strategy&
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Digital Auto Report 2020

Navigating through a post-pandemic world

VOLUME 1

pwc

Digital Auto Report 2020 – Volume 1

- ✓ Ninth annual Digital Auto Report, developed by Strategy& and PwC
- ✓ Global consumer survey with a focus on the US, EU and Asia (n = 3,000)
- ✓ Quantitative market outlook until 2035 based on regional structural analysis
- ✓ Interviews and survey with >60 industry executives at OEMs and suppliers, leading academics and industry analysts

Volume 1

Anticipating post-pandemic market dynamics

- Market outlook – penetration of technologies and mobility types
- Technology – shifting gears in connected, electric, automated
- Customers – changing mobility preferences: shared no more?
- Regulation – slowdown or acceleration of key policies?

Volume 2

Rethinking business models and investments

- New business opportunities – hype or reality?
- Economic value – market growth and unit economics
- Investment strategy – OEMs vs. VCs vs. Tech players
- OEM survival guide for a post-crisis market reality

Volume 3

Building a software-enabled automotive company

- Capabilities of a software-enabled company
- Deep dive on automated software development and testing
- Capability build-up strategy – a platform approach

The mobility ecosystem is transforming into a fragmented future w/different adoption patterns and use cases by region

Executive summary – Volume 1

- With adjusted technology expectations and changing post-pandemic customer preferences, CASE evolves. **Consumers do not expect** fully **automated cars before early 2030s**. **Shared mobility growth is slowing down,** relevance of seamless mobility remains high
- Total **vehicle parc expected to shrink in Europe** (-0.5% p.a.) while **growing in the US** (+1.1% p.a.) **and China** (+3.9% p.a.) until 2035, driven by 1) mobility growth (highest in China), 2) customer preferences for sharing (lowest in US) and 3) vehicle disposal rate
- **Regulatory requirements** are driving **basic connectivity** in **EU** and **US** (>85% penetration of new cars in 2020), while **China is still at 44%**. **Total connected vehicle parc will pass 50% mark in Europe by 2025**; in US as early as 2023 and in China latest by 2029
- **EU and China are leading the e-mobility transformation** with expected new car **BEV share of 17% and 19% by 2025**. **US significantly lower with 5% by 2025** given fewer government incentives and attractive ICE alternative in terms of TCO
- **Automated driving** will emerge in a broad spectrum of use cases with specific requirements that are difficult to scale. While e.g. L4 pilot projects with people movers are running today, **L4 share** of new vehicles is expected to reach **17% by 2035 in EU** (vs. 16% in China)
- Shifts in individual **mobility patterns require a new segmentation** in terms of **private vs. shared** and **active vs. passive driving** – each with multiple use cases at different automation levels. **Shared-active** (e.g. rental, subscription) expected to grow strongest **in EU** (10% of total person kilometers by 2025), while **shared-passive** (e.g. ride-hailing) is expected to grow **significantly more in China** (10% vs. 1-3% in US and EU)
- The **increasing proliferation of use cases and business models** requires many players to **re-evaluate their CASE strategies** with a fact-based view on available technology, value pool sizes and unit economics as well as investment requirements and right to win (→ covered in our next report volume No 2)

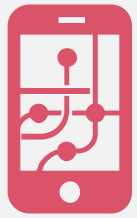
Note: Please refer to respective section for detailed assumptions and sources behind stated propositions

“

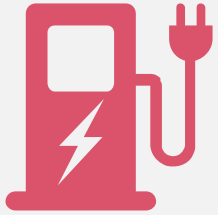
With adjusted technology expectations and changing post-pandemic customer preferences, CASE evolves”

S for **Shared** becomes **Smart** (Mobility)*

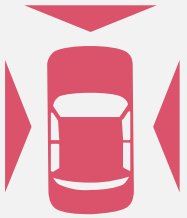
*Smart Mobility describes a transportation ecosystem where stakeholders use data and connectivity to move people and goods sustainably and efficiently.
Shared mobility remains as a sub-segment and an important value pool in this ecosystem focusing on people transport with passenger vehicles.



Connected



Electric



Automated

Smart Mobility

Source: Strategy&

Triggered by the effects of the COVID-19 pandemic, many players will have to reevaluate their CASE strategies

Consumer

COVID-19 postpones consumer spend during lock-downs. Demand recovery expected with preference for EV

Technology

COVID-19 shatters old industries and will lead to market shakeout. Digital and remote tech is on the rise

Regulation

COVID-19 imposes new norms for work environments, consumer interactions and international trade

Economics

COVID-19 cuts topline, accelerating saving needs of OEMs and suppliers as liquidity becomes critical to survive

Connected

COVID-19 digitizes society and increases acceptance and demand for digital – and connected – services

Automated

COVID-19 modifies competition: Big Tech benefits, asset-heavy OEMs struggle to keep up required R&D invest

Smart mobility

COVID-19 reverses preference for mobility modes – own vehicles regain preference against shared

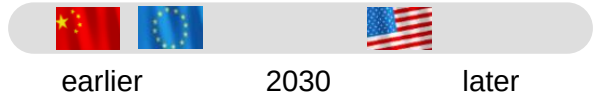
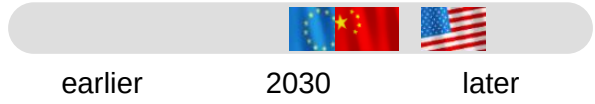
Electric

COVID-19 cools down economies, leads governments to subsidize EVs and increases EV market demand

Source: Strategy&

The acceleration of technology penetration will occur at varying times and speeds globally, as local mobility transforms

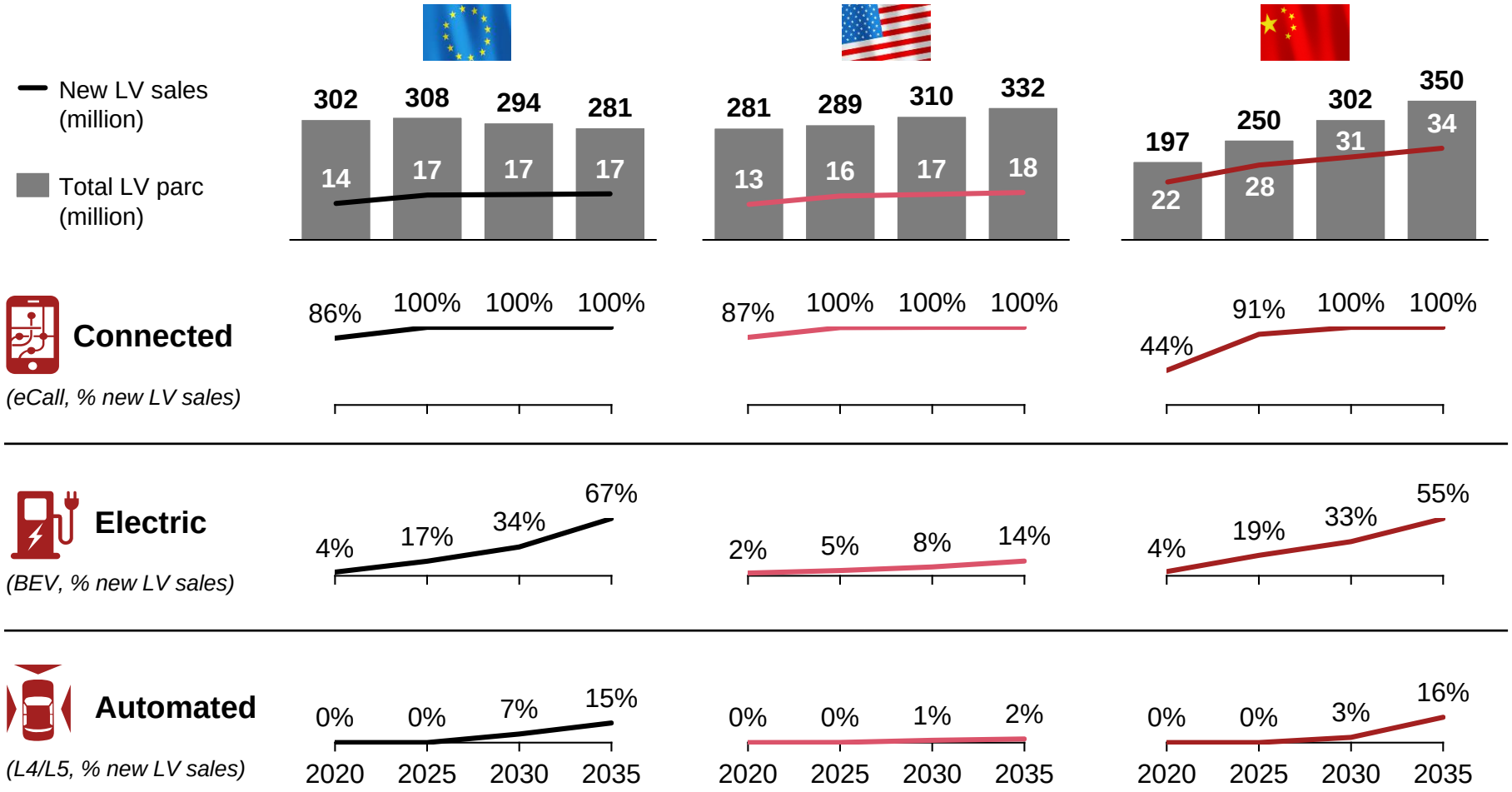
Key considerations to anticipate tipping point of exponential technology adoption

