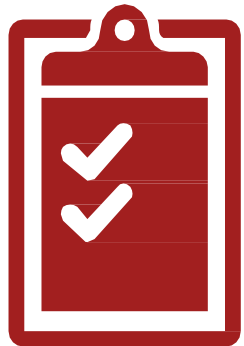

Digital Auto Report 2021/22

Accelerating towards
the “New Normal”

VOLUME 2

Digital Auto Report 2021/22 – Volume 2



- ✓ Tenth annual Digital Auto Report, developed by Strategy& and PwC
- ✓ Global consumer survey with a focus on the US, EU and China (n = 3,000) plus new view on Japan (n = 1,000)
- ✓ Quantitative market outlook up to 2035, based on regional structural analysis
- ✓ Interviews with industry executives at OEMs and suppliers, and with leading academics and industry analysts

Volume 1 (2021)

Assessing global mobility market dynamics

- Market outlook – penetration of technologies and mobility types
- Technology – shifting gears in connected, electric, automated
- Customers – changing mobility preferences: everything-as-a-service?
- Regulation – slowdown or acceleration of key policies?



Volume 2 (2022)

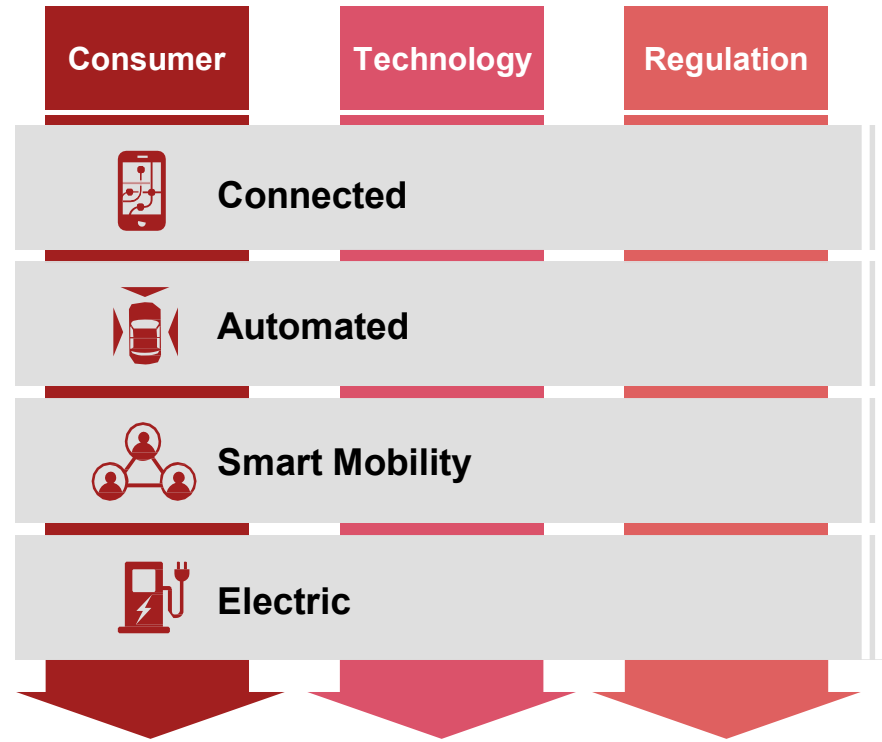
Capturing value with new mobility business models

- Vehicle – how to package winning connected services?
- Transportation – what is the true potential of robotaxis in large cities?
- Infrastructure – how to move from charge points to mobility and service hubs?



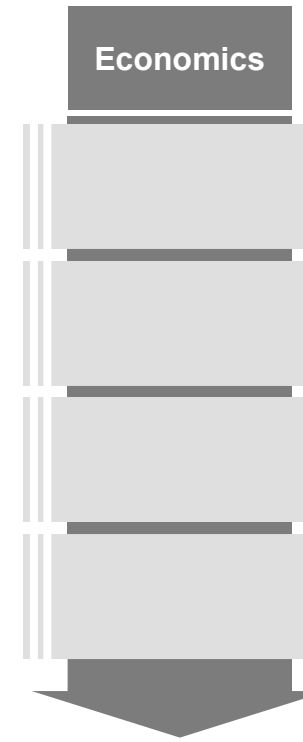
This volume focuses on how to capture value with vehicle-related services, AD transportation and infrastructure concepts

Volume 1 – Recap



- **Sustainability** and competitive pressure from **digital disruptors** have major **impact on CASE mobility**
- **Consumers** are seeking **convenient/safe mobility** – **private transport modes** remain important
- **Technology** progresses fast – **software-defined vehicle architecture** and **chip shortage** most pressing topics
- **Regulation** is aiming to accelerate the mobility transformation – various **regions have followed** very **different approaches**

Volume 2 – Scope of this document



- Capturing more **economic value¹⁾** in a **transforming mobility market** requires a fresh view on
 - 1 Vehicle** – focus on connected services and alternative powertrains
 - 2 Transportation** – grow into new markets with robotaxis at superior economics
 - 3 Infrastructure** – monetize traffic at charging stations through ecosystem partner integration and hub concepts

1) Note: As this report takes a long-term view (up to 2035), current market economic and geo-political disruptions (e.g. Ukraine war) are not reflected
Source: Strategy&

Value creation in automotive is growing beyond (1) vehicles to (2) transportation services and (3) new infrastructure concepts

Executive summary – Volume 2

For car manufacturers, **value creation in mobility is growing** beyond the (1) **vehicle with components and connected services** to (2) **mobility and transportation services** on the one side and (3) **mobility infrastructure provisioning** on the other side – for each direction a **distinct view is needed to define a winning strategy**

Today's **connected services** improve vehicle experience along safety, convenience, entertainment and infrastructure. OEMs apply **different bundling** approaches with **German players** providing a **large number of individual services at €19-880 p.a.**, while **new US/Chinese players** offer **fewer packs at higher prices**

Capturing value with digital services remains challenging as other industry sectors (media, retail, ...) fight for the same customer wallet. Total market in Europe, US and China estimated **at \$66bn in 2035**. Vehicle-features on demand create additional service revenue opportunities – but partly at the cost of vehicle sales

Zooming into vehicle components, **electric powertrains and batteries show substantial growth** potential. In 2035, the market is expected at **\$238bn in Europe** – vs. **\$128bn in the US** and **\$314bn in China**. 75-80% of those revenues can be attributed to battery cells and packs – clearly proving the strategic relevance for OEMs

In the context of **automated driving**, even the **largest players are forming partnerships** along the value chain. First **regular robotaxi operations** are expected in Europe early 2023, but **scale-up will take another 5 years**. By 2030 annual **robotaxi sales** in large cities expected globally **at 0.2m vehicles vs. 2.4m in 2035**

With **cost per robotaxi kilometer below €1 by 2030**, a tipping point with attractive consumer prices is reached in that year. As a result, **robotaxi service revenues** in large cities are expected to grow **from €31bn in 2030 to €400bn in 2035**. OEM revenues for selling robotaxis vehicles expected at one fourth of that market (€103bn)

In the third value pool centering around infrastructure, the **EV charging market** has substantial growth potential. In Europe, the market is **expected to grow from €4.5bn in 2021 to €75.5bn in 2035**. Charge point operators have different levers to reach favorable economics – beyond improved price, utilization and CAPEX the key lever for profitability are completely new business models – with a B2B focus, such as **fleet operations hubs**, or a B2C focus, such as **multimodal mobility hubs**

