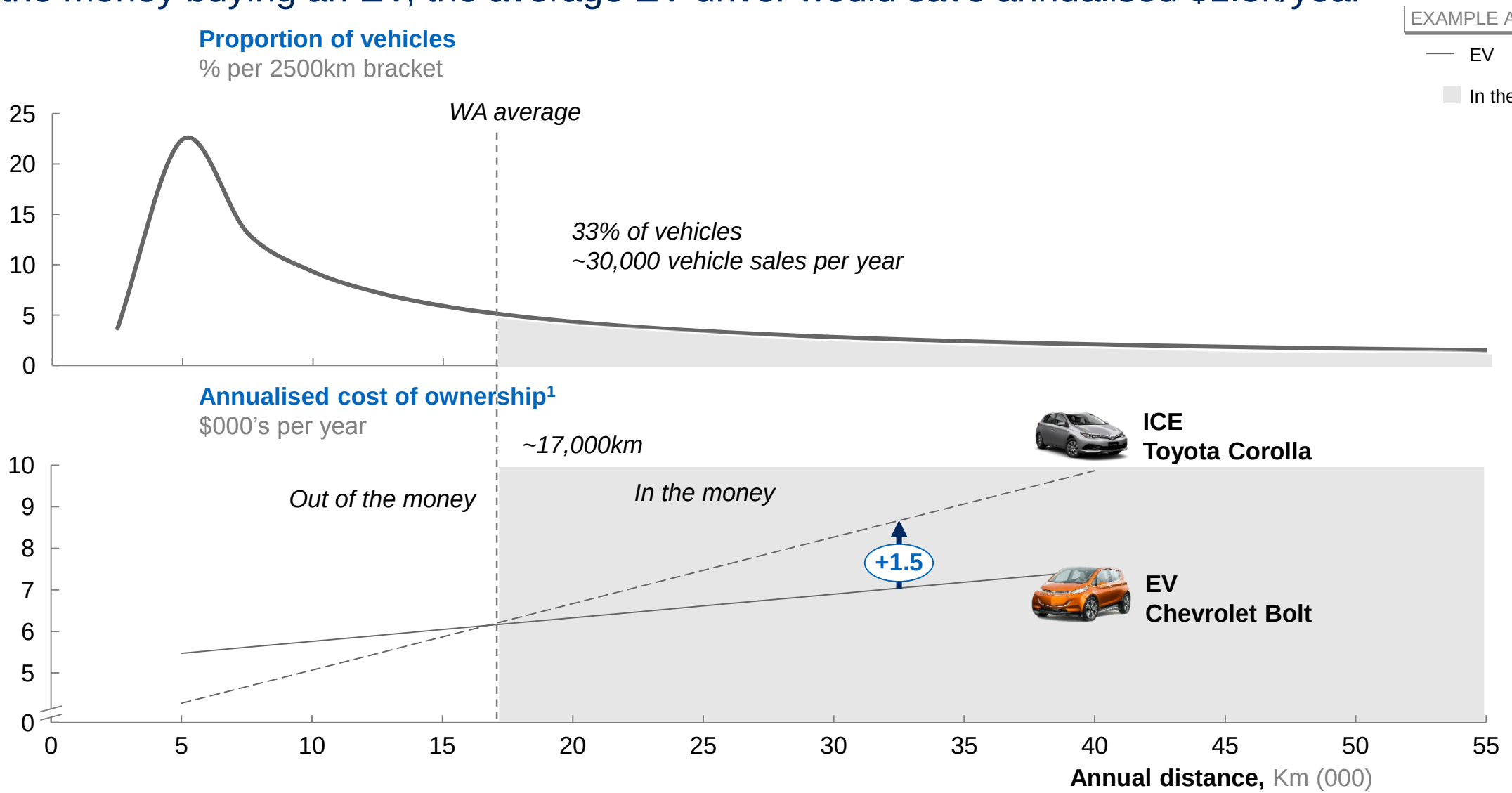
Average NPV of Total Cost of Ownership[3] (TCO) $000's

- **EV $7k higher TCO in NPV**

1 US prices scaled to Australian dollars; 2 Assumptions of $1.35/L for unleaded petrol, 20c/kwh for grid electricity (25% coming from decentralised solar @7c/kwh and 75% from the grid at 25c/kwh); 3 10 year life span, residual value based on Redbook, 7% finance rate

SOURCE: http://gmauthority.com/blog/gm/chevrolet/chevrolet-bolt-ev/2017-bolt/ http://www.zeroto60times.com/vehicle-make/toyota-0-60-mph-times/ http://www3.toyota.com.au/corolla/specifications/ascent-sedan-manual

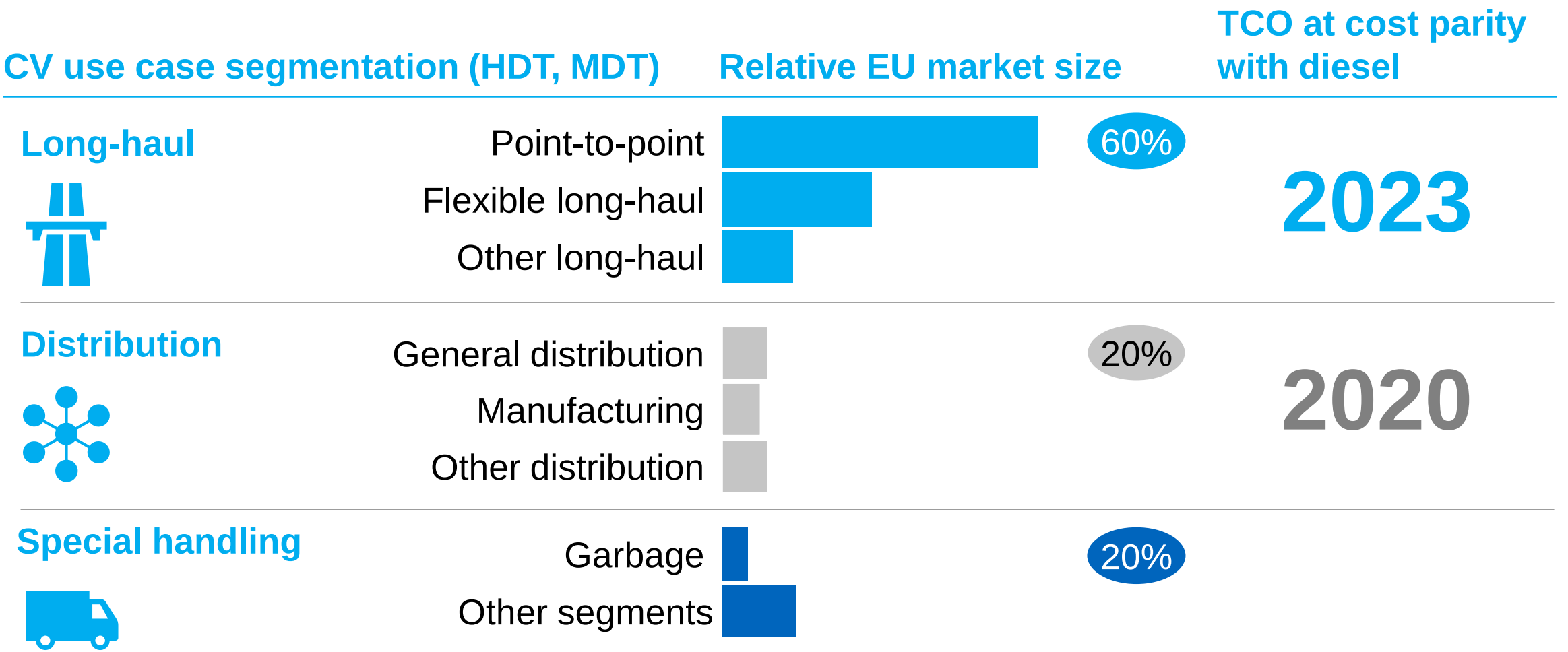
1 It's not the average consumer that counts - in this case, 30% of consumers are already be in the money buying an EV, the average EV driver would save annualised $1.5k/year



1 Central assumptions of $1.35/L for unleaded petrol, 20c/kwh for grid electricity (25% coming from decentralised solar @7c/kwh and 75% from the grid at 25c/kwh), 10 year life span, residual value based on Redbook, 7% finance rate; 2 ICE models chosen as close performance and segment substitutes; 3 WA car sales in 2015

SOURCE: Manufacturers Websites, RAC WA, IHS Automotive DRIVEN BY Polk

1 Electrification for commercial vehicles is approaching a clear tipping point with specific use cases breaking even with diesel over the next years