	Technology	Consumer	Regulation	Economics	*Expected tipping points*
Connected	• Connected service **content and UX** • Vehicle **system/EE architecture** • **Network infrastructure**	• **"Digitally savvy" share** of population • **"Freemium" segment** services	• Scope and timing of enforced **connectivity requirements** • Scope of **data privacy restrictions**	• **Indirect value capture** by OEM • **Effective end consumer pricing**	
Electric	• **Battery and powertrain performance** • EV **manufacturability and production capacity** • Charging infrastructure	• **Premium/early adopter** segment size • "**Rational green**" segment size	• **Emission target levels** • **BEV/PHEV incentives** • **Diesel/ICE bans/restrictions** in cities	• Superior **total cost of ownership** (TCO) of BEV vs. ICE in relevant number of segments • **Additional revenues/savings** from V2G/V2X charging	
Automated	• **ADAS** capability by use case • **Data processing** • **Driver UI** • **Network and traffic infrastructure**	• **Premium/early adopter segment** size • **Technology openness**	• Scope and timing of **enforced ADAS safety features** • Geographic **range and quantity of AV test drive/ vehicle approvals**	• **Superior TCO vs. non-AV** in first commercial cases • **Additional value capture** from riders	
Smart Mobility	• **Smartphone penetration** • **Access and fleet availability**	• **Intermodal openness** • People/**traffic density** "**Frequent** user" segment size	• **Private car restrictions**/ taxes • Passenger **transport regulation**	• **Superior TCO** vs. own vehicle • **Dynamic pricing** for opt. use and availability	

ADAS = Advanced Driver Assistance Systems; EE = Electric/electronics, V2G = Vehicle to grid, TCO = Total cost of ownership
Note: A tipping point is defined as the start of exponential growth within a segment of the mobility transformation
Source: Expert interviews, PwC AutoFacts®, Strategy&

Total car parc growth strongest in China with high penetration of connected and electric; automation relevant after 2025

Total vehicle parc and technology penetration (in million, %)



Assumptions

- **Total vehicle parc** driven by
  - Growing economic mobility demand after COVID-19
  - Build-up of new mobility fleets with high annual mileage
  - Disposal of outdated vehicles
- **Basic connectivity with high penetration** due to regulation in US/EU; share with over-the-air (OTA) capability significantly lower
- **BEV with strong growth in EU/ China** due to government subsidies and earlier “total cost of ownership” parity (vs. ICE) than in the US
- **Delay of automated vehicle penetration** at L4/L5 due to technical challenges and investment cuts; L3 with first useful applications before 2025

Source: PwC AutoFacts®, Strategy&

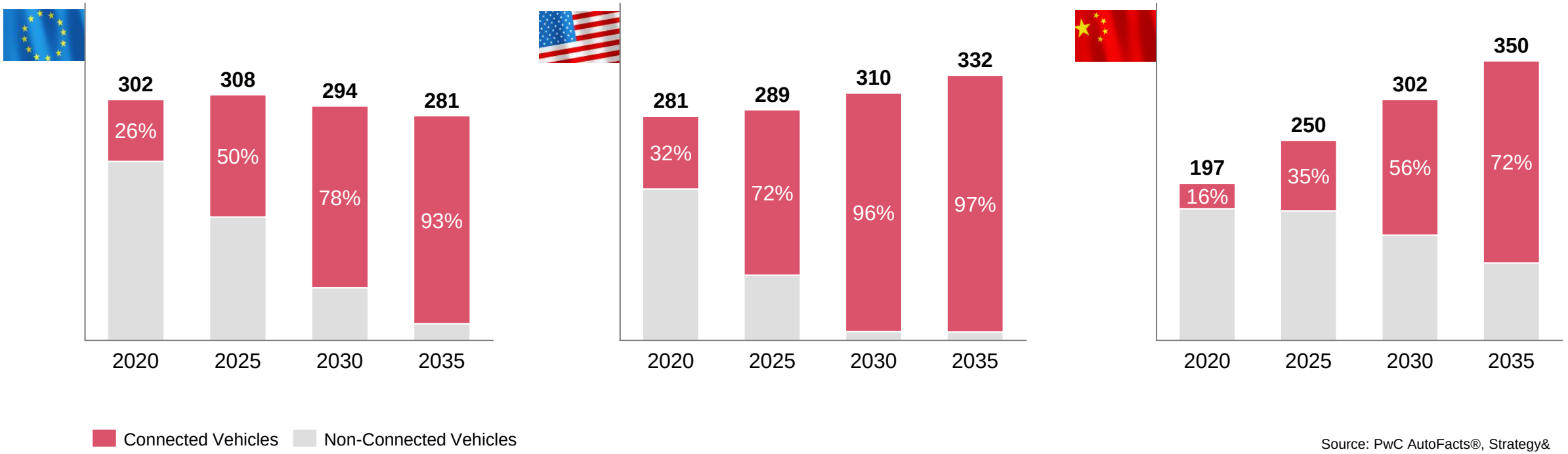
LV = Light vehicles = Cars + light commercial vehicles < 6t GVW

BEV = Battery electric vehicle

ICE = Internal combustion engine

Connectivity will rapidly penetrate total car parc; OEMs need to leverage platforms for scale, while maintaining distinct UX

Total vehicle parc and connected car share (in million, %)

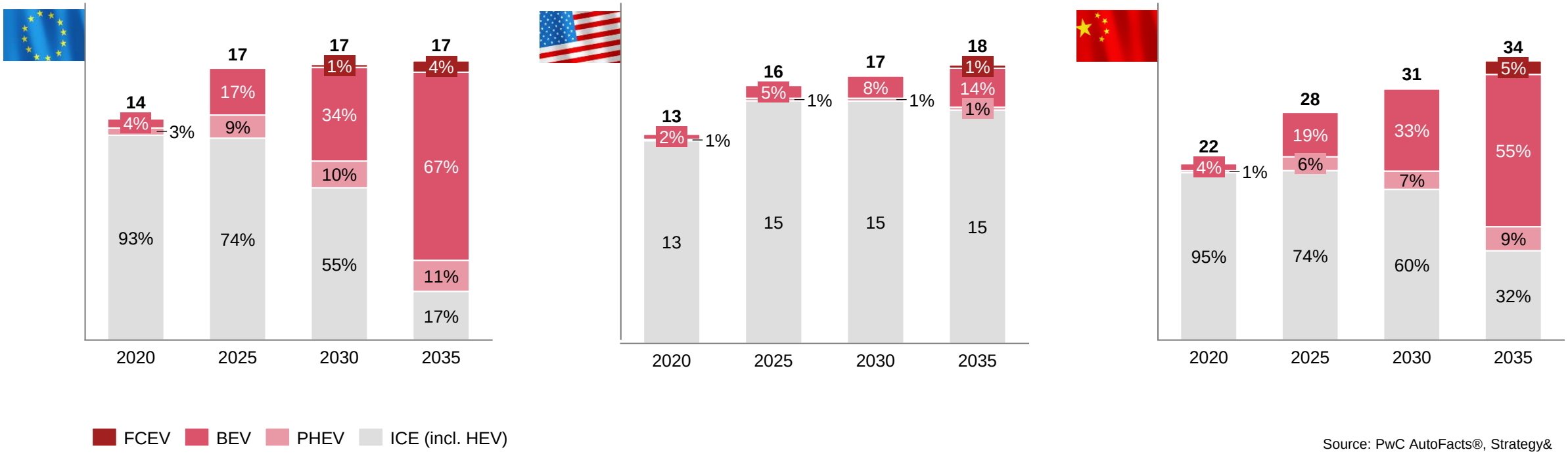


Source: PwC AutoFacts®, Strategy&

> “Total vehicle parc expected to shrink in Europe (-0.5% p.a.) while growing in the US (+1.1% p.a.) and China (+3.9% p.a.) until 2035 – connectivity penetration >50% after 2025 in Europe and US.”

The shift from conventional to electric powertrains is under-way; China and Europe head-to-head in market penetration

New vehicle sales by powertrain (in million, %)

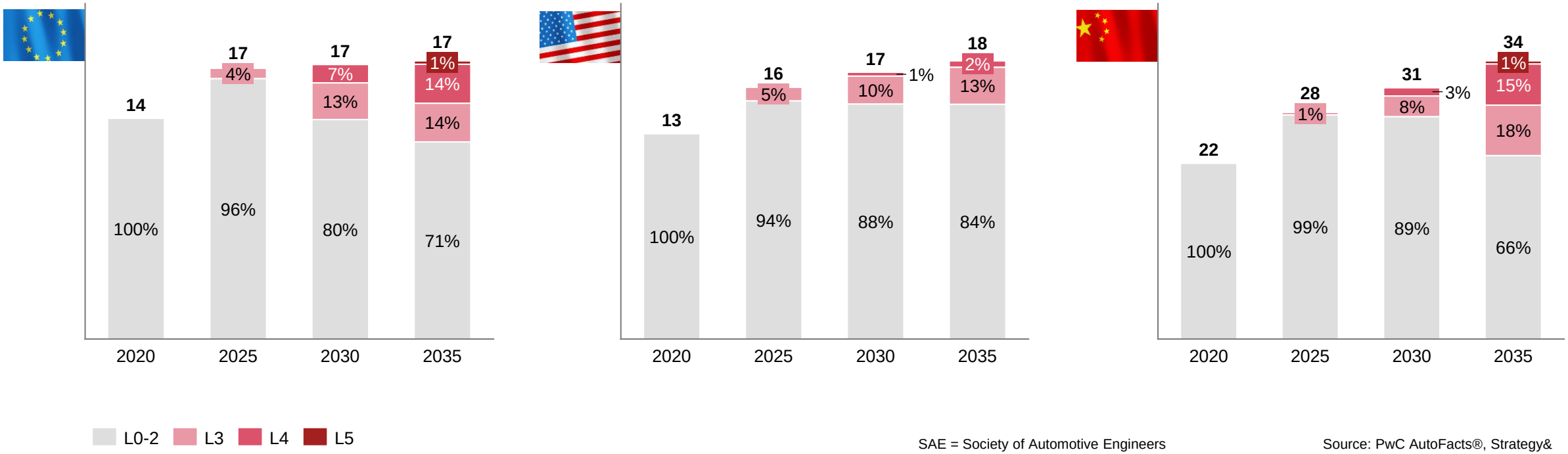


Source: PwC AutoFacts®, Strategy&

> "Tightening CO_2 emission targets in the EU and new national guidelines in China accelerate BEV penetration in these regions significantly faster than in the US."