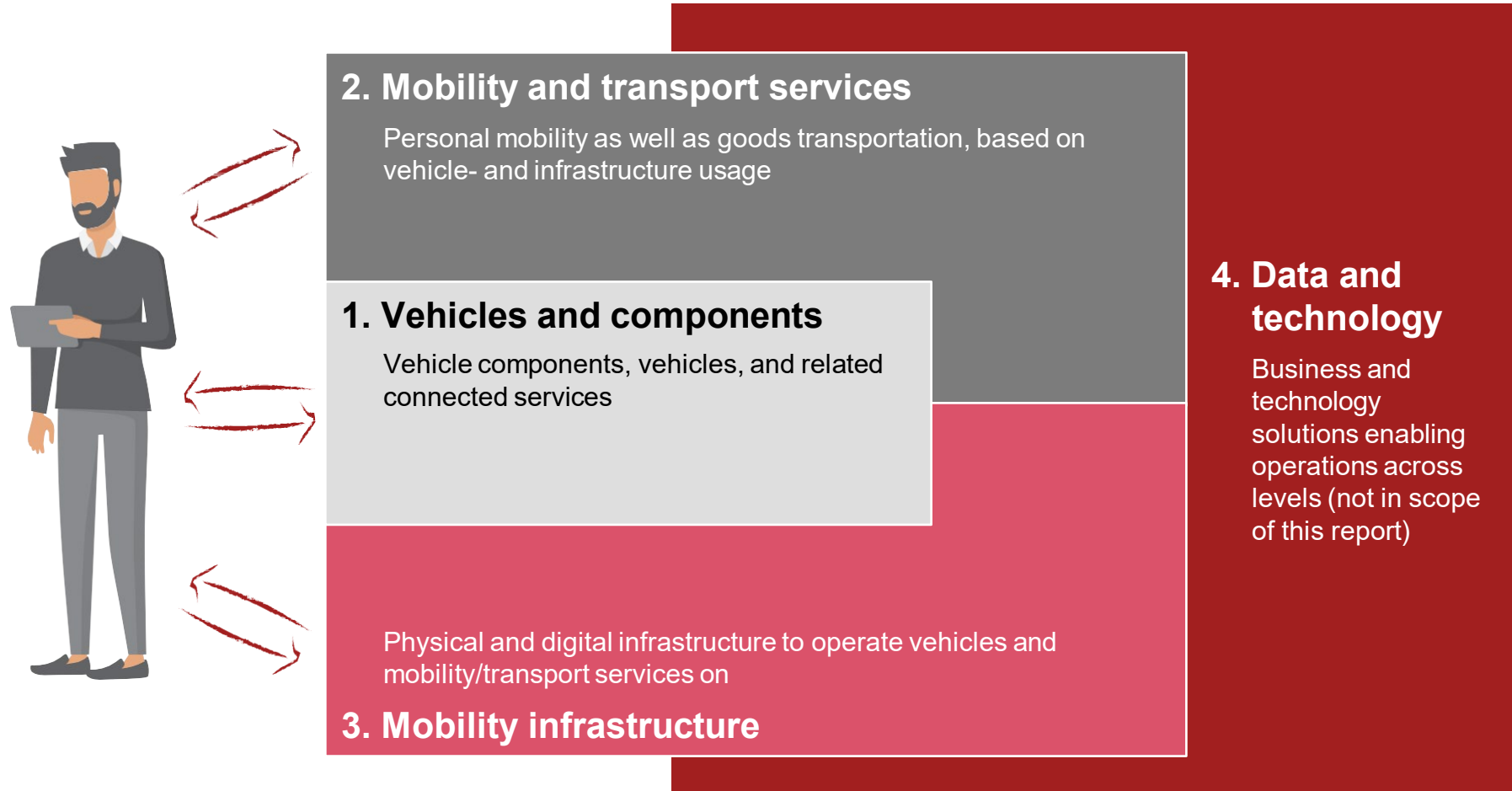
Depending on the starting position of an individual mobility stakeholder, **different capabilities** need to be upgraded. E.g. auto OEMs need to **enhance their system integration capabilities** towards software, suppliers need to **move from component supply to solution provisioning**, traditional transport operators and utilities can grow by **turning their infrastructure and real estate into smart, bundled B2B service hot-spots**



Volume **2** Capturing value with new
mobility business models

Mobility value creation is growing from vehicle and components to mobility and transportation to mobility infrastructure

Structural overview



- Value creation in the digital mobility ecosystem takes place on four levels, all integrated with each other
- The increasing popularity of mobility services drives the need not only for underlying vehicles, but also integrated infrastructure solutions, opening up a plethora of business opportunities
- Boundaries between these levels and whole underlying industries are continuously blurring

Today's connected services improve vehicle experience along safety, convenience, entertainment and infrastructure

Connected services – Most common features

	Safety and security	Convenience	Entertainment	Infrastructure
Vehicle features-as-a-service <i>Hardware offered on demand (technical components built in)</i>	Autopilot and Cruise Control Weather-regulated headlights Suspension Smart wheel axles and servo steering Automatic distance control Novice driver modus	Ambient lightning Remote door opening/mobile key Remote horn and turn signal Remote park assistant Full self driving Seat/steering wheel heating	Smartphone integration Pace tracking Video drive recorder of environment Perceptible engine sound 360° exterior camera	Sensor-based automatic accident report Automatic emergency calling
Vehicle-centric services <i>Integrated support offered via additional vehicle functions</i>	Fatigue warning Traffic sign recognition	Advanced navigation Smart route planning Personal assistant Voice control Behavior capture (e.g. ventilation) Mobile temperature regulation	Digital radio reception/Own channel Gaming Music and media streaming Caraoke Soccer streaming (WeScore) Mood-based In-Car experience	Loyalty program WiFi-Hotspot
Beyond-vehicle offering <i>Services offered outside/beyond the vehicle (often 3rd party involvement)</i>	Roadside assistant Vehicle theft assistant Vehicle status report	Parking search and pay Gas and charging station search Vehicle monitoring	Smart home connection	Plug and Charge service P2P car and ride sharing Concierge service Price benefits with IONITY Remote security service
Data/insights services <i>Collection, evaluation and usage of data offered (B2B)</i>	Fleet management Diagnostics on Demand	Driver's log Live maps Live traffic information Discounted services GPS tracking		Predictive maintenance Car data-based insurance Car data B2B marketplace

Note: Not all services are monetized separately: P2P = Peer-to-Peer
 Source: Strategy& analysis, expert interview

Service bundling varies – German OEMs sell digital services individually, while Tesla/NIO rather go with all-in packages

Connected services – Bookable offerings beyond standard equipment

Tesla (DE)	General Motors (US)	Volkswagen (DE)	BMW (DE)	Mercedes (DE)	NIO (CN)
<p>Package option 1 digital package with a monthly subscription (Premium Connectivity)¹⁾</p> <p>Single service option Only one service option ("Full self driving")</p>	<p>Package option 4 digital packages with a monthly subscription</p> <p>Single service option 5 single services²⁾ with a monthly subscription</p>	<p>Package option 1 digital package with staggered duration and fixed price (we connect plus)¹⁾</p> <p>Single service option 10 additional³⁾ single services with an infinite duration and fixed price (we upgrade)</p>	<p>Single service option A 4 single services with an only infinite duration and fixed price</p> <p>Single service option B 7 additional single services with an monthly, annual or infinite duration and fixed price</p>	<p>Single service option A 17 single services with staggered duration and fixed price (me connect)</p> <p>Single service option B 4 single services with an infinite duration and fixed price (on-demand)</p>	<p>Package option 2 digital packages with an infinite duration and fixed price (selected/complete pack)¹⁾</p> <p>Single service option 2 single services with a monthly subscription</p>
<p>Distribution channel Tesla Account, Tesla App</p>	<p>Distribution channel OnStar website/app</p>	<p>Distribution channel We Connect Webshop, We Connect App</p>	<p>Distribution channel BMW Connected Drive Store, MyBMW App</p>	<p>Distribution channel Mercedes MePortal, Mercedes MeApp</p>	<p>Distribution channel NIO Account, NIO App</p>
<p>Individually offered services <i>Several services incl. without extra costs</i></p>	<p>Individually offered services <i>Several services incl. without extra costs</i></p>	<p>Individually offered services <i>Several services incl. without extra costs</i></p>	<p>Individually offered services <i>Several services incl. without extra costs</i></p>	<p>Individually offered services <i>Several services incl. without extra costs</i></p>	<p>Individually offered services <i>Several services incl. without extra costs</i></p>

■ Safety and security
 ■ Convenience
 ■ Entertainment
 ■ Infrastructure

1) Standard digital package included already without additional costs, e.g.: Tesla basic maps navigation, music streaming; VW WeConnect available for free after activation; Nio Anti Theft Alert, Nio Radio, Nomi etc.