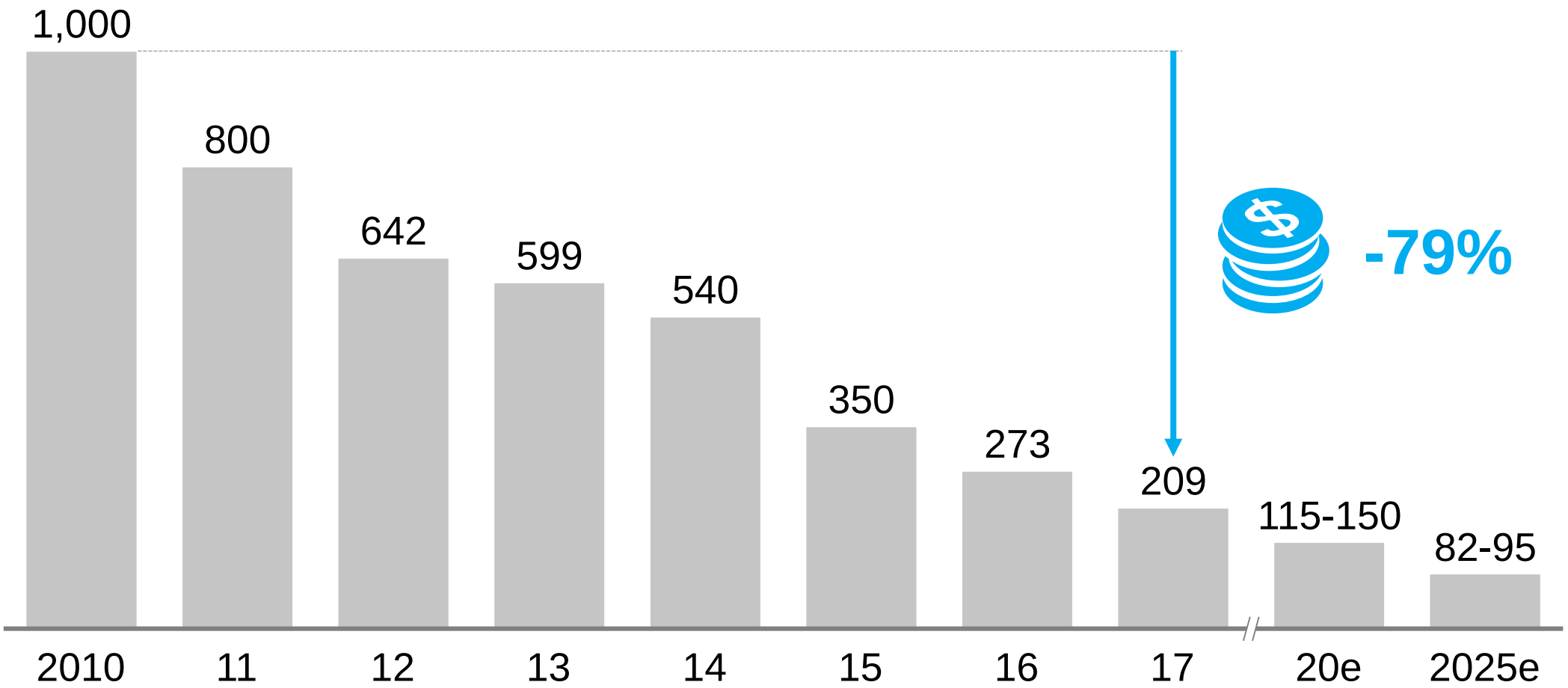


Trigger points: regulation, toll, battery technology, TCO, charging infrastructure, NLR

SOURCE: IHS Automotive; McKinsey Center for Future Mobility

1 Lithium-ion battery pack prices keep on decreasing

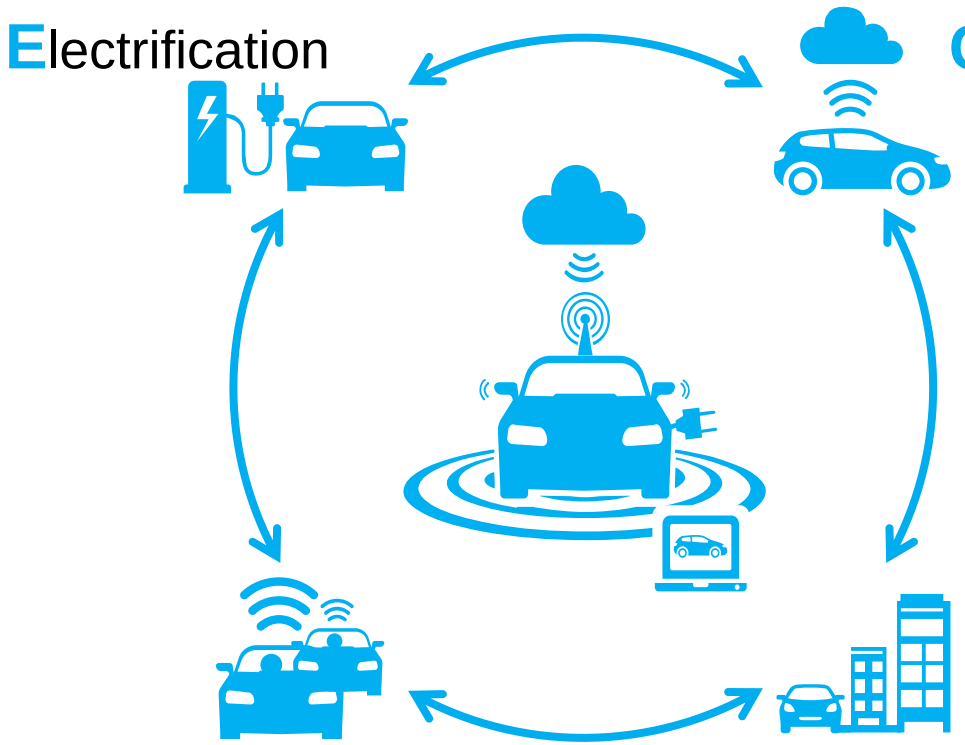
Lithium-ion battery pack price development, USD/kWh



SOURCE: BNEF; Bernstein; McKinsey Center for Future Mobility

2

Four disruptive technology-driven trends…



… radically changing the mobility industry

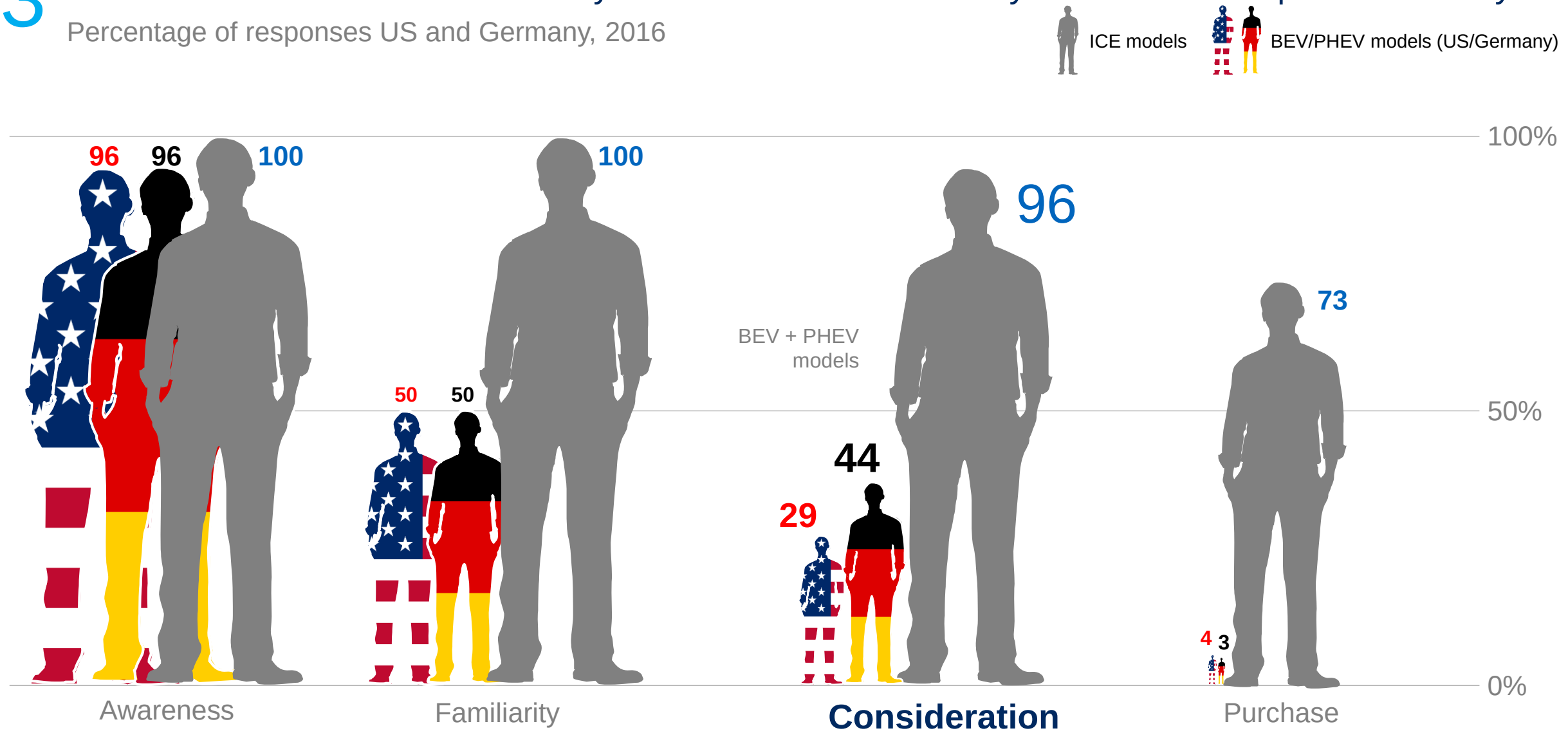
- Changes in mobility behavior
- Shifting markets and revenue pools
- Diffusion of advanced technology
- New competition and cooperation