Automated driving will not arrive with a *big bang*: Various useful functions and features will pave the way for L4

New vehicle sales by SAE level (in million, %)



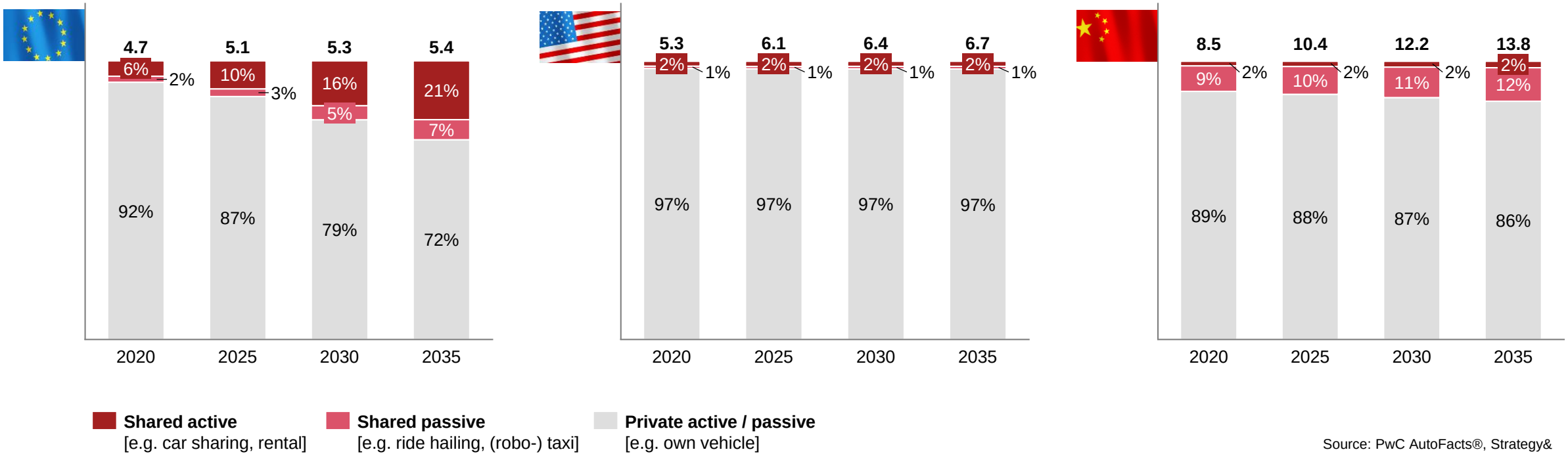
SAE = Society of Automotive Engineers

Source: PwC AutoFacts®, Strategy&

> “Before deploying L4 passenger vehicles at scale, players will push the next years for specific automated driving applications in transport / fleets and logistics / industrial areas to recover investments.”

Transformation of mobility refocused towards shared active and passive modes due to COVID-19 and slower automation

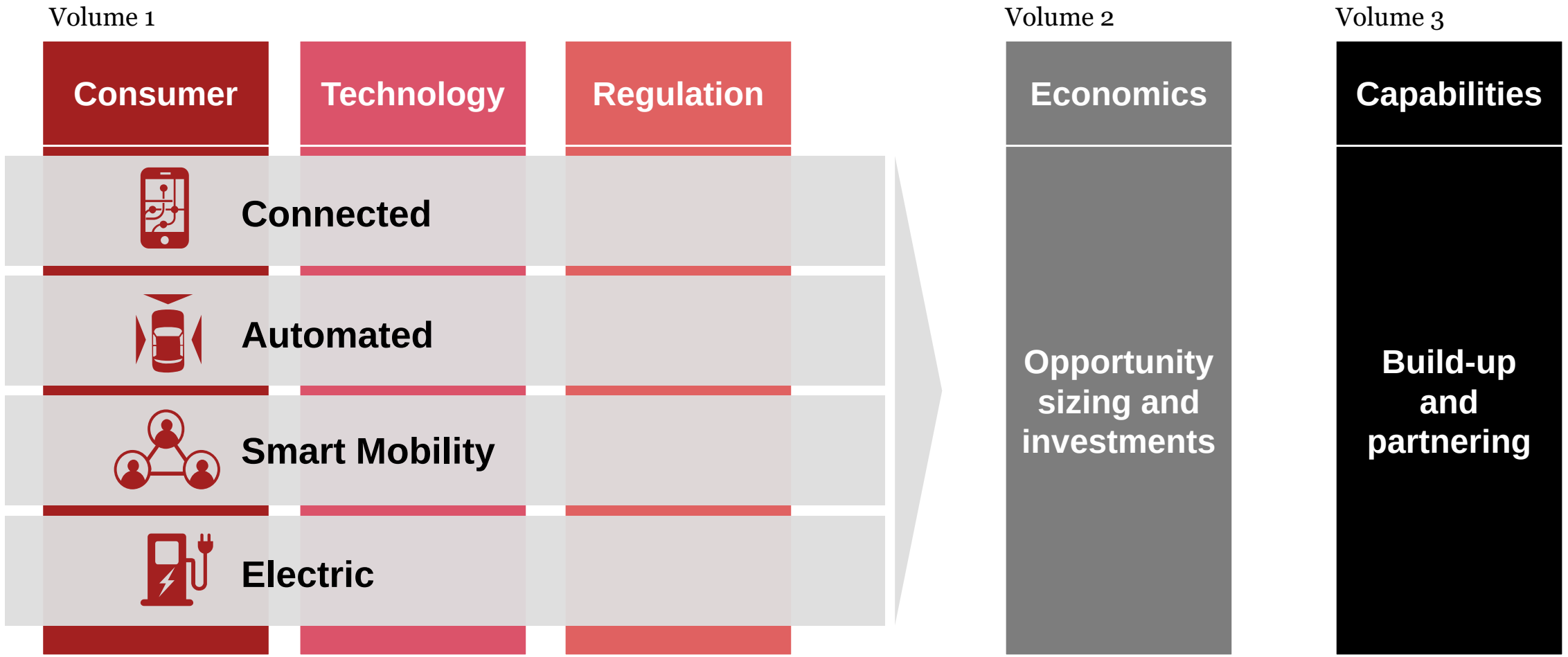
Market penetration by mobility mode (in '000 trillion person-kilometer, %)

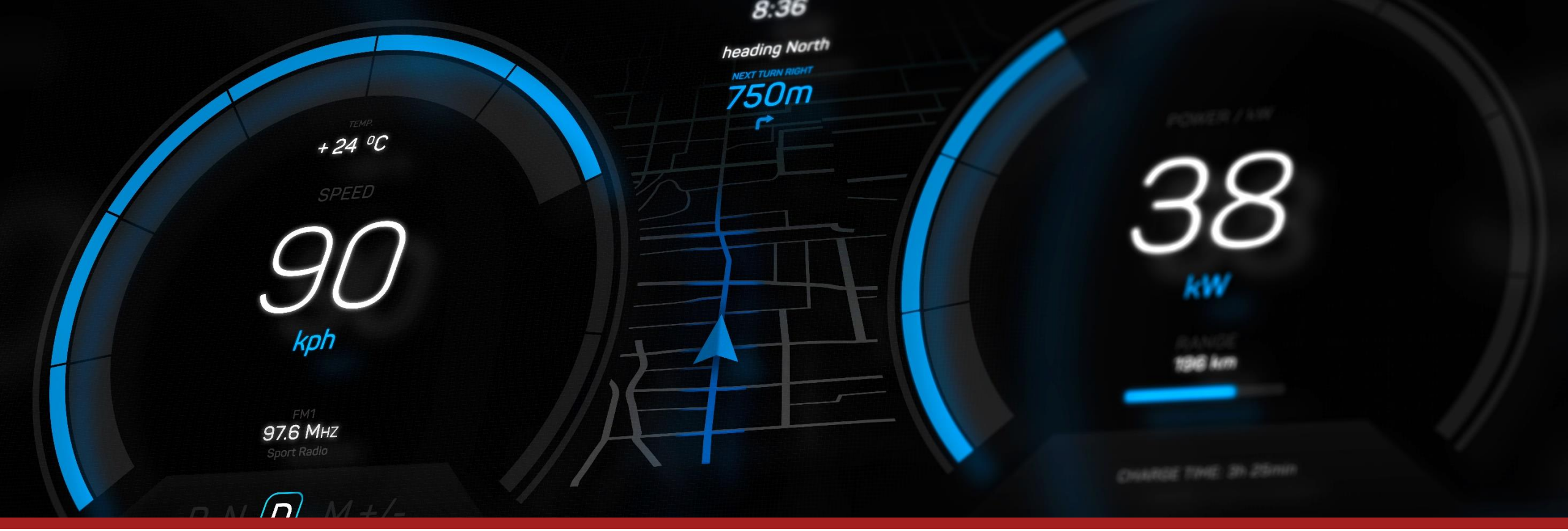


Source: PwC AutoFacts®, Strategy&

"Global market remains difficult to address with one mobility service given high proliferation of different active & passive driving use cases – new players invest in multi-mode transport platforms."