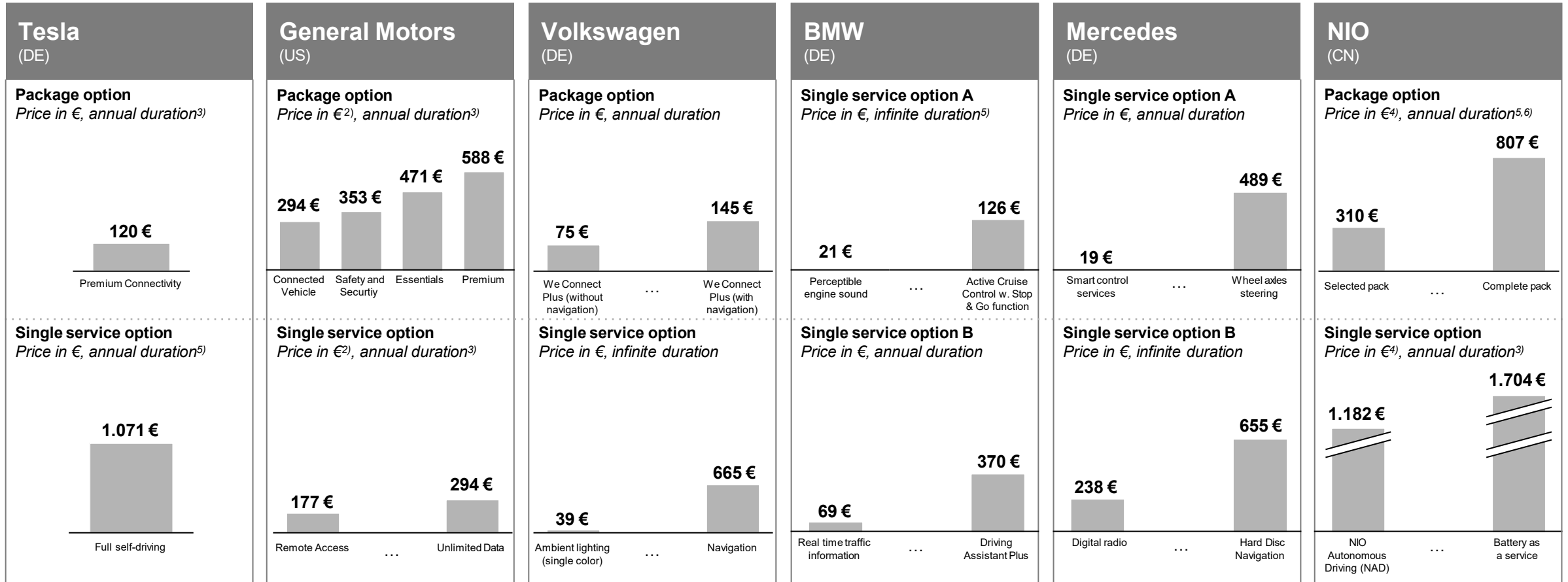
2) Services from packages offered singularly 3) In addition to packages

Note: Total number of services in portfolio (available in online store) per OEM = sum of single services within packages as well as additional single services offered to end customer at extra costs on demand

Source: Strategy& analysis, expert interview

Price levels of connected services packs range between 19 and 807 EUR p.a. – ADAS services currently at 370-1.071 EUR

Connected services – Portfolio-pricing¹⁾

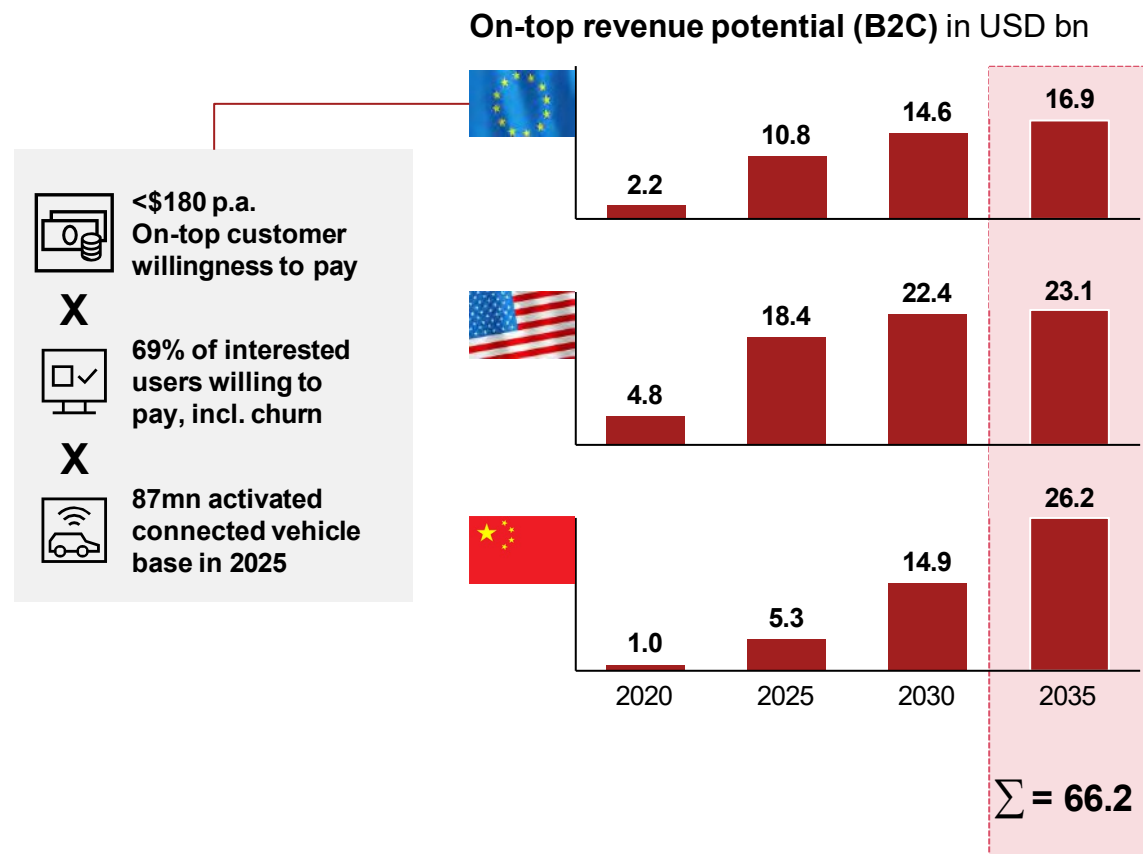


1) Prices may vary depending on OEM vehicle type
 2) Exchange rate \$1:0.97€
 3) Values extrapolated on an annual basis from monthly offering
 4) Exchange rate ¥1:0.14€
 5) Values extrapolated on an annual basis from infinite duration; taken average of 7 years car ownership as infinite base
 6) Continuous upgrades of NIO pilot features
 Source: Strategy& analysis, expert interview
 Note: AD = Autonomous Driving
 ADAS = Advanced Driver Assistance System

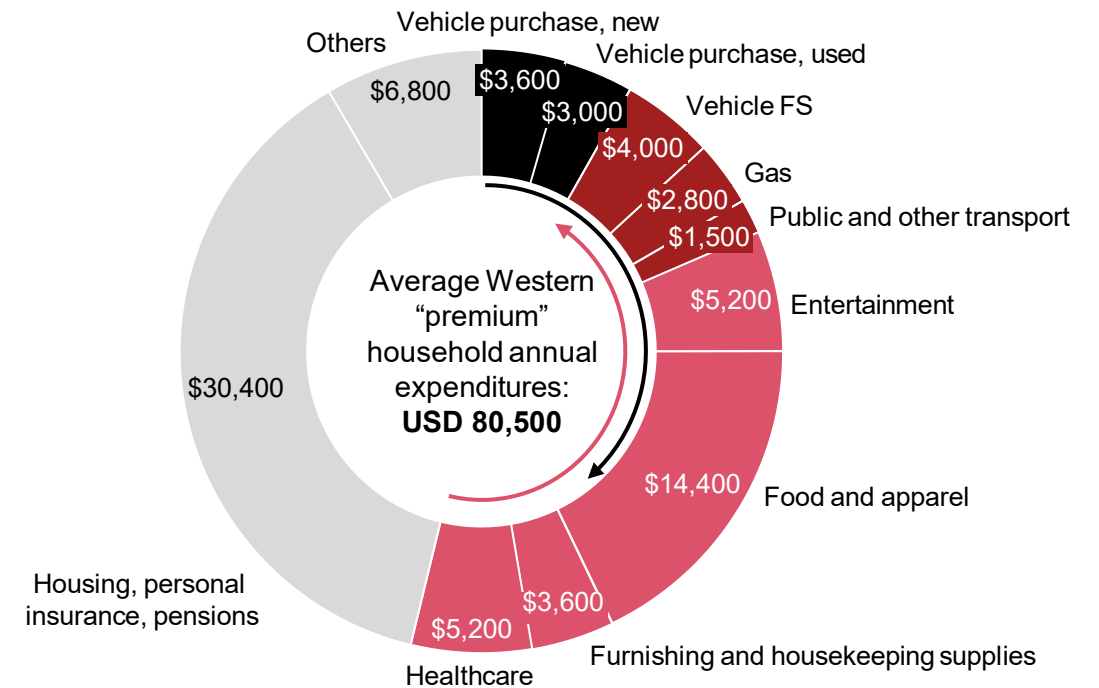
Overall, connected service monetization remains challenging – - potential for B2C monetization estimated at \$66bn by 2035

Connected services – Market outlook

Limited on-top revenue potential from connected services...