39% of Chinese consumers do not think it is necessary anymore to own a car given the alternatives

SOURCE: McKinsey Center for Future Mobility

3 Between 30 and 45% of vehicle buyers in the US and Germany consider an EV purchase today

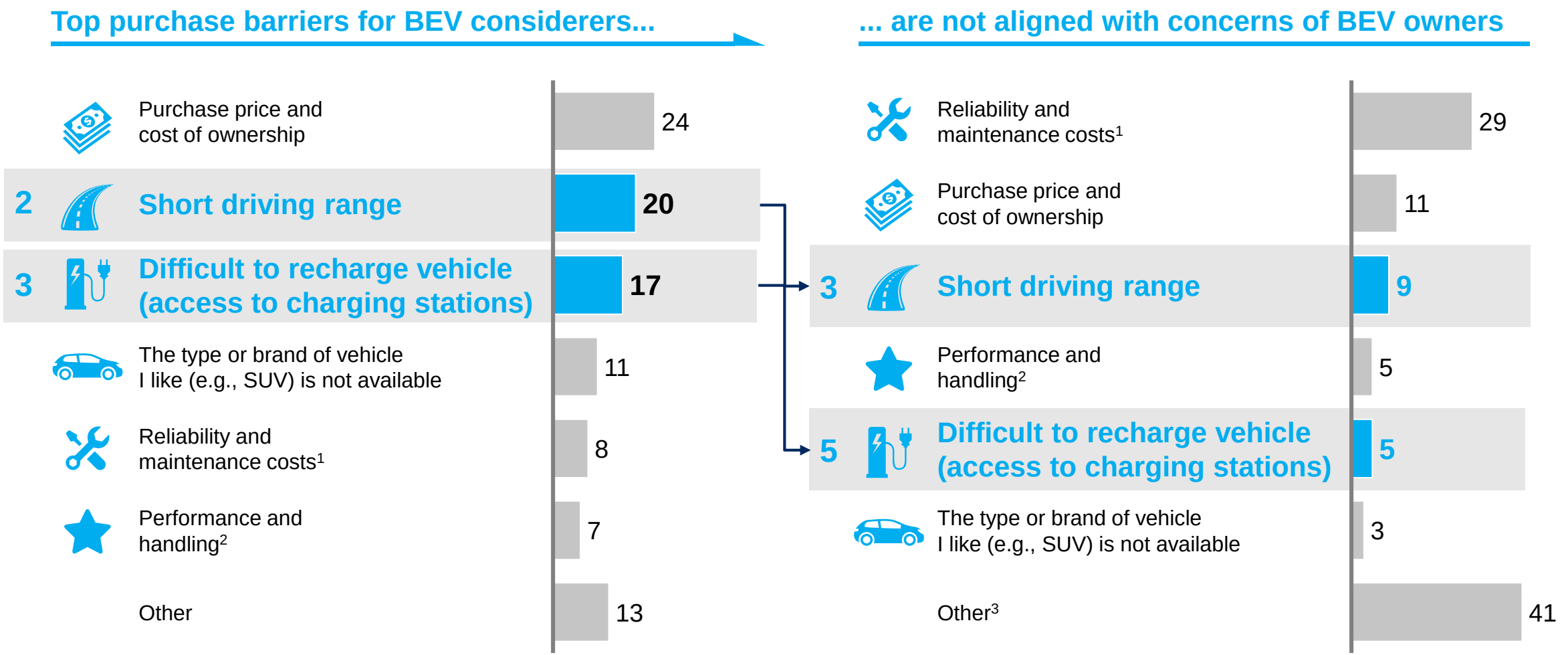
Percentage of responses US and Germany, 2016



SOURCE: McKinsey 2016 Electrified Vehicle Consumer Survey,

3 Some perceived customer concerns of electric vehicles are not issues during ownership

% of survey respondents



1 Includes “maintenance cost” and “battery pack reliability”
2 Includes “poor power/acceleration performance" and “not fun to drive“
3 Price of electricity (11%) , reduced range when running accessories (8%), time to charge battery (8%), service availability (7%), I don’t understand/trust the technology (5%)

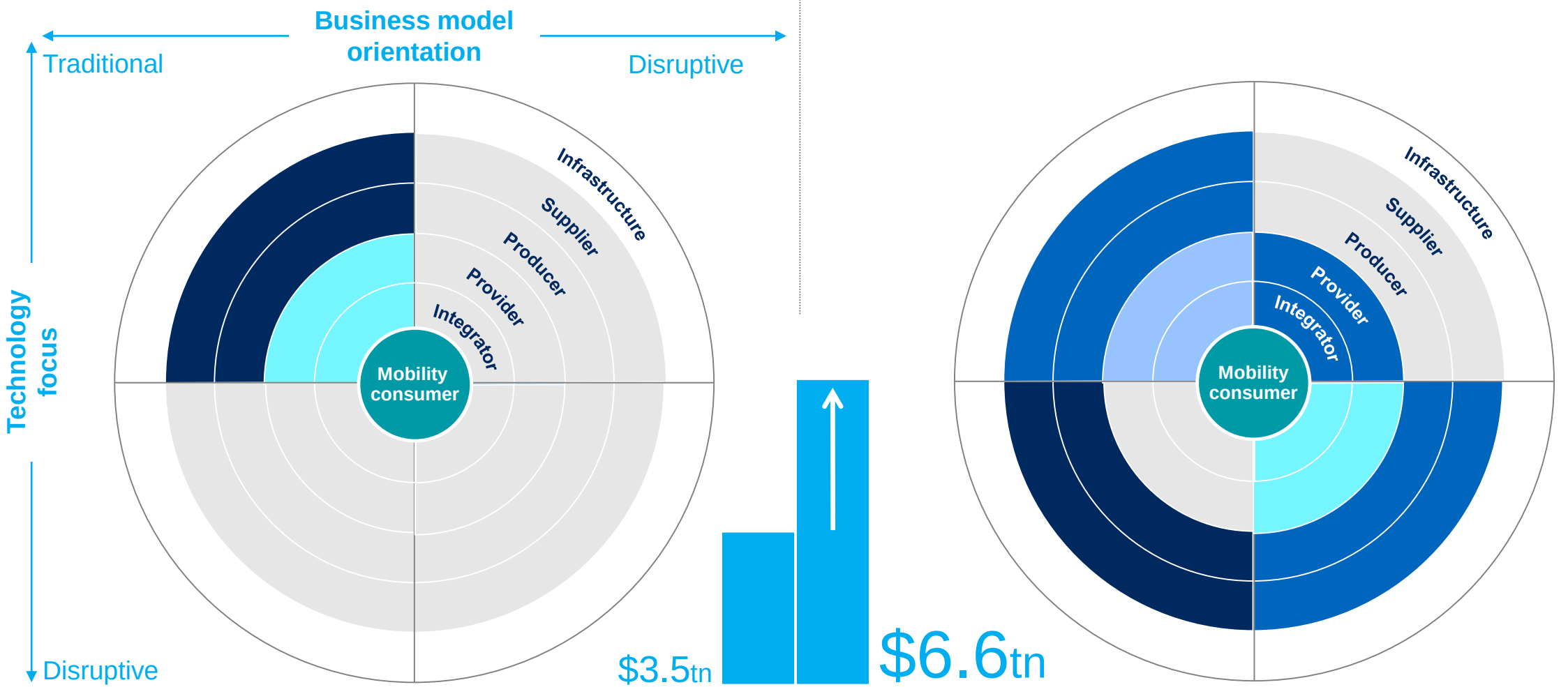
SOURCE: McKinsey 2016 Electrified Vehicle Consumer Survey