This report series lays out in three volumes 1) CASE drivers, 2) economic opportunities, and 3) capability implications





Volume 1 Anticipating post-pandemic market dynamics

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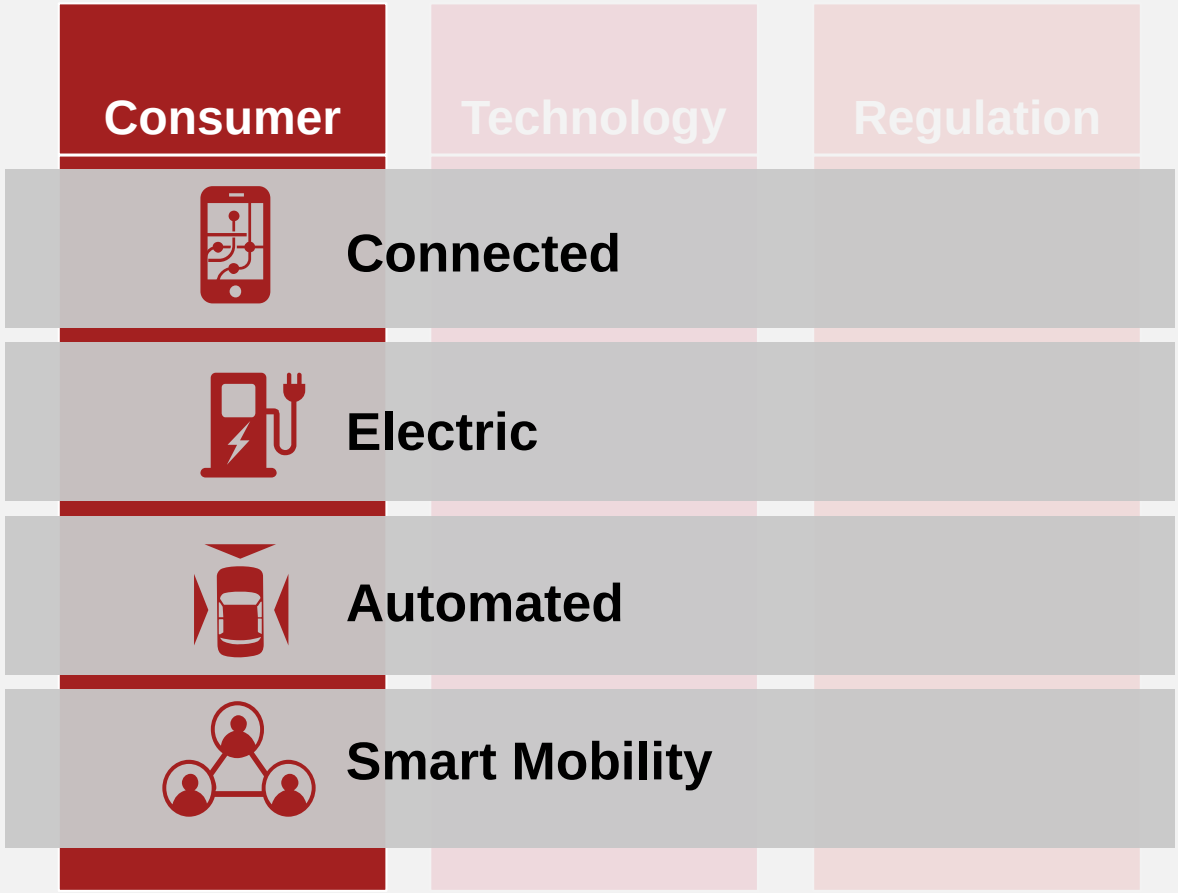
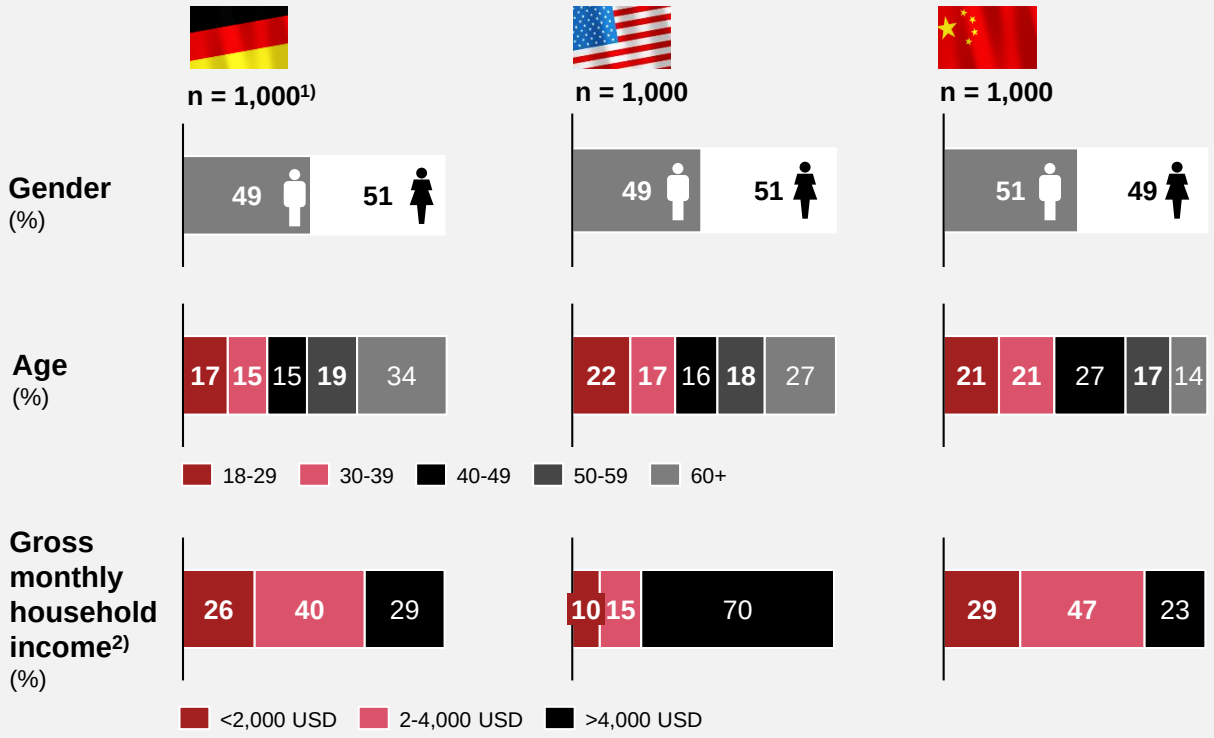
Consumers seek convenient and safe mobility – private transport modes regain importance”



Source: Strategy&

Survey among 3,000 consumers in Germany, the US and China shows latest shifts in consumer mobility preferences

3 regions | **>20** questions | **>3,000** Respondents[1)]



Key results

- Respondents confirm relevance of connected services – **security** & **navigation most important**
- However, **willingness to pay** overall **lower** than most OEMs hoped for