...due to cross-industry customer share of wallet war

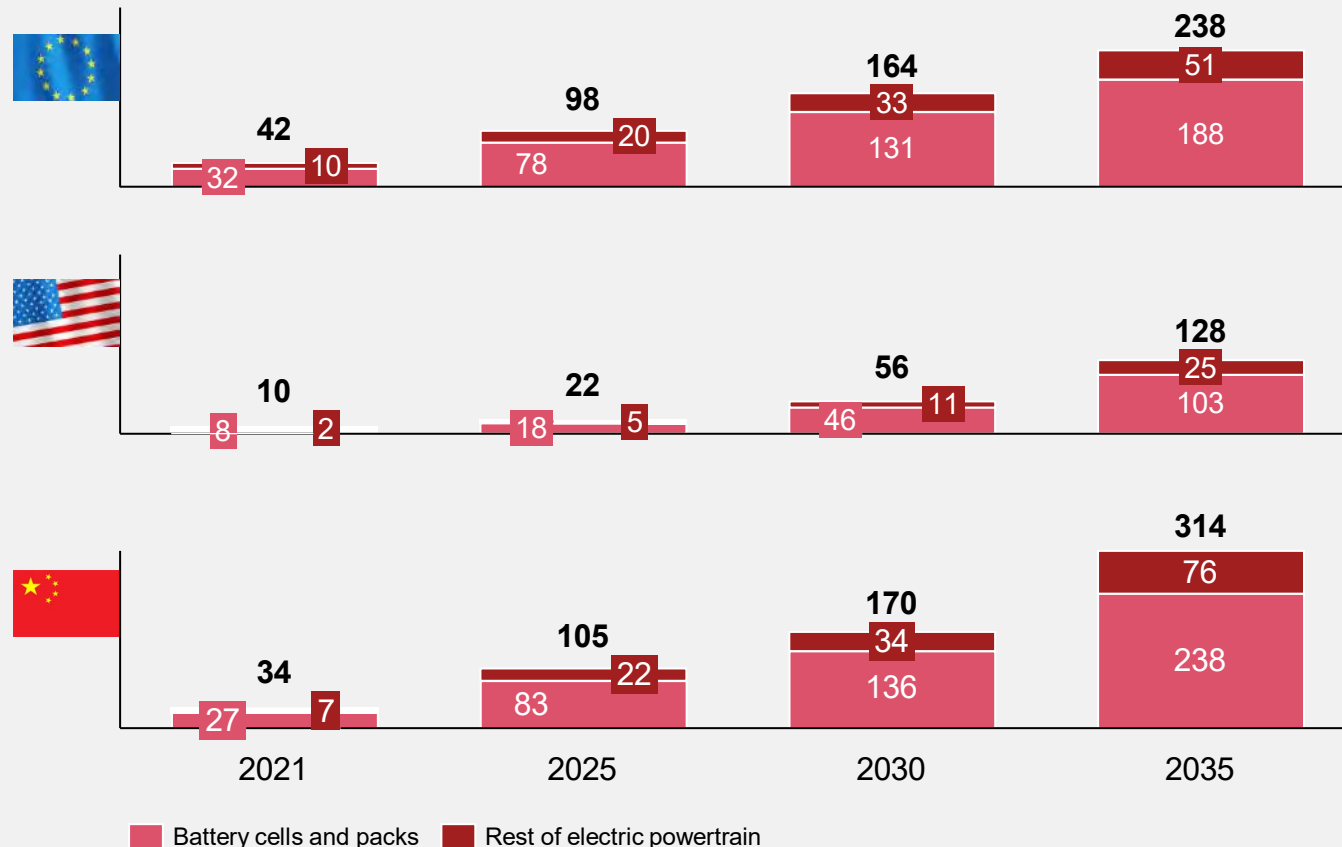


- While automotive OEMs are trying to increase customer share of wallet to generate on-top revenues, other industry verticals follow similar approaches
- Connected service plays will unlock an increase in profit margins over today's revenues rather than increasing revenues

Electric powertrain and battery markets expected to grow strongly, especially in EU and China

Electric powertrain and battery – Market outlook

Revenue potential¹⁾ (in USD billion)



Comments

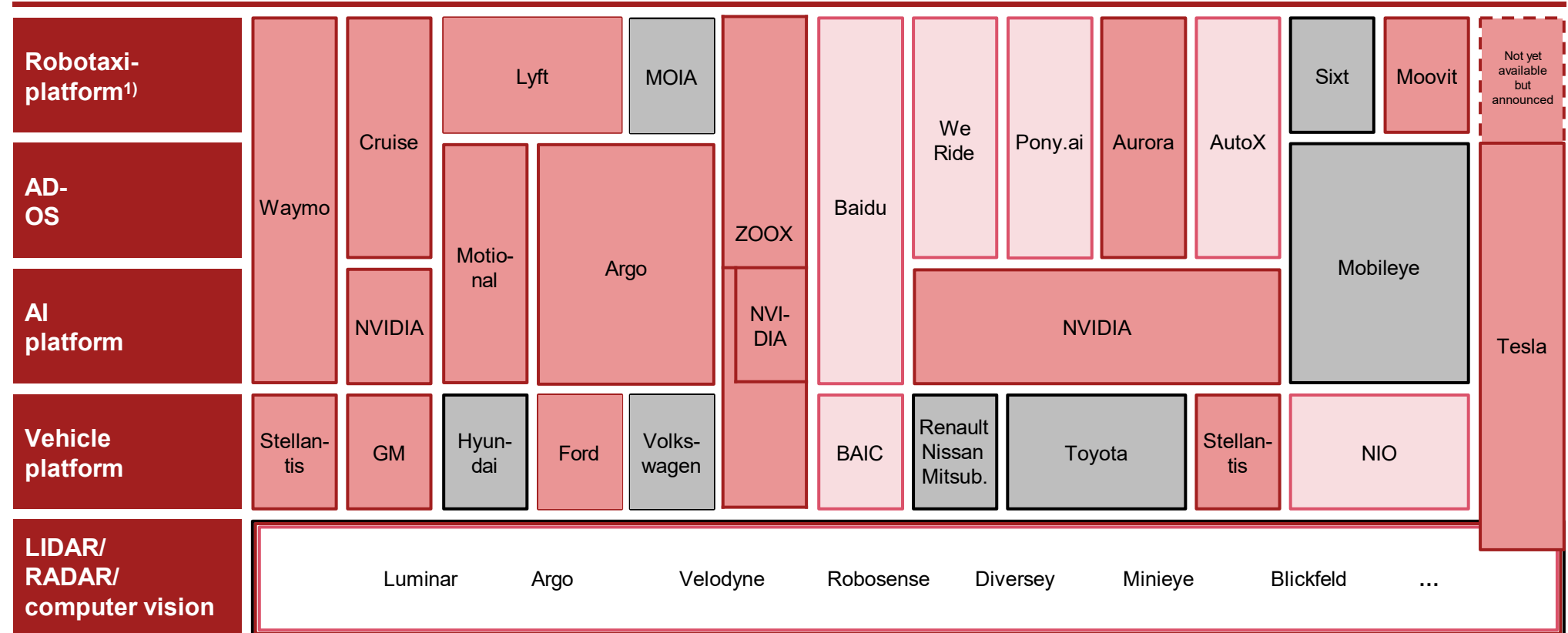
- **Market potential development** driven by **significant increase** in **alternative powertrain penetration**
- Increasing number of **favorable legislations** (e.g. city bans for combustion engines) and **general popular sentiment** are underlying drivers for **global electrification trend**
- **Battery cells and systems** experiencing large drop in costs, but still represent by far the largest cost share in electric powertrains
- Next to battery, second largest cost share of electric powertrain within **e-axle** (covering electric motor, inverter and gear)



In automated driving, global players are forming diverse partnerships with different strategies on value chain depth

AD partnerships

Selected partnerships of major players in the AD ecosystem



Comments

- Players like **Waymo**, **Cruise** or **Baidu** are able to provide the **complete software**, forming partnerships with **OEMs**
- **Increasing figure** of players are relying on **Nvidia** as **AI-platform**
- **Tesla** targets to own the **complete value chain**
- **US** and **China** partnerships **dominant**
- **Consolidation** has already started (e.g. **Uber**)
- **VW** and **Sixt** as **German players** and **first announced European pilots**

USA China Other



With headlines on robotaxi launches becoming more frequent, a clear definition of those vehicles is needed

Robotaxi L4 – Assumptions and expected features (first taxis 2025)