4 Today, the industry revenue comes from traditional business models and traditional technology while by 2030 it will be divided across many more areas

USD 0 0.1 0.4 0.7 2.0 3.5tn

Status quo 2017

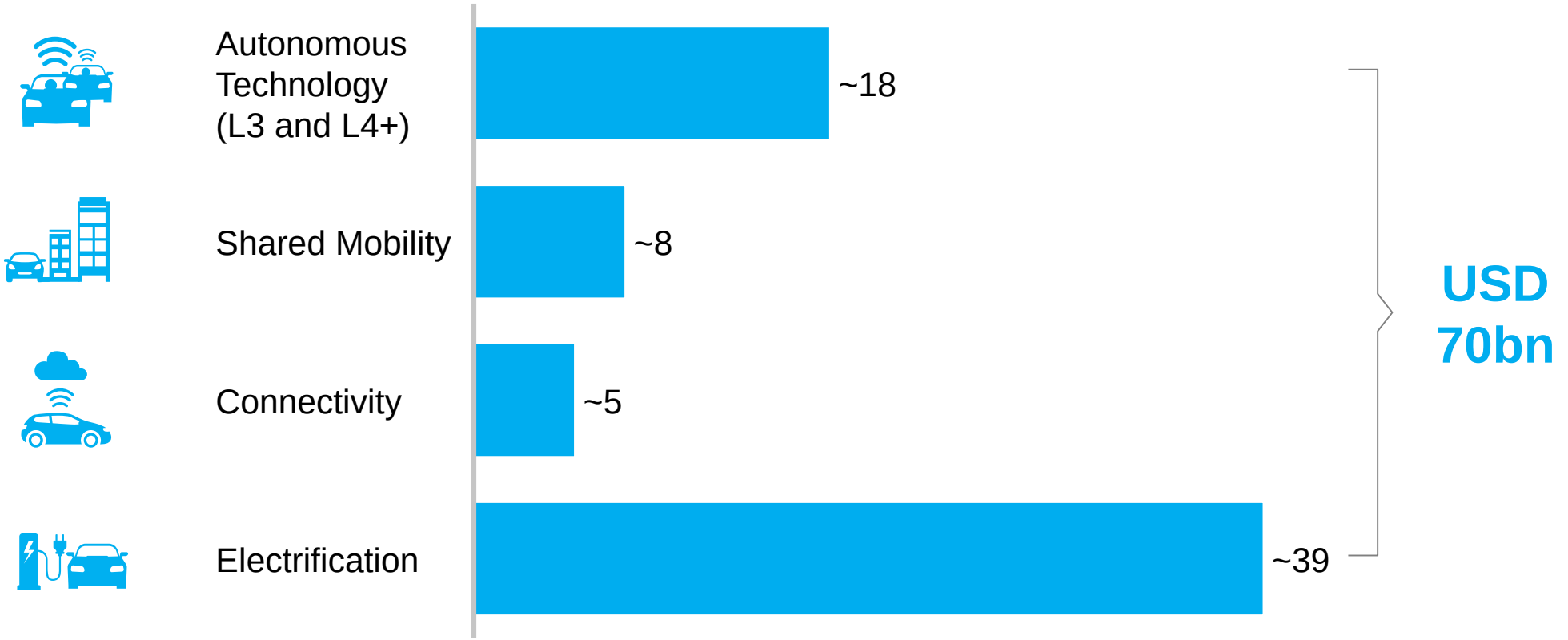
Disruption to personal mobility 2030



SOURCE: McKinsey Center for Future Mobility

4 To participate across all new technologies, individual players will struggle to invest a required USD 70 bn over the next 10 years

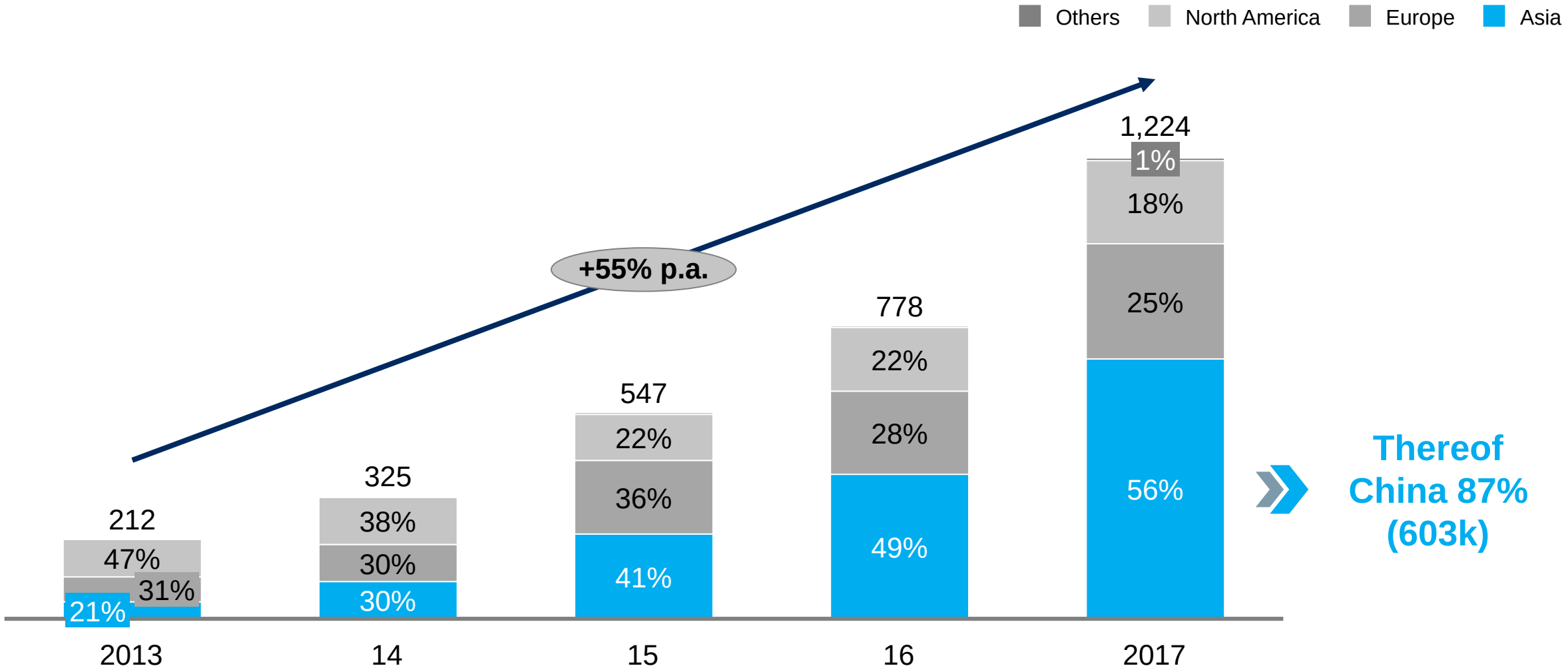
Expected investment volume required for a "fully integrated mobility player", USD bn



SOURCE: McKinsey Center for Future Mobility

5 Asia continues to expand its global market share in EV sales now combining 690,000 units

Global light electric vehicle sales by region, 2010-2017 in thousand units



1 China, Japan, South Korea, Hong Kong, Taiwan, Malaysia, Sri Lanka, Thailand, Indonesia, Singapore, India, Philippines 2 EU28 + Norway and Switzerland 3 USA and Canada