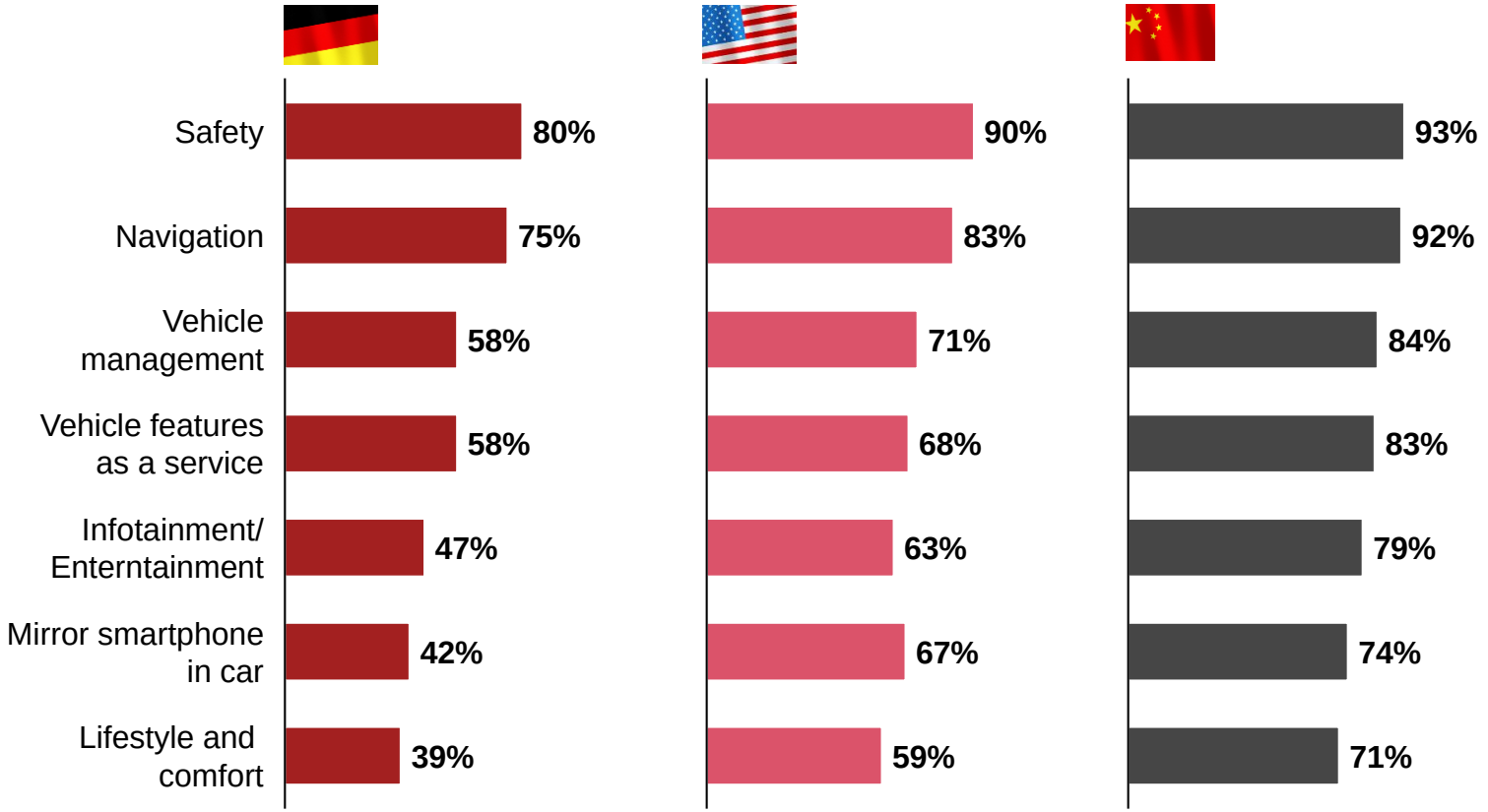
- Consumers expect **AD vehicles** in the early 2030's; first in transportation, later in private cars
- **Two thirds of respondents** would use **automated vehicles**; of those **75% would pay a premium** for an automated driving of **5 – 20%** per ride

- While **new car purchase options lead across regions** pre- and post-pandemic, interest in **car subscription** is growing strongly in China
- **Regular** cleaning / **disinfection** has become most important feature for shared mobility offerings to ensure usage during **COVID-19**

1) Questions on COVID19 effects of mobility behaviour in DE partially n=2,000 2) converted from EUR/CNY (Mid of August 2020) Remaining % up to 100% "not specified"

Respondents highlight the importance of connected services – safety and navigation rated as most important features

Connected services – By importance for consumers[1)]



Question: *"Which connected service categories are particularly important to you?"*

In Germany in particular, **safety** and **navigation rank as most important** services.

Winning consumers in other categories requires **strong USP** and compelling story.

1) Share of respondents, who want to have connected services in their vehicles
Source: PwC Strategy& consumer research 2020; n=3,000 (1,000 DE, 1,000 US, 1,000 CN)

Customers want in-vehicle connected services; however, willingness to pay might be lower than OEMs hope

Connected services – Willingness to pay[1)]

Monthly willingness to pay	vs.	reference prices of other digital & media services			
Fully-fledged connected service offering		Spotify subscription[2]	Mobile voice & data contract	Premium sports stream[3)]	iPhone leasing[4)]
$ 19.5 at 31% willingness		**$ 11.9**	**$ 34.6**	**$ 14.2**	**$ 39.5**
$ 17.6 at 40% willingness		**$ 10.0**	**$ 43.6**	**$ 19.9**	**$ 35.3**
$ 4.3 at 58% willingness		**n/a**	**$ 9.8**	**$ 10.3**	**$ 33.4**

Question: *"Would you like to have Connected Car services integrated in your vehicle and are you willing to pay a surcharge for this? If yes, how much…"*

China with **highest share of consumers** (58%) who are **willing to pay an extra** for connected services .

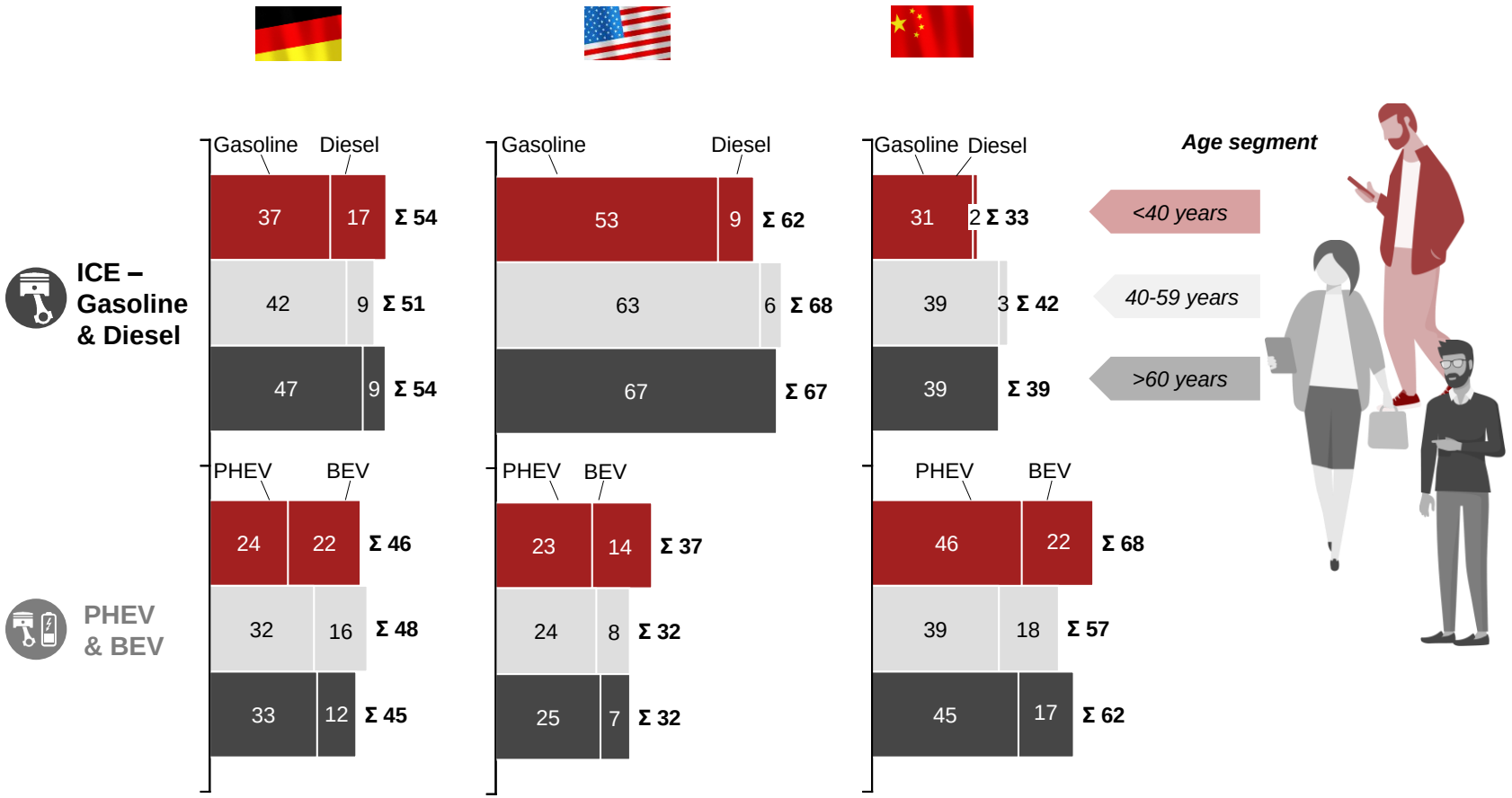
Capturing this value requires providers to compete partially against other digital services.

1) Local currency conversion to USD as of mid of August 2020 2) "Individual" plan 3) DAZN basic package for GER and USA, basic Tencent package in China 4) iPhone 11 64GB, 24 months leasing

Source: PwC Strategy& consumer research 2020; n=3,000 (1,000 DE, 1,000 US, 1,000 CN); International Telecommunication Union 2019

Gasoline still most preferred type of powertrain in Germany and the US; hybrid gains popularity and is most popular in China

Preferred type of powertrain by age (%)



Question: *"Suppose you wanted to buy a car: Leaving aside financial aspects, legal requirements and lack of infrastructure […] – which type of drive do you like best?"*

While **68% of Chinese** consumers below 40 years **prefer electric powertrains** over gasoline, only 46% in Germany and 37% in the US share this preference.