	Driving at crossings	<ul style="list-style-type: none"> • Stop at crossings • Stop on red light • Turn left/right 		Emergency assistant	<ul style="list-style-type: none"> • Emergency stop at next possible area
	Maintain speed	<ul style="list-style-type: none"> • Assumption speed limit 60 km/h 		Driver	<ul style="list-style-type: none"> • No driver and no safety driver (remote supervision only)
	Car following	<ul style="list-style-type: none"> • Following another car to maintain traffic flow 		Passengers	<ul style="list-style-type: none"> • Passenger can engage in other tasks
	Lane centering	<ul style="list-style-type: none"> • Needs visible marking on the roads • Only approved urban areas 		Areas	<ul style="list-style-type: none"> • Approved areas with necessary infrastructure
	Lane switching/overtaking	<ul style="list-style-type: none"> • The vehicle can switch lanes and overtake other vehicles 		Road types	<ul style="list-style-type: none"> • Only approved roads within urban areas using markings for positioning
	Merge into traffic	<ul style="list-style-type: none"> • The vehicle can automatically merge into traffic 		Weather conditions	<ul style="list-style-type: none"> • Ordinary weather conditions • No strong rain, ice or snow
	Route planning	<ul style="list-style-type: none"> • The vehicle choose the route independently using V2X communication 		Traffic conditions	<ul style="list-style-type: none"> • Up to 60 km/h • Simple traffic conditions
				Exceptional events/incidents	<ul style="list-style-type: none"> • Take over control by remote driver service



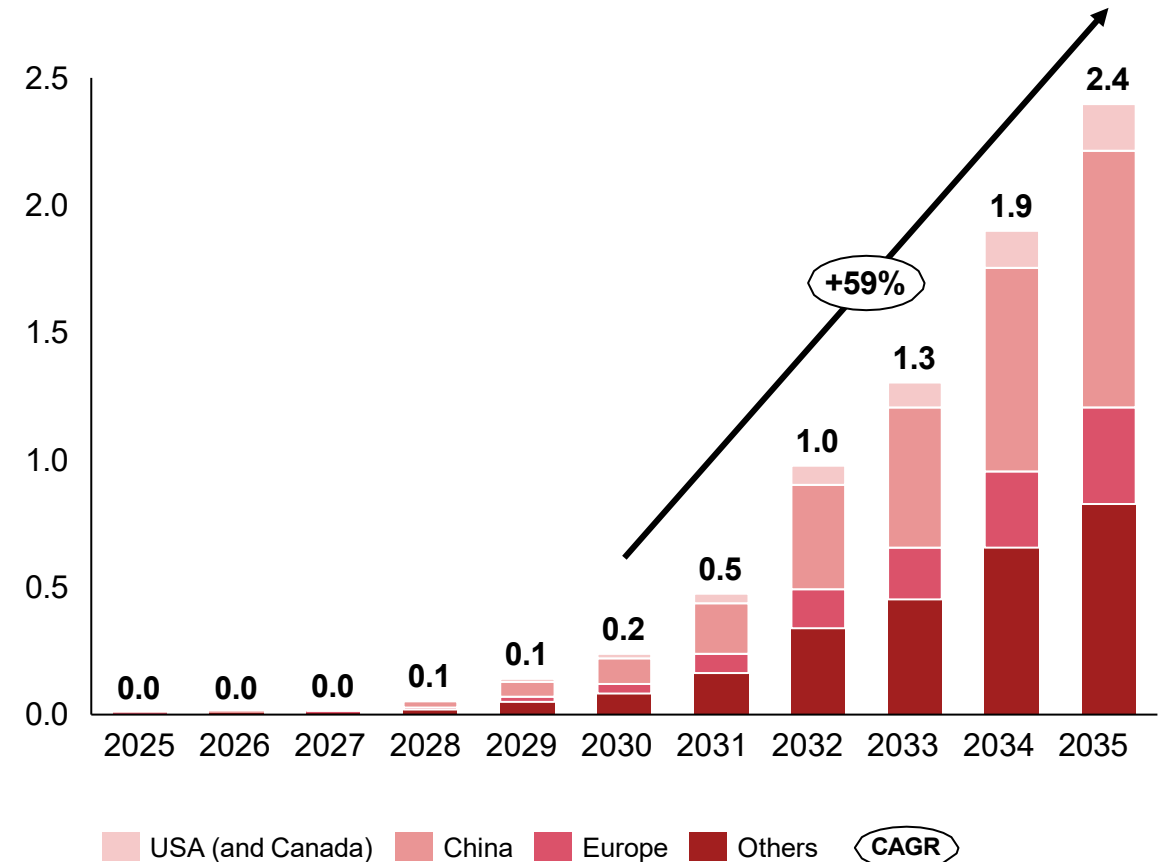
Based on 17 relevant use cases in large cities and respective demand, we estimate 2.4mn robotaxis to be sold p.a. by 2035

Robotaxi new vehicle market scenario “large cities”

Key use cases

- | | |
|--|---|
|  Go to work |  Travel from/to airport |
|  Go grocery shopping |  Travel from/to train station |
|  Go out in the evening |  Furniture/large item shopping |
|  Leisure activity outside city |  Housing relocation |
|  Leisure activity inside city |  Trips to doctor |
|  Short business trip |  Delivery services from restaurant, supermarket, ... |
|  Multi-day business trips |  Pick up/bring children to school |
|  Weekend trip |  Parcel delivery service outside business hours |
|  Holiday | |

of robotaxi vehicle sales p.a. (large cities, in mn)

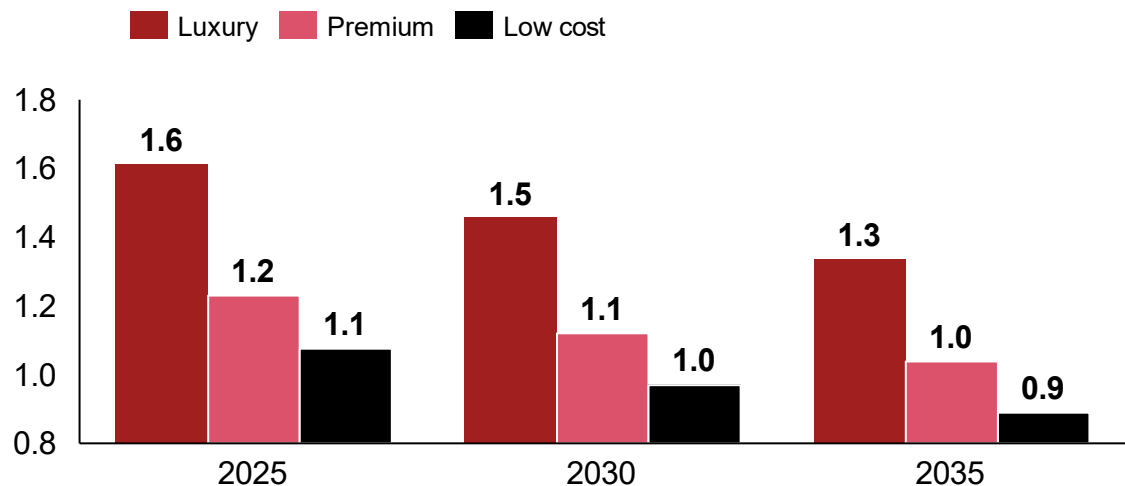




With attractive costs per vehicle-km, we expect global robotaxi revenues in large cities to reach ~\$400bn by 2035

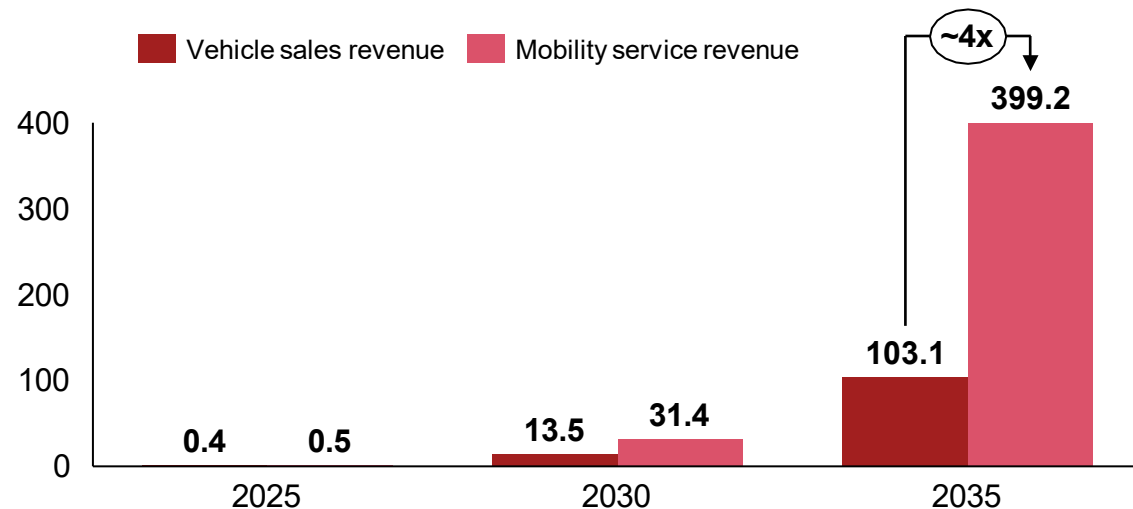
Robotaxi cost assumptions and revenue expectations