SOURCE: EV Volumes, McKinsey

5 China is positioning itself as a lead market for e-mobility

61 Chinese brands selling EVs in 2018 in China

5mn Charging poles by 2020

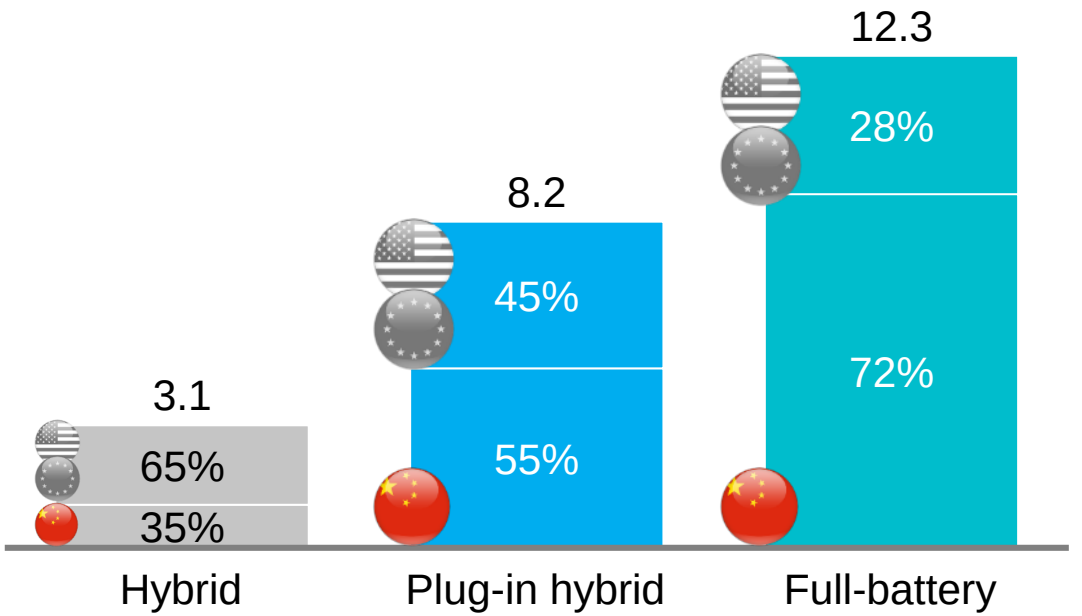
5.5bn government subsidies in China on EV in 2017 in USD

68% China share of global refined Cobalt production in 2017

>60% China share of global Li-Ion capacities in 2028

New vehicle sales by powertrain type

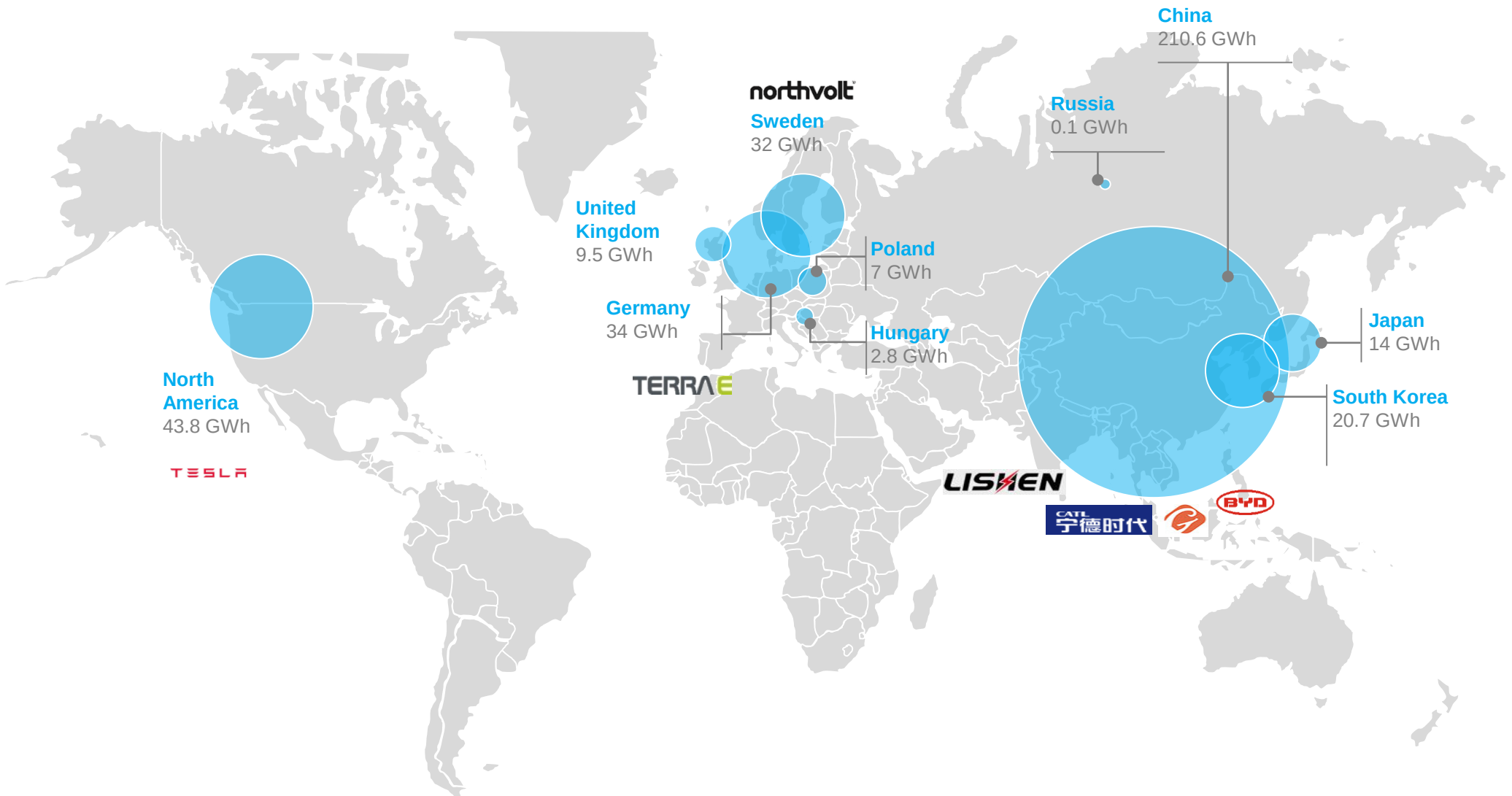
K units, Base case 2030, Europe, US, China combined



~60% China share of global EV sales across all 3 categories

SOURCE: IHS, Fuji, Bernstein, MCFM

5 Battery manufacturing capacity is expected to reach ~370 GWh by 2028, mostly driven by China



Notes: Benchmark estimates; not all data disclosed by companies; 2 GWh production capacity for rest of world

SOURCE: Visual Capitalist; Benchmark Mineral Intelligence; press search

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Back-ups

Over the past 2 years, significant additional momentum has been built along all four disruptive trends

Autonomous driving

80% of the top 10 OEMs plan to have **highly autonomous technology** by 2025

Connectivity

40% of consumers would **change** the **car brand** for better connectivity (+20 pp vs 2014)

Electrification

>40% of models announced **until 2021** will have **xEV powertrains**

Shared mobility

At least **$32 billion** have been invested **in ridesharing start-ups**

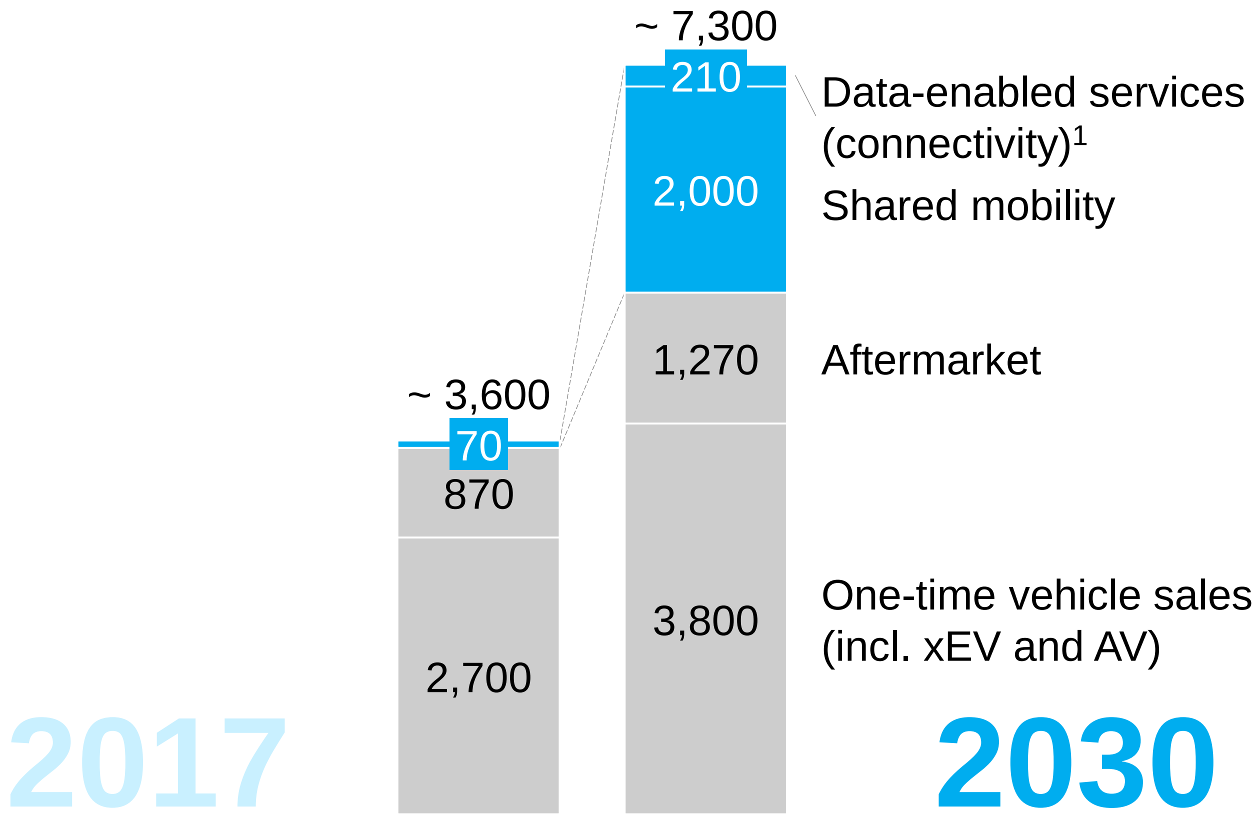
SOURCE: McKinsey Center for Future Mobility