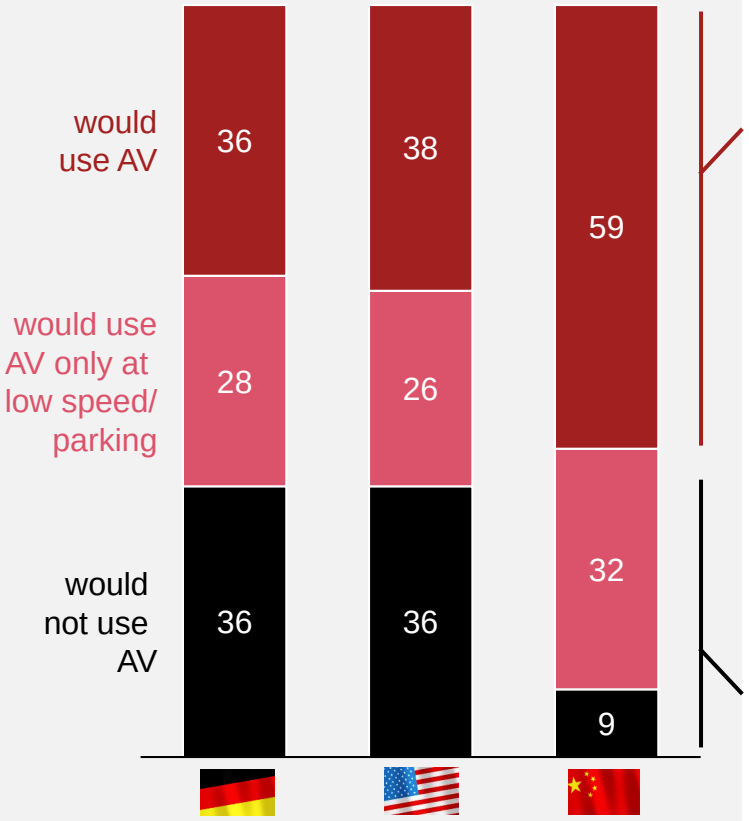
Source: PwC Strategy& consumer research 2020; n=2,000 DE, n=1,000 US, n=1,000 CN

Percentages may not total 100% due to rounding

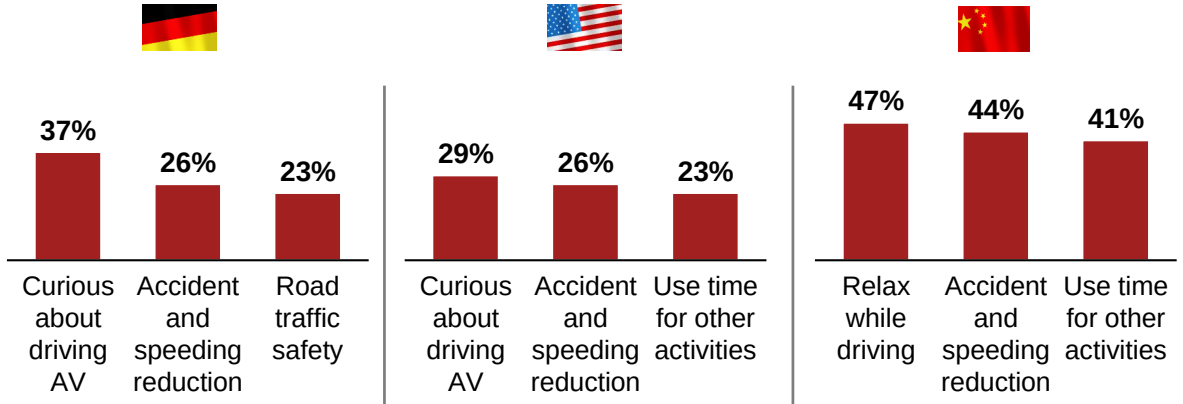
Two thirds of respondents would use automated vehicles; of those, 75% would pay a premium for an automated driving service

Automated driving – Consumer attitude, impact factors and willingness to pay

Attitude towards AV (%)

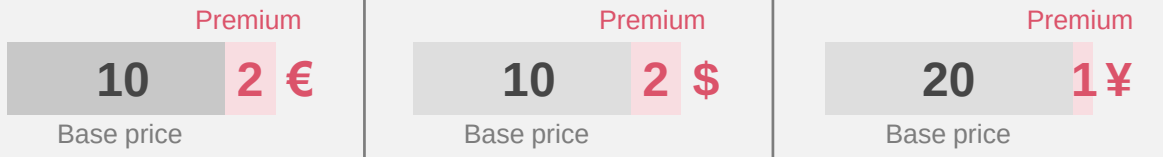


Top 3 Persuasive factors for using AV
(% of respondents)

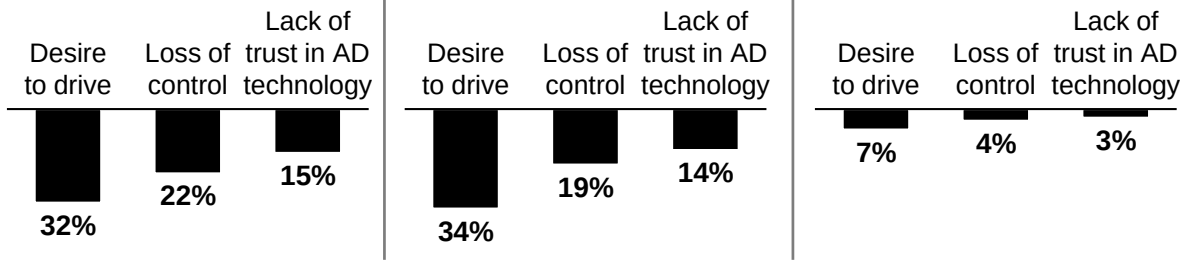


Willingness to Pay

"Would you be willing to pay a premium for an AV (e.g. car sharing, ride hailing)? If yes, how much more would you pay for a 5 km trip with a base price of 10 €/10$/20¥?"



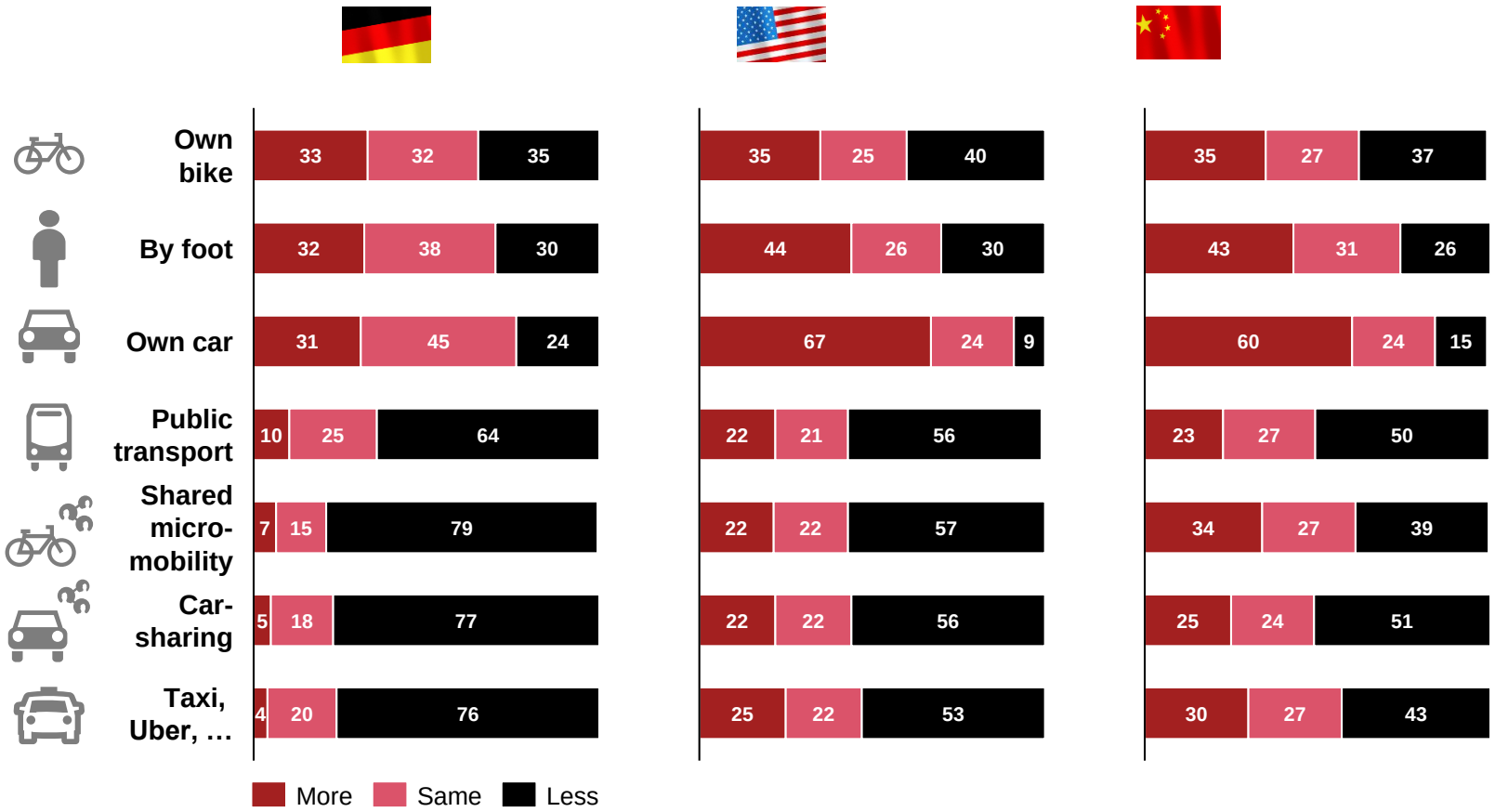
Top 3 Deterrent factors for using AV
(% of respondents)



Source: PwC Strategy& consumer research 2020; n=3,000 (1,000 DE, 1,000 US, 1,000 CN)
* Average willingness-to-pay a premium for a 5km ride with an automated vehicle instead of having a chauffeur or self-drive

Mobility modes shift due to effects of COVID-19 – use of own vehicle preferred over shared mobility and public transport

Mobility patterns after COVID-19 restrictions (%)[1)]



Question: *"Assuming COVID-19 restrictions are lifted again, how would you use the following mobility modes compared to pre-COVID-19 times?"*

Own car is the clear winner in the US and China. In **Germany**, the **intended increase of car usage is on par with bike and foot**.