Cost per robotaxi category assumption (in € per vehicle km)



- Depending on the vehicle price and services (Low cost, Premium, Luxury) there are different price points per km
- Depending on the size of the local robotaxi provider, there are further economies of scale in terms of operation and management of the vehicles, which allow further price reductions to be achieved
- We expect a price-per-km reduction over time as the cost of vehicles, AD technology, and related services fall over time

Global robotaxi revenue (large cities, in € bn)

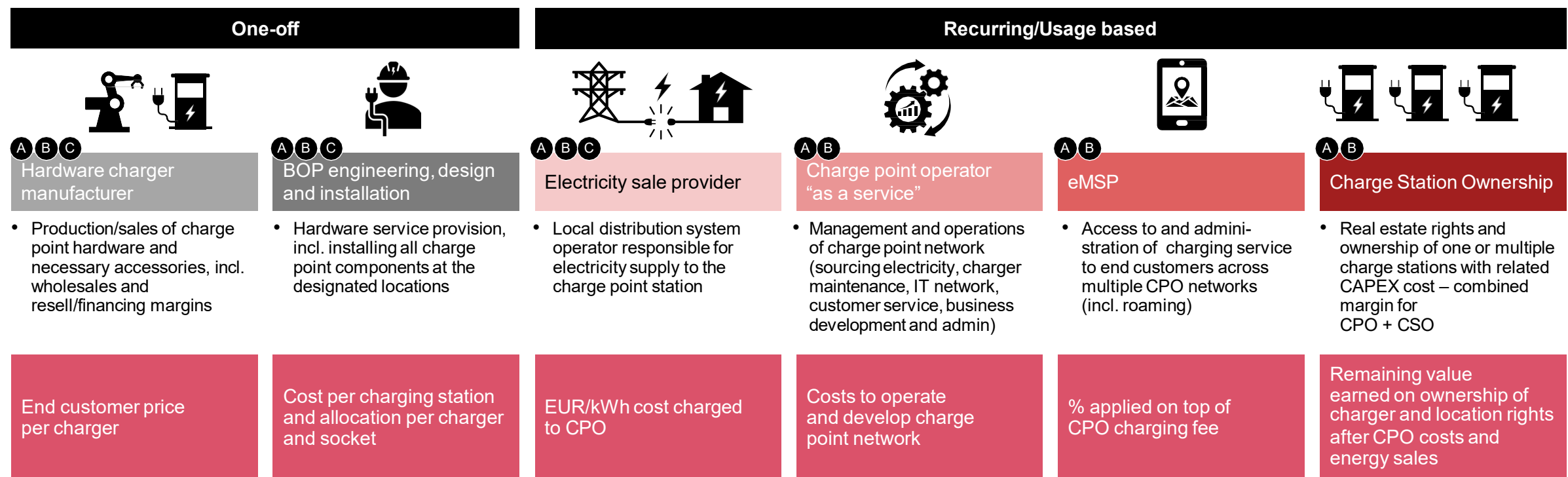


- Expected first series applications in 2025 and breakthrough will then come around 2030
- Robotaxis will replace existing cabs, but the technology must become more robust and the vehicles must be able to operate in bad weather without any restrictions
- The depicted scenario assumes sufficient supply of vehicles and parts

There are six main value pools in the EV-charging value chain, from infrastructure build-up to pure-play software positions

Main value pools and model parameters

Analyzed charging market components for private and public charging segments



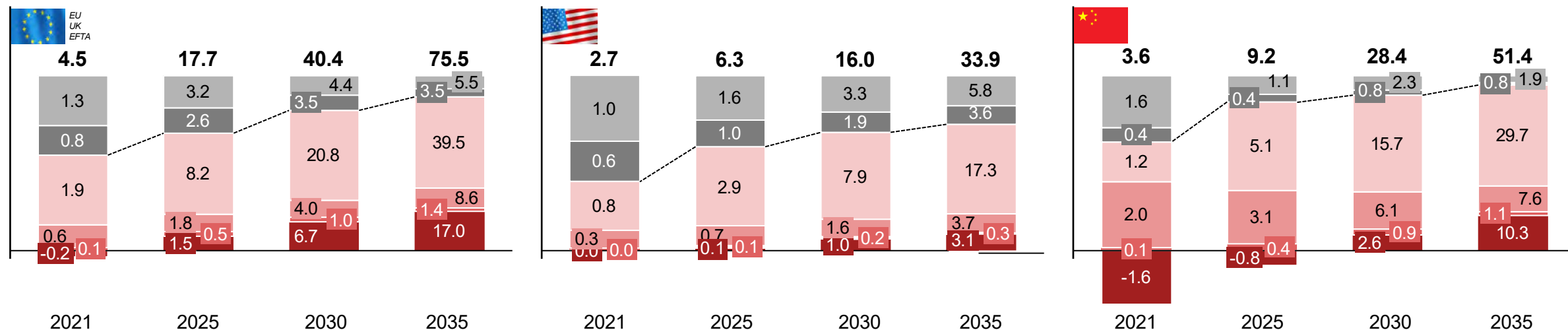
Additional value pools out of scope: Demand from PHEV, Smart energy (vehicle to grid and behind the meter solutions), location and owner specific Value Added-Services

DC = Direct current AC = Alternating current BOP = Balance of plant CPO = Charging point operator eMSP = Electric mobility service provider CSO = Charging station owner

A Public fast charging
 B Public slow charging
 C Private charging

By '35, the market potential across the regions is ~€161bn with move away from infrastructure build up to recurring sales

Charging ecosystem – Market outlook (EUR billions)¹⁾



Key characteristics

- Larger share of hardware and BOP services as private and public infrastructure is being built to keep up with BEV adoption
- Increased shift to public charging with higher adoption of BEV and a greater utilization of installed network expected to tilt the CPO/CSO business to profitability

Key characteristics

- Longer average driving distances characterizes the market size per vehicle unit in the US
- Greater share of expected private charging reduces the magnitude of CPO, CSO and eMSP relative to Europe and China
- Given charger build-up and volume of charging, CSO expected to be EBITDA neutral already in '21

Key characteristics

- Public infrastructure expansion ahead of EV-adoption has led to low utilization rates, we expect the gap to narrow yet leading to a longer period for CSO to recoup CAPEX
- Greater share of public (especially fast charging) and lower cost hardware leads to higher CPO, CSO and eMSP shares

Negative/zero values for CSO due to low public fast charging network utilization rates resulting in cost/revenue paid for CPO and energy services being higher than total charging revenue. The 2021 magnitude in China relates to infrastructure roll out in 2015-2020, when chargers were installed not necessarily in line with where the demand has been.