With disruptive scenarios becoming more likely, the share of revenues from disruptive business models could increase to 20-25% by 2030

Traditional business models | Disruptive business models

Automotive revenues based on consumer spend in 2017 and 2030

"Disruption to personal mobility" scenario, $ bn



The world we have to believe in for this scenario

Examples

80-90% ridesharing mobile app adoption on smartphones globally

10x growth in rideshare vehicle miles travelled, with shared mobility accounting for **up to 20% in dense cities**

100% connectivity saturation by 2021 and **robotaxis covering 6%** of passenger miles travelled by 2030

~50% of vehicles sold are electrified and many regulators only allow PHEV/BEV in new cars

1 Revenues only, not comprising cost saving potentials

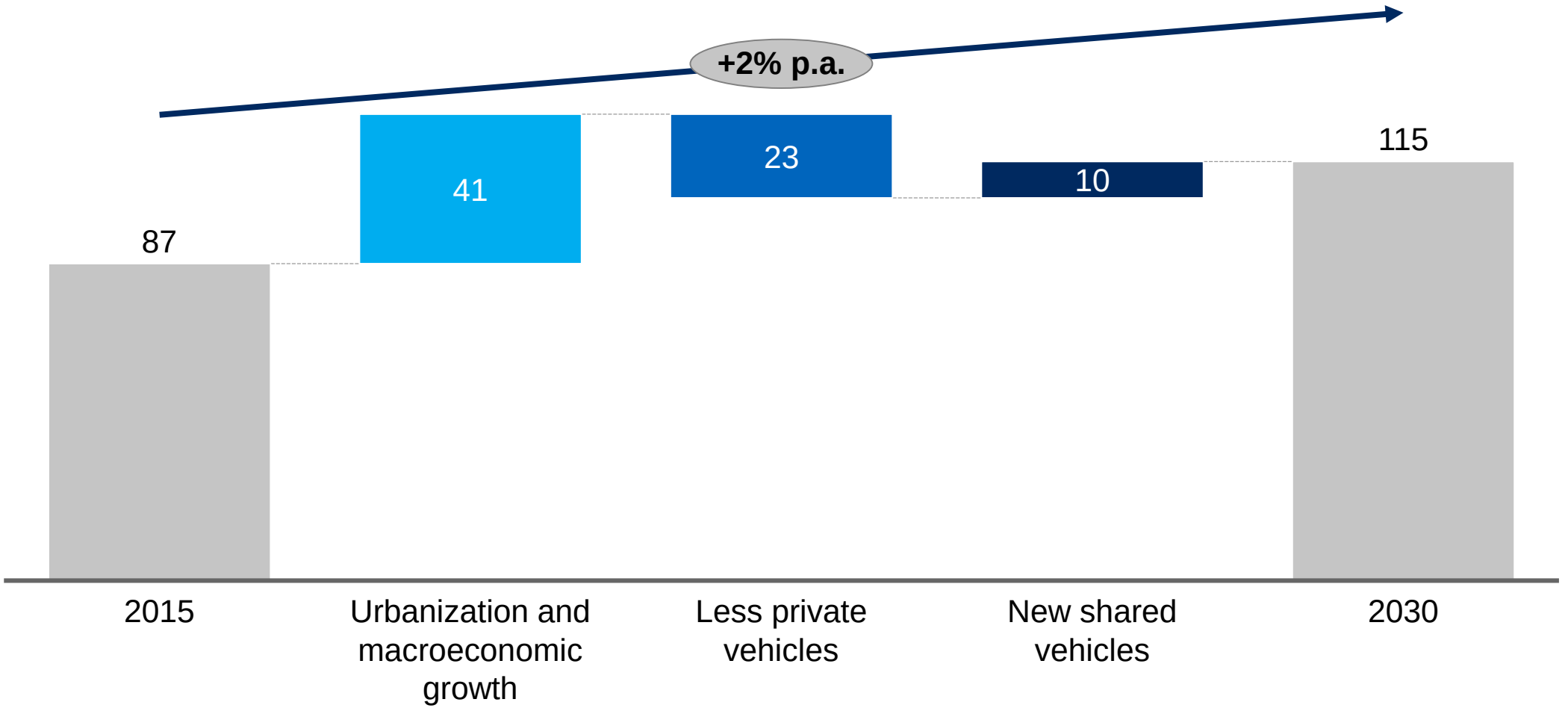
SOURCE: McKinsey Center for Future Mobility

E-mobility industry dynamics

SOURCE: McKinsey Center for Future Mobility

1 Vehicle growth until 2030 is driven by urbanization and shared mobility, which favor the roll-out of electric vehicles

Current and future annual global vehicle sales, millions

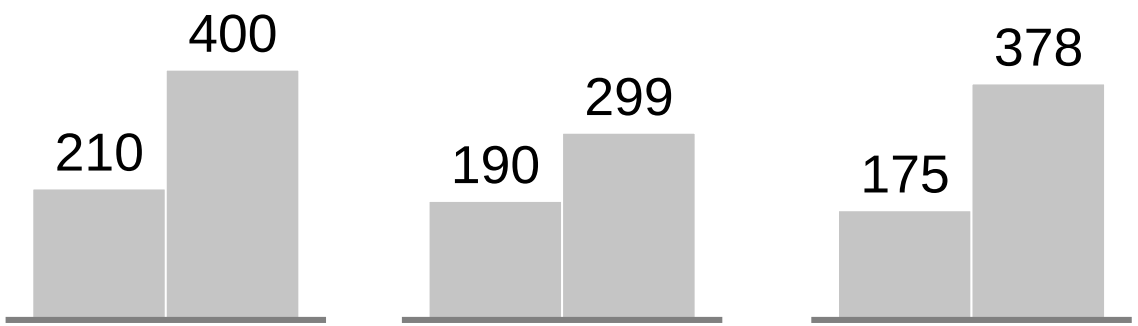


SOURCE: McKinsey Center for Future Mobility

2 Advances in battery technology go in line with a range increase

Electric driving range by model year in km (NEDC)