At the same time, Germans move away strongly from shared modes.

1) On the example of transportation to/from work

Source: PwC Strategy& consumer research 2020; n=1,259 DE, n=593 US, n=779 CN; Percentage may not total 100% due to rounding

Shared mobility providers win consumers back with clear disinfection concepts rather than with lower prices

Attitude towards shared mobility after COVID-19 lockdown (%)

42	58

1| Regular **cleaning and disinfection** by the provider (28%)
2| Lower/**cheaper** prices (25%)
3| Reliable **availability** (24%)
…
8| Offer of **gloves** and **masks** in the vehicle (15%)
9| **Higher quality/premium** vehicles (11%)

17	83

1| Regular **cleaning and disinfection** by the provider (50%)
2| Lower/**cheaper** prices (40%)
3| **Provision** of **disinfectants** to/in every **vehicle** (39%)
…
8| **Reserved parking** spots (26%)
9| Extensive geographical **coverage** (17%)

2	98

1| Regular **cleaning and disinfection** by the provider (49%)
2| **Provision** of **disinfectants** to/in every **vehicle** (49%)
3| Lower/**cheaper** prices (42%)
…
8| Extensive geographical **coverage** (33%)
9| **Reserved parking** spots (32%)

Question: *"Which requirements should providers fulfill to ensure that you would continue using shared mobility offerings after COVID-19 lockdown?*

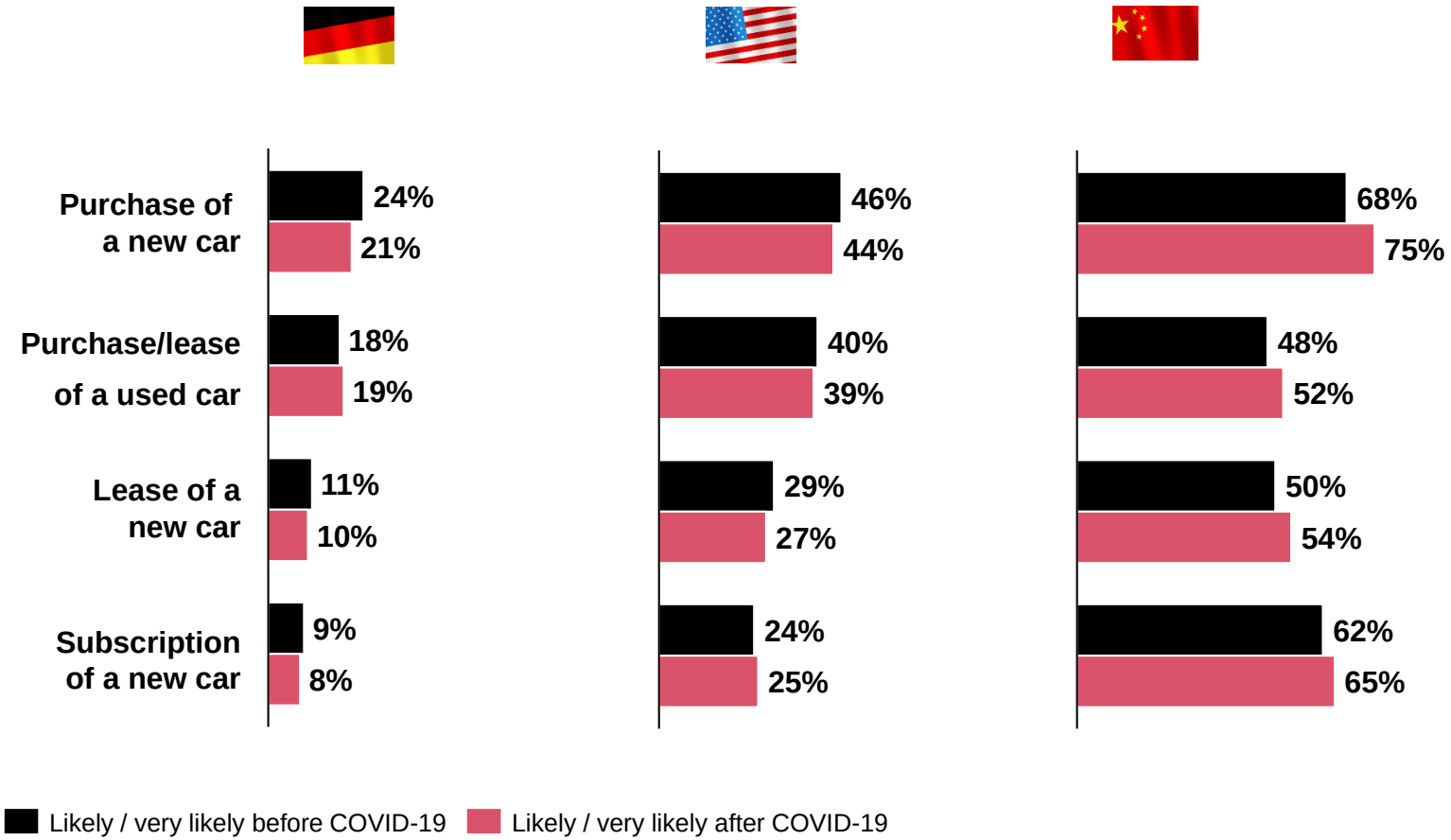
In Germany, **quality / premium vehicles** seen as **least important** factor to return to shared modes – after cleaning, **price** and **availability are most important**.

No usage of shared mobility offerings at all | Open towards usage of shared mobility offerings

Source: PwC Strategy& consumer research 2020; n=2,000 DE, n=1,000 US, n=1,000 CN

Purchasing a new vehicle remains preferred option across regions; China shows strongest increase in subscription intent

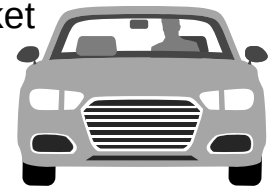
Likelihood to buy/lease/subscribe to a car before/after COVID-19 (%)[1)]



Question: *"Taking the position of pre-COVID-19, how likely was it that your household would buy, lease or subscribe to a new vehicle in 2020/2021? How likely is it now?"*

China, and partly the US, are **open towards subscription models**.

In Germany, further market education needed to win subscription customers.