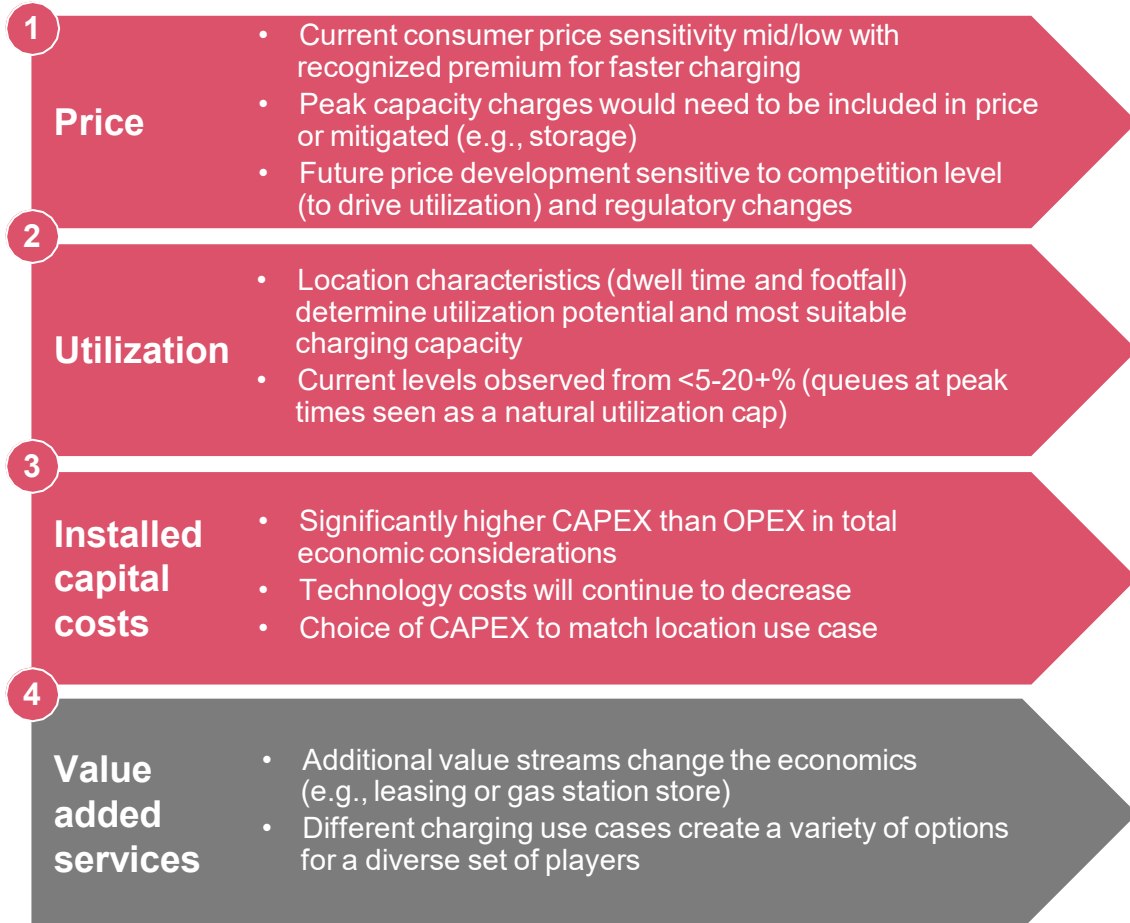
¹⁾ Annual sales in 2021 values for passenger vehicles <3,5t, excl. current effects from evolving energy crisis mid 2022



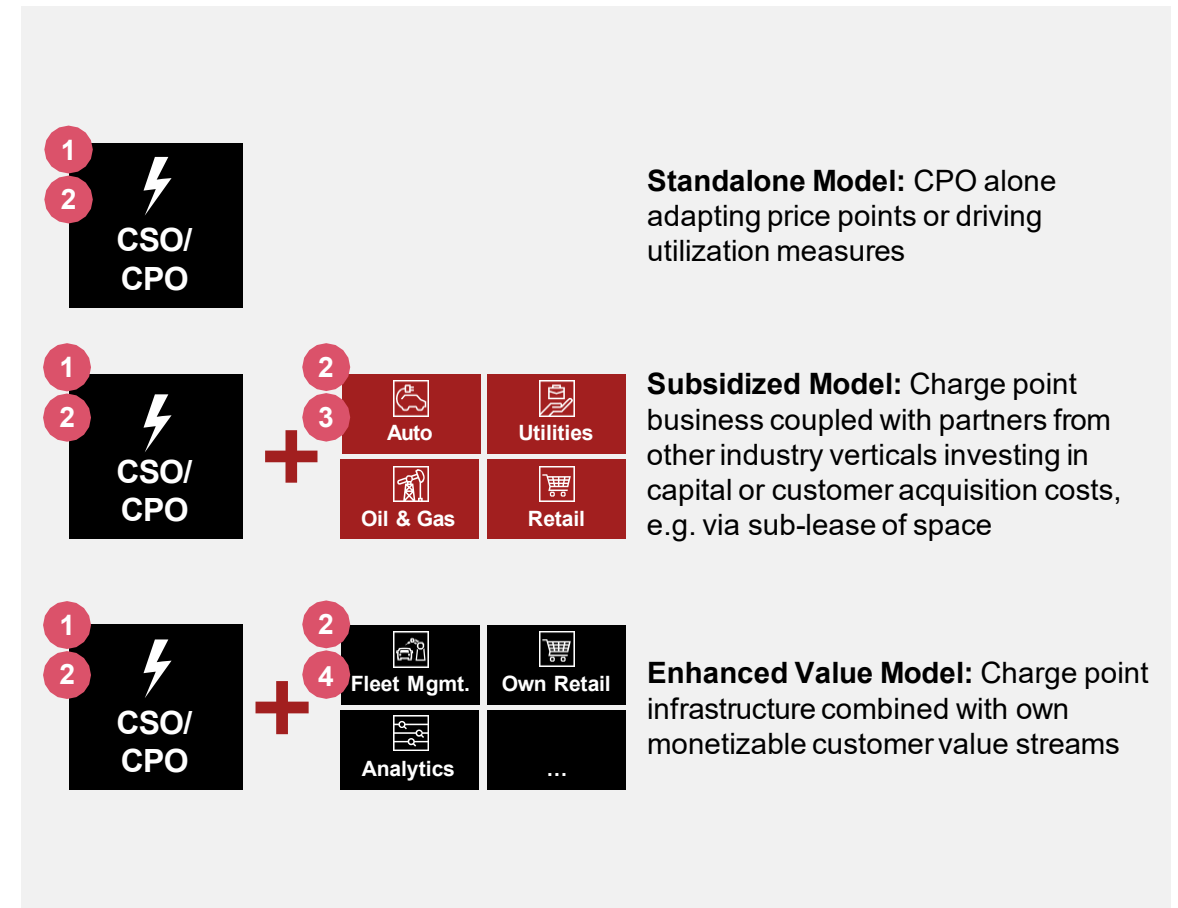
BOP = Balance of plant; eMSP = Electric mobility service provider; CPO = Charging point operator (as a service); CSO = Charging station owner (incl. real estate & charger)

Charge point operators/owners may pull four levers to increase 'standalone' EV charging station profitability

Key factors impacting public charging economics

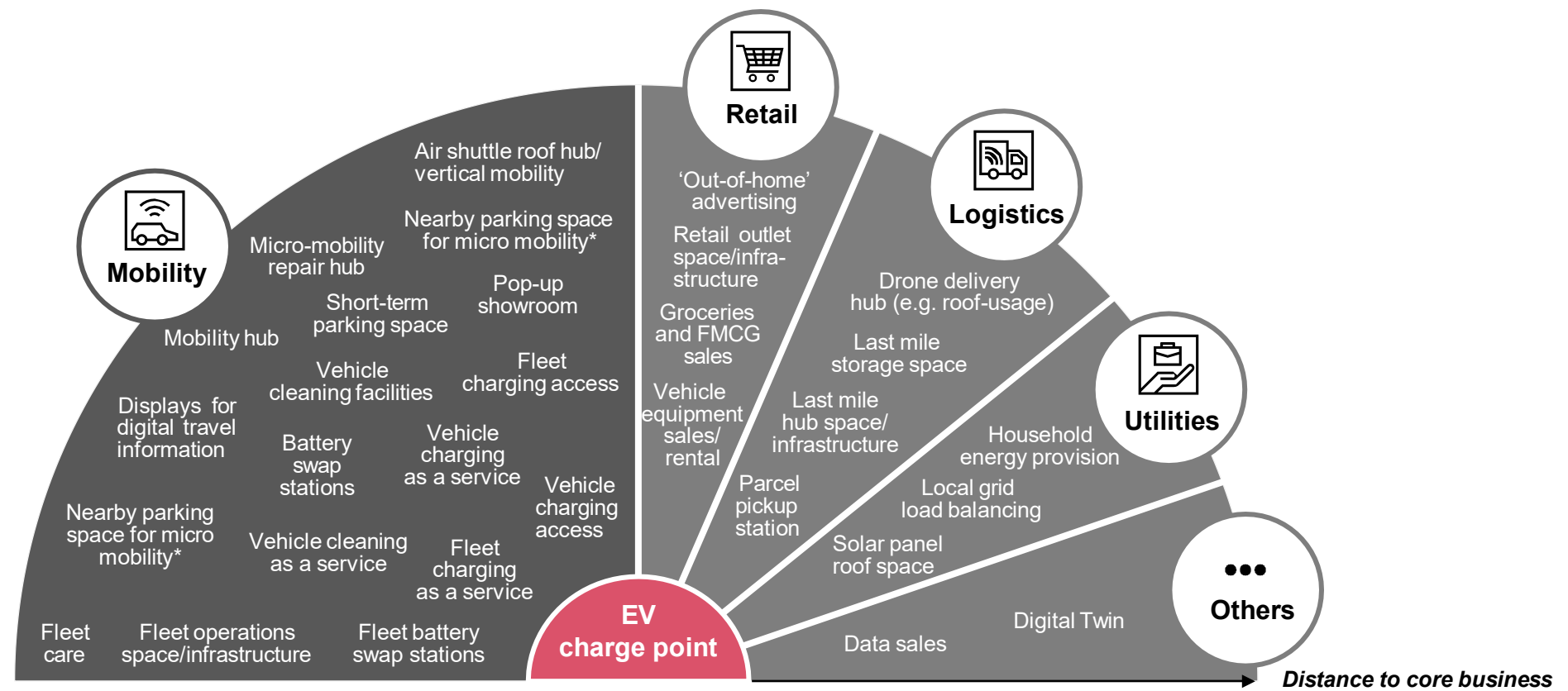


EV infrastructure business models



Moving beyond typical customer groups and mobility sector allows charging providers to tap into new value added services