Updated models

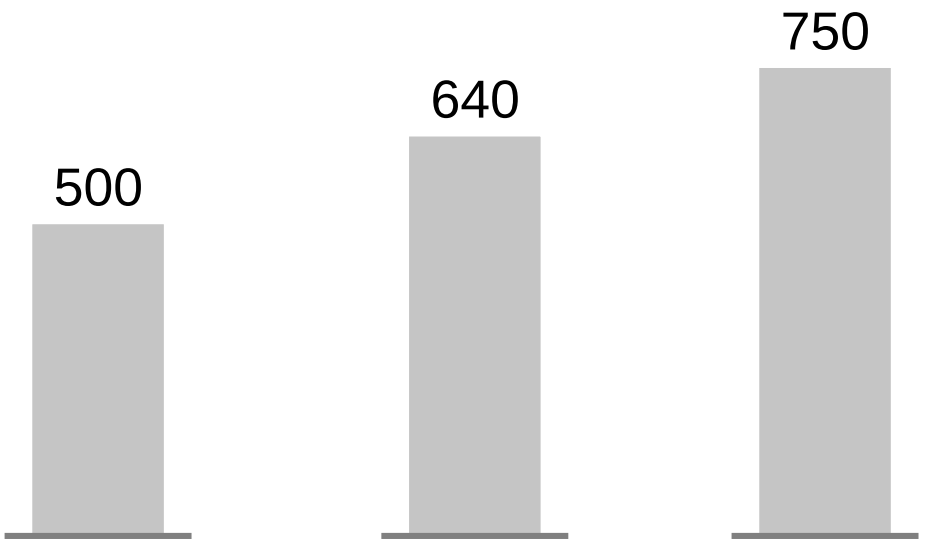


Renault Zoe

BMW i3

Nissan Leaf

New launches



Porsche Taycan

Lucid Air

BMW iNext

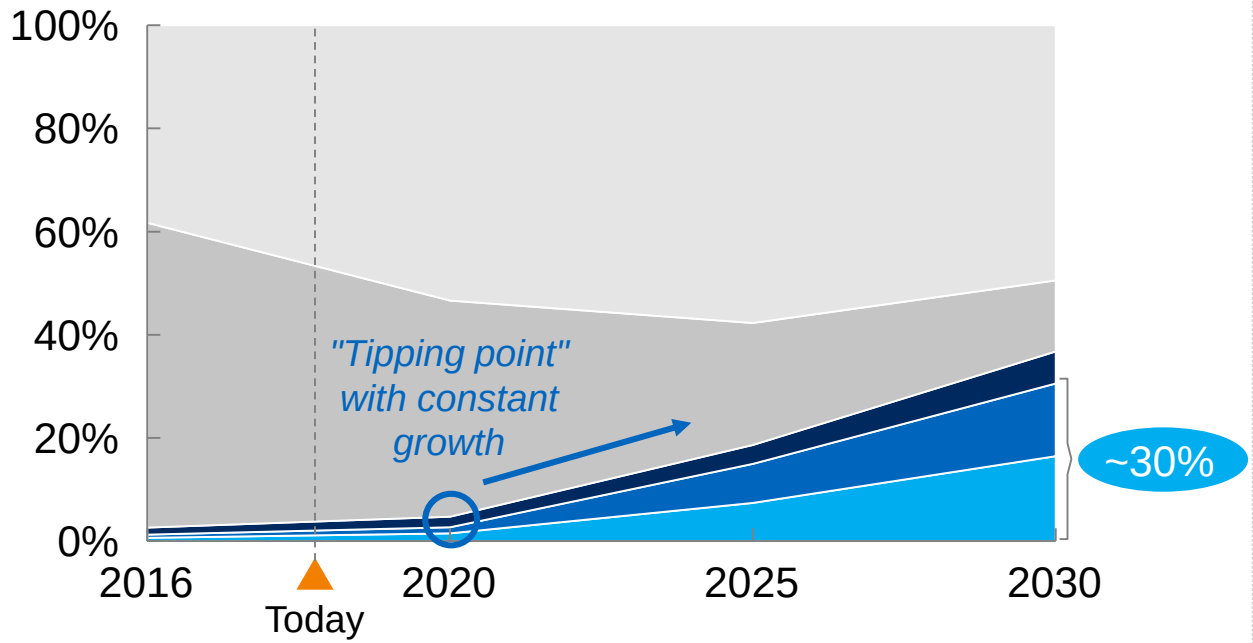
SOURCE: EV Volumes; McKinsey Center for Future Mobility

xEV market scenarios – BEVs reaching up to ~30 percent market share in Europe by 2030

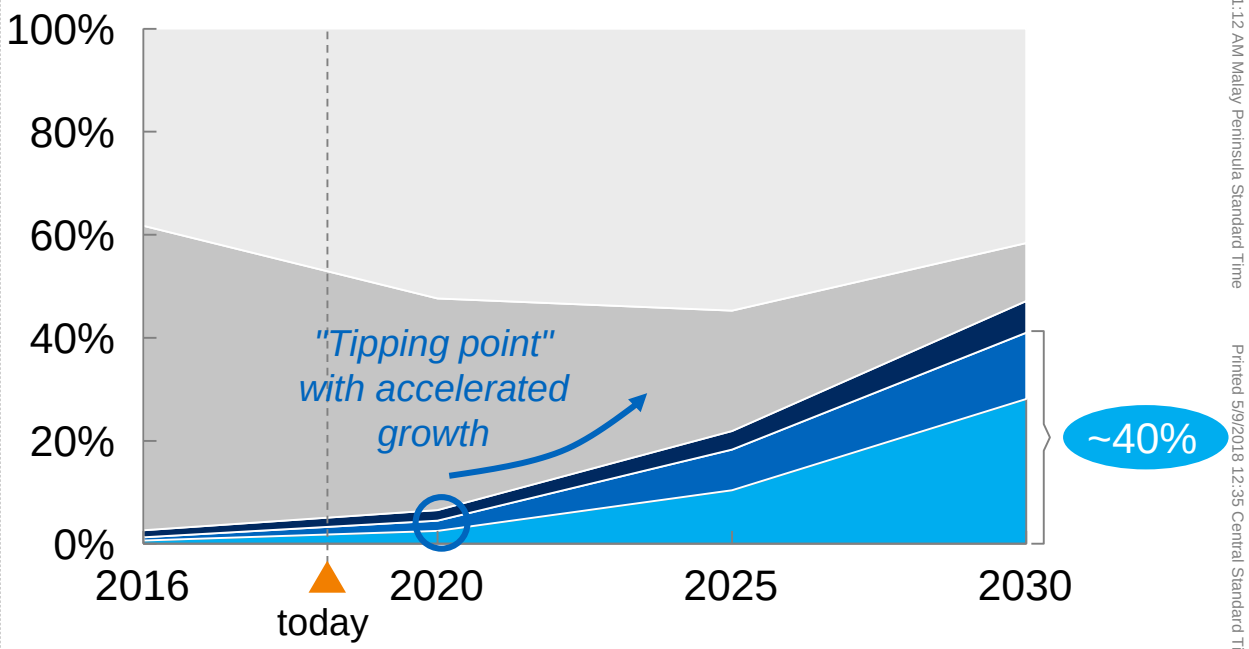
Share of new light vehicles sold in percent

Gasoline[1] Diesel[1] BEV/FCEV PHEV HEV

Base case



Breakthrough scenario



Base case scenario assumptions 2030

~90 USD/kWh *(pack level)*	67 g/km CO_2	~10% shared vehicle sales

Breakthrough scenario assumptions 2030

~55 USD/kWh *(pack level)*	57 g/km CO_2	~15% shared vehicle sales

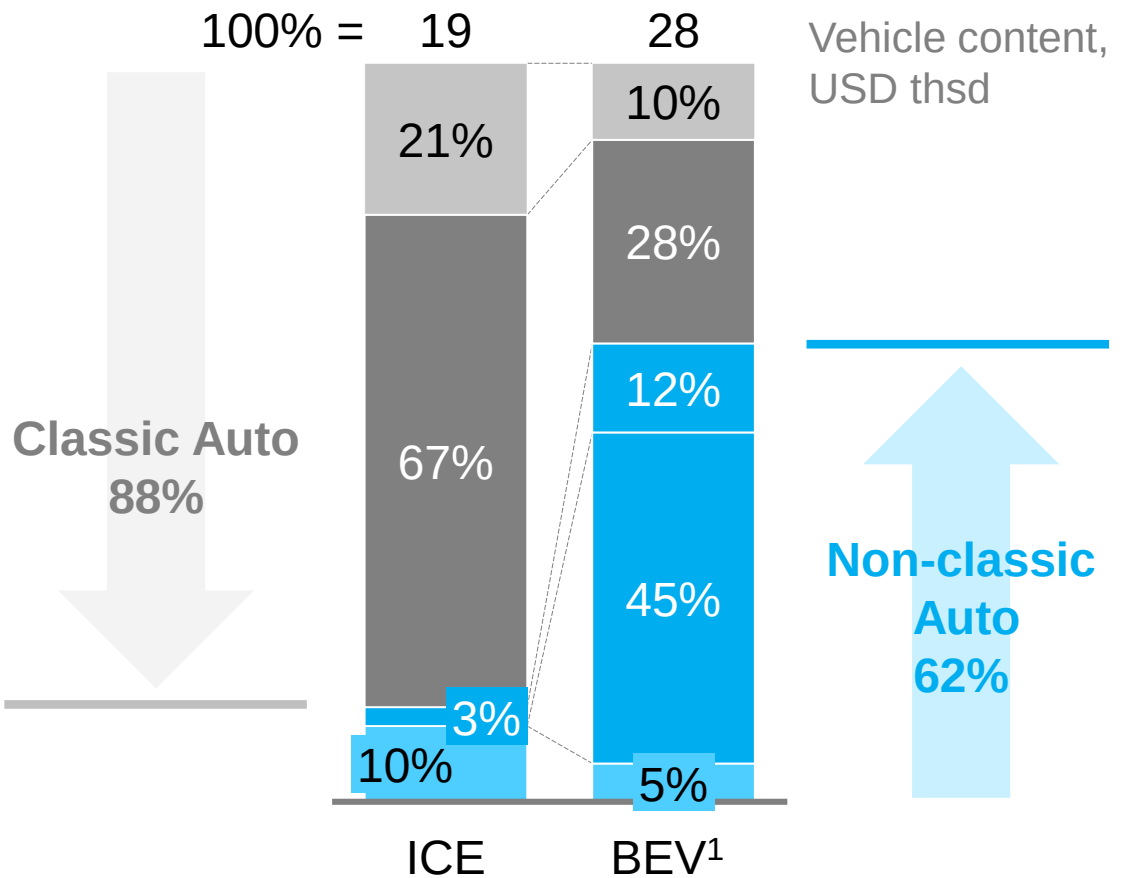
1 incl. 48V MHEV and alternative/ biofuels