Value added services – Expansion beyond EV charging

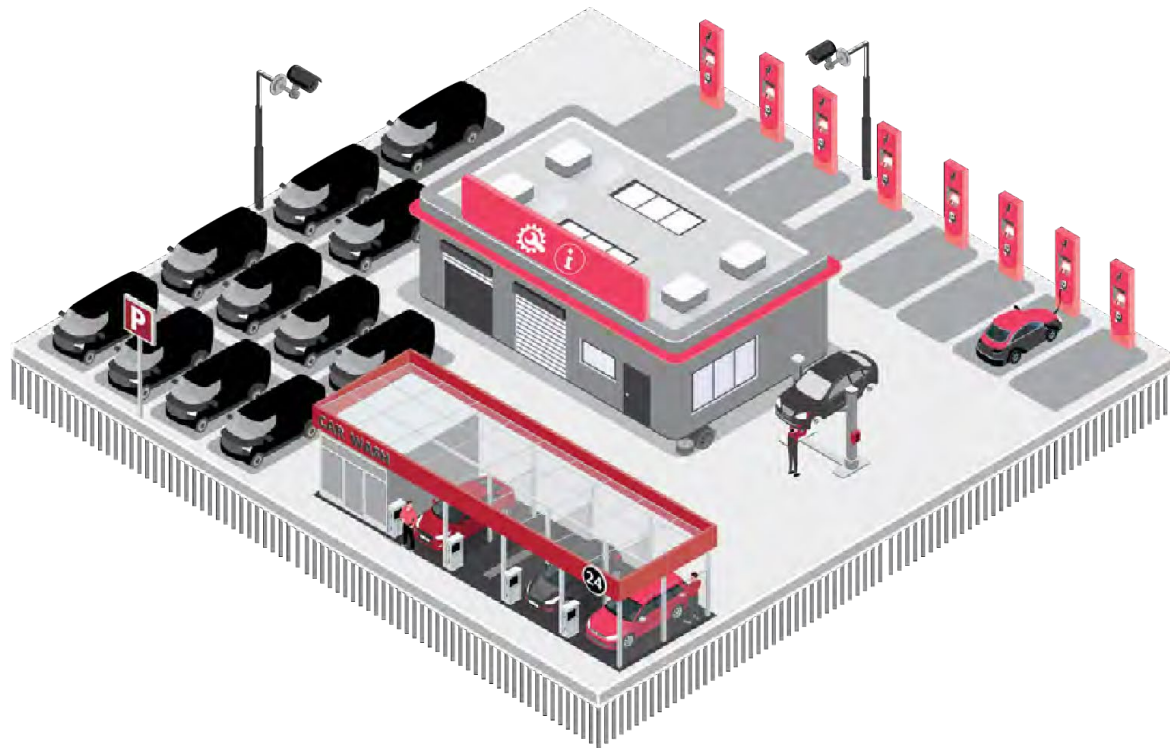


Considerations

- Traditional charge point operators as well as gas stations may utilize their existing hyperlocal footprint to offer broader mobility services
- Similarly, tapping into adjacent industry verticals displays a worthwhile option, as industry boundaries continuously blur

Fleet operations hubs build the local home base for (automated) mobility fleets

B2B mobility offering – Fleet operations hubs



- Fleet operations hubs are integrated infrastructure solutions primarily for maintenance activities and daily fleet operations
- Hubs with fully fledged service offerings may cover up to 40% of total vehicle-km costs in autonomous mobility services. This may add up to ~\$160bn p.a. globally by 2035

Key B2B offering components



Parking

To provide a legal and safe space for fleets during non-operating hours



Charging

To allow efficient (rapid) charging e.g. overnight



Cleaning

To bring vehicles to desired condition (e.g. especially inside hygiene)



Maintenance

To keep operating ability, e.g. combined with other daily/weekly fleet services



(Smart) Repair

To keep operating ability in addition to maintenance activities

Key differentiators



Hyperlocal Footprint

Sufficient regional coverage to minimize distances



Fast Turn-Around

Integration of services to achieve maximum vehicle uptime







Mobility hubs are the physical puzzle piece to integrate multi-modal mobility

B2B mobility offering – Mobility hubs




- Mobility hubs represent the melting pot of mobility and other physical services
- Value capture mainly via increased own service usage as well as additional revenue sources from audience monetization, value-added space rental, and neighborhood development

Key B2B offering components

- | | | | |
|--|---|--|---|
|  | Interchange
To efficiently connect intermodal passenger journeys |  | Parking space
To cater car and micro mobility passengers |
|  | Customer service
To enable a local face to customer |  | Retail space
To address passing passenger volume |
|  | Operations space
To enable hyperlocal service offerings (e.g. last mile grocery delivery) |  | Ad inventory
To monetize passenger audience with out of home advertisements |

Key differentiators

- | | | | |
|---|--|-----|-----|
|  | Location
Central intersection points or outer city/rural switch points | ... | ... |
|---|--|-----|-----|

In this blurring mobility ecosystem, strategic recommendation for value creation depends on individual starting position

Recommendations for mobility value creation



Automotive OEMs

Occupy ecosystem control points

Leverage system integration and tech capabilities to occupy strategically relevant positions

Become the mobility asset backbone

Leverage strong financial service expertise to master fleet ownership and management activities across mobility service providers



Automotive suppliers

Develop adaptable technology platforms

Organize own offering around a modular platform with open interfaces to seamlessly integrate new technology partners

Move into mobility enablement

Evolve from supplying cars to enabling mobility solutions where strong engineering or system integration capabilities are needed



Traditional transport operators

Mitigate potential passenger erosion

Actively create multi-modal mobility offerings integrating own core services with 3rd party offerings

Build B2B offerings across the mobility ecosystem

Utilize existing physical footprint and assets to supplement third parties' offerings, move into revenue sharing models



New mobility service providers

Increase customer experience and cost efficiency

Continuously scan for local opportunities to improve user experience while investing in scalable tech platforms for operational efficiency

Build partnerships for rapid local scale-up

Complement public transport and limitations of existing physical mobility infrastructure via partnerships with local incumbents



Energy and utility

Utilize existing assets

Exploit existing asset portfolio from (renewable) generation to smart grid/cities/home to defend or grab market share

Leverage public sector/regulator relationships

Build on deep understanding of municipalities to create new services, e.g. combining access to parking space and electricity grids

Network contacts



Jörg Krings

joerg.krings@
strategyand.de.pwc.com

Automotive Europe



Dr. Andreas Gissler

andreas.gissler@
strategyand.de.pwc.com

Digital Transformation



Jonas Seyfferth

jonas.seyfferth@
strategyand.de.pwc.com

Connected and Smart Mobility



Hartmut Güthner

hartmut.guethner@
strategyand.de.pwc.com

Automated Driving



Dr. Jörn Neuhausen

joern.neuhausen@
strategyand.de.pwc.com

Alternative Powertrains



Thilo Bühnen

thilo.buehnen@
pwc.ch

Mobility Venturing



Akshay Singh

akshay.singh@
pwc.com

Automotive US



Steven Jiang

steven.jiang@
strategyand.cn.pwc.com

Automotive China



Kentaro Abe

kentaro.abe@
pwc.com

Automotive Japan



Milos Bartosek

milos.bartosek@
pwc.com

Infrastructure Deals

Contributors

Steven van Arsdale

Jorgen Frost Bo

Sophie Kulig

Sarah Nolte

Dr. Philipp Rose

Patrick Schwenke

China contacts



Jun Jin

Mainland China and Hong Kong
Automotive Leader
jun.jin@
strategyand.cn.pwc.com



Huchu Xu

Partner
huchu.xu@
strategyand.cn.pwc.com



Steven Jiang

Partner
steven.jiang@
strategyand.cn.pwc.com



刘昕

Partner
frank.xb.liu@
strategyand.cn.pwc.com



刘恬恬

Senior Manager
tina.tt.liu@
strategyand.cn.pwc.com



张莉

Senior Manager
ashley.l.zhang@
strategyand.cn.pwc.com