SOURCE: McKinsey, ICCT, IHS Automotive

The example on electrification shows how supply is shifting from traditional to non-traditional suppliers and how business models are changing and expanding to adjacent areas

OEM value add | Classic tier 1 | Powertrain electronics suppliers | Battery suppliers | Raw materials

New technology focus



New business models

> Greencarreports - Nov 6, 2017
>
> **BMW, Mercedes, Ford, VW, Audi launch Ionity high-power fast charging across EU**

> Electrek - May 2, 2018
>
> **Ford to launch new all-electric vehicles for ride-hailing services in China**

> Chicago Tribune - Mar 30, 2017
>
> **Would you buy a new car online? Lynk & Co is betting on it**

1 Chevy Bolt example

SOURCE: UBS estimates, McKinsey

We identified 5 strategic archetypes along the breadth of their "portfolio of plays"; each can vary in shape depending on individual player choices

Defined play field | Alternate positioning

Portfolio of plays

Broad — Narrow

Fully integrated mobility player

Holistic mobility concept for end consumer with (close to) exhaustive portfolio of offers

Holistic system player

End-to-end development and provision of selected systems to broad audiences

Pointed niche player

Application or used-case-specific focus on narrow set of products or services

Component/service step specialist player

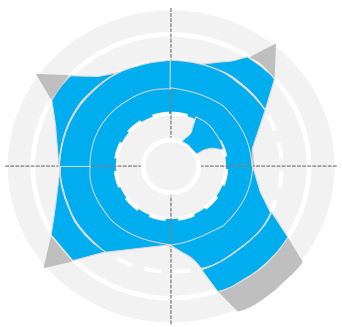
Focus on "owning" single key components or service steps of any offering

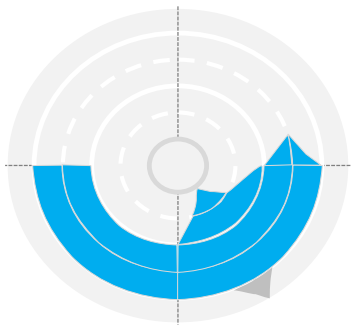
Platform-only player

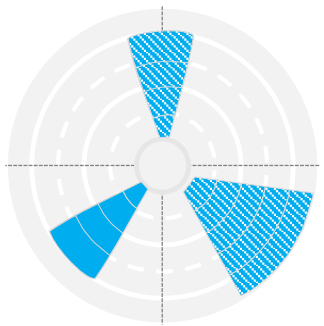
Specialization in moderating interfaces and facilitating collaborations (often directly with consumers)

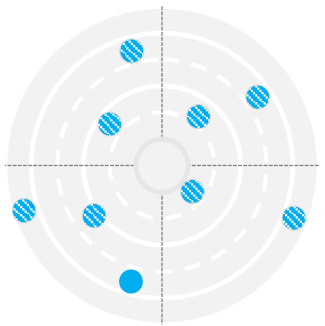
BUSINESS MODEL ORIENTATION

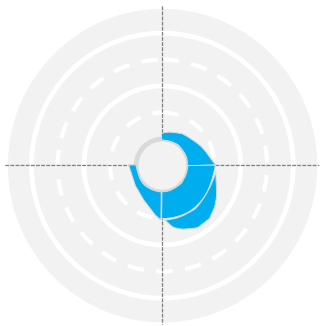
TECHNOLOGY FOCUS











DAIMLER GM

BOSCH WAYMO

AURORA

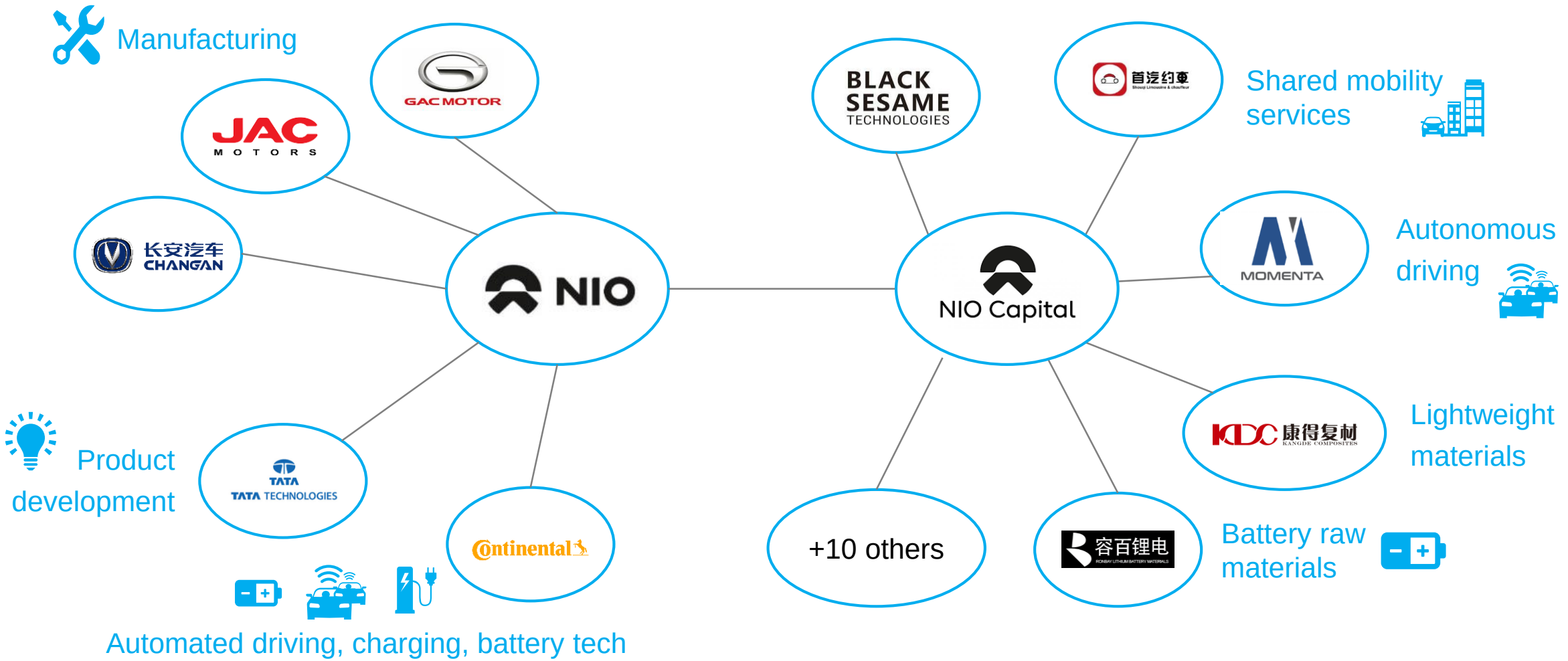
EVELOZCITY

UBER lyft

SOURCE: McKinsey Center for Future Mobility

Players can manage their reach across technologies and business models through partnerships and strategic investments as the example of electric vehicle startup NIO shows

Nio's ecosystem with a mix of partnerships and investments along the value chain



SOURCE: McKinsey Center for Future Mobility