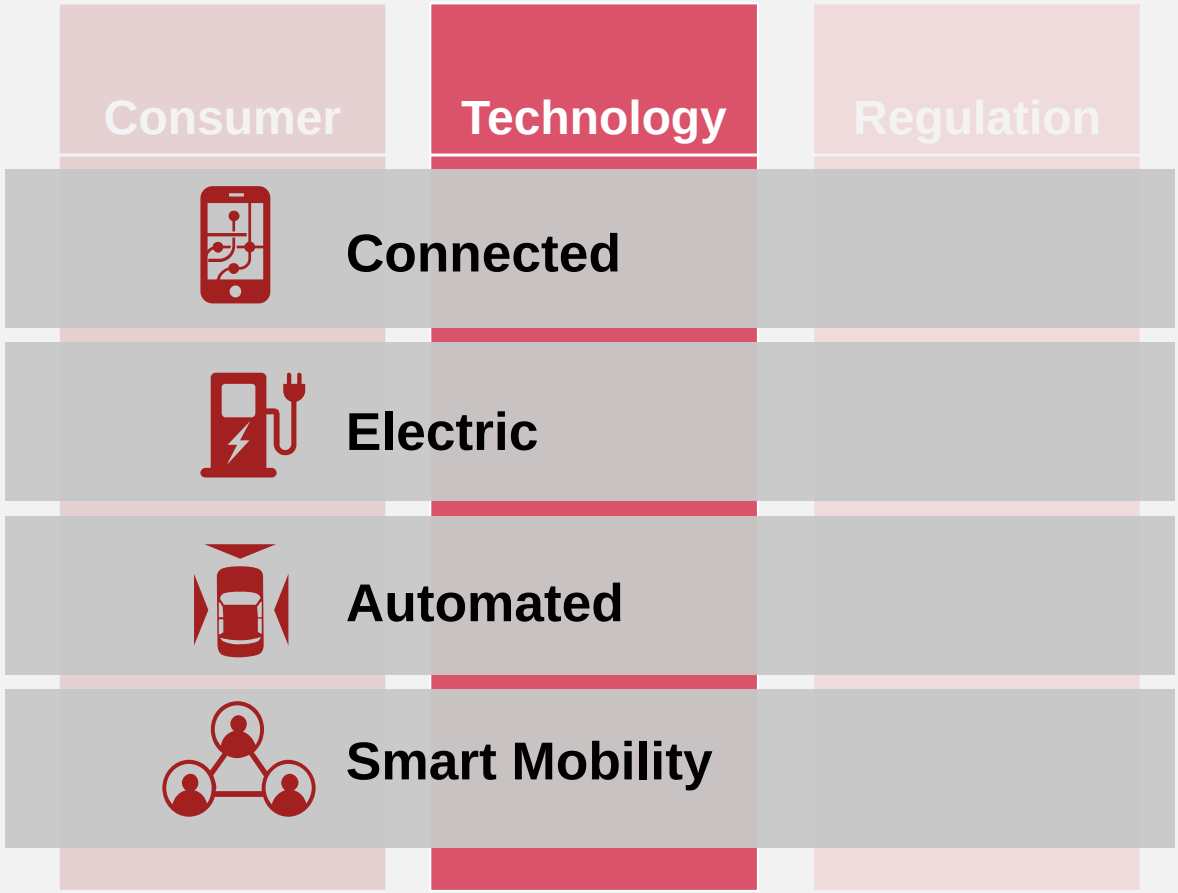


1) Before= 1 year ago, after = within next 1-2 years
Source: PwC Strategy& consumer research 2020; n=2,000 DE, n=1,000 US, n=1,000 CN

Difference to 100%: no/low likelihood to buy/lease/subscribe a car

“

Technology progresses fast – yet complexity of autonomous driving has been underestimated”



In connected services, OEMs are currently rethinking their "build vs. buy strategy" on key technology components

Connected services components

	Enabler	Hardware	Software	Integration	Content/Service	Sales and CRM
	Plan – Build – Ship – Update – Sunset					
Key value blocks	Cloud infrastructure	Vehicle architecture and ECUs	Automotive security	User interface and controls	Vehicle-based services and apps	Offering bundling and pricing
	Mobile/local network	I/O devices (e.g., sensors, displays)	Vehicle OS, over-the-air-update and cloud platform	System integration	3rd party content and services	User ID and personalization
	Regulation	3rd party hardware (e.g. VR glasses)	Data analytics	Data interfaces and APIs	Cloud/hybrid services incl. vehicles health services	Customer support
Current limitations	• Cloud infrastructure costs • MNO costs • Regional regulations	• Centralized E/E architecture with zonal ECUs • Sensor fusion and virtual sensors	• OTA update functionality • Data processing and intelligent data fusion • Security of data connections	• UI design (e.g. graphical vs. voice only), • Online-first vs. offline-first • Open vs. closed APIs	• 3rd party content and app store integration • Transmission, collection, and analysis of vehicle health data (e.g. based on sensor data)	• Subscription vs. life-time offer model • Customer identification • VIN to UID • Data privacy
Current develop-ments	• Leverage eSIMs for customers and more frequent MNO tenders	• Evaluate sweet spot between complexity reduction and profitability • Enable expendable vehicle architectures	• Define software-value-add strategy Use virtualization to securely separate domains	• Focus on differentiating adaptive user interface • Provide and monetize SDKs and interfaces for 3rd parties	• Leverage smartphone integration for non-connected markets	• Bring user sign-up and log-in journey to perfection • Connect to existing ecosystems (e.g. phone)

Crucial value blocks (own know-how necessary)

CRM = Customer relation management ECU = Electronic control unit HW = Hardware I/O = Input/Output MNO = Mobile network operator
SDK = Software Development Kit SW = Software VR = Virtual reality V2X = Vehicle-to-x communication Source: Strategy&

Technology progress in e-mobility must be evaluated in the context of tech trends across various alternative powertrains

Alternative powertrain developments

ICE

Internal combustion engine

Electrification

- Recuperation and boost as standard features with 12V (budget) or 48V
- Increased electrification of auxiliaries (water/oil pumps, cam phaser, etc.)
- P2 topology avoiding drag torque

Reduction of friction losses

- Coatings and microstructural modifications on cylinder
- Optimization of crankshaft bearings
- Ball bearings for turbocharger

Combustion/emission optimization

- Increasing injection pressures
- Variability in valve trains
- Particle filters for most powertrains including DI gasolines
- Variable compression ratio through variable connection rod

PHEV / BEV

Electric drivetrain *(electric motor, inverter, transmission)*

Efficiency improvement

- Silicon carbide power semi-conductor switches (inverter)
- Bar windings and increased notch filling degree in electric motor

Cost reductions

- Increased integration of inverter and motor

High voltage system and architecture

Architecture

- Integration of power-units (OBC, DCDC, DC charger)
- Top models up to 800 V, standard in volume 400 V

Auxiliaries

- Increasing commoditization of electrified auxiliaries

HV battery system

System design

- Structural integration of housing into vehicle body
- System design incl. recyclability

Cell innovation

- Increased cell capacity through larger cells
- Cathode cost reduction by minimization of cobalt content and cobalt-free cells
- Increased anode energy density via silicon
- Intrinsic safe cells by application of solid state electrolytes (polymers, inorganics, blends)
- Dry (solvent-free) processing of electrode coatings

FCEV

Fuel cell system

Stack

- Increase of power density
- Optimization of catalyst compositions (reduction of Pt) and nano-scale microstructure
- Optimization of bipolar plate coatings

Balance of plants

- Stack internal humidification and simplified water mgmt.

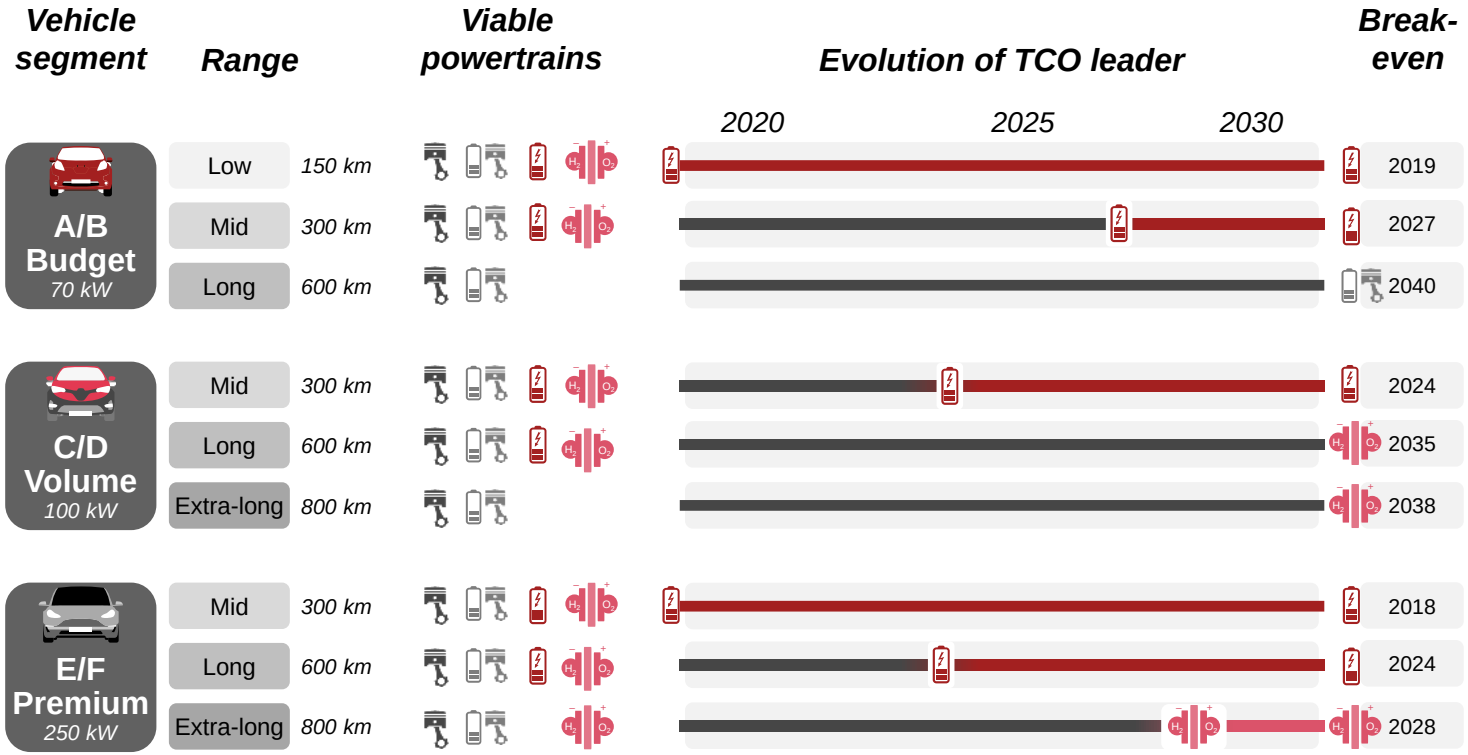
Tank

- Optimization of fiber winding layout and process
- Mixed materials to reduce costs
- Compressed H_2 as standard for passenger vehicles

OBC = Onboard charger DC charger = Direct current charger
Source: Strategy&

BEVs will become economical for several segments – but extended ranges (600 km+) will not be viable with BEVs

Electric powertrain operating cost break-even timeline (vs. ICE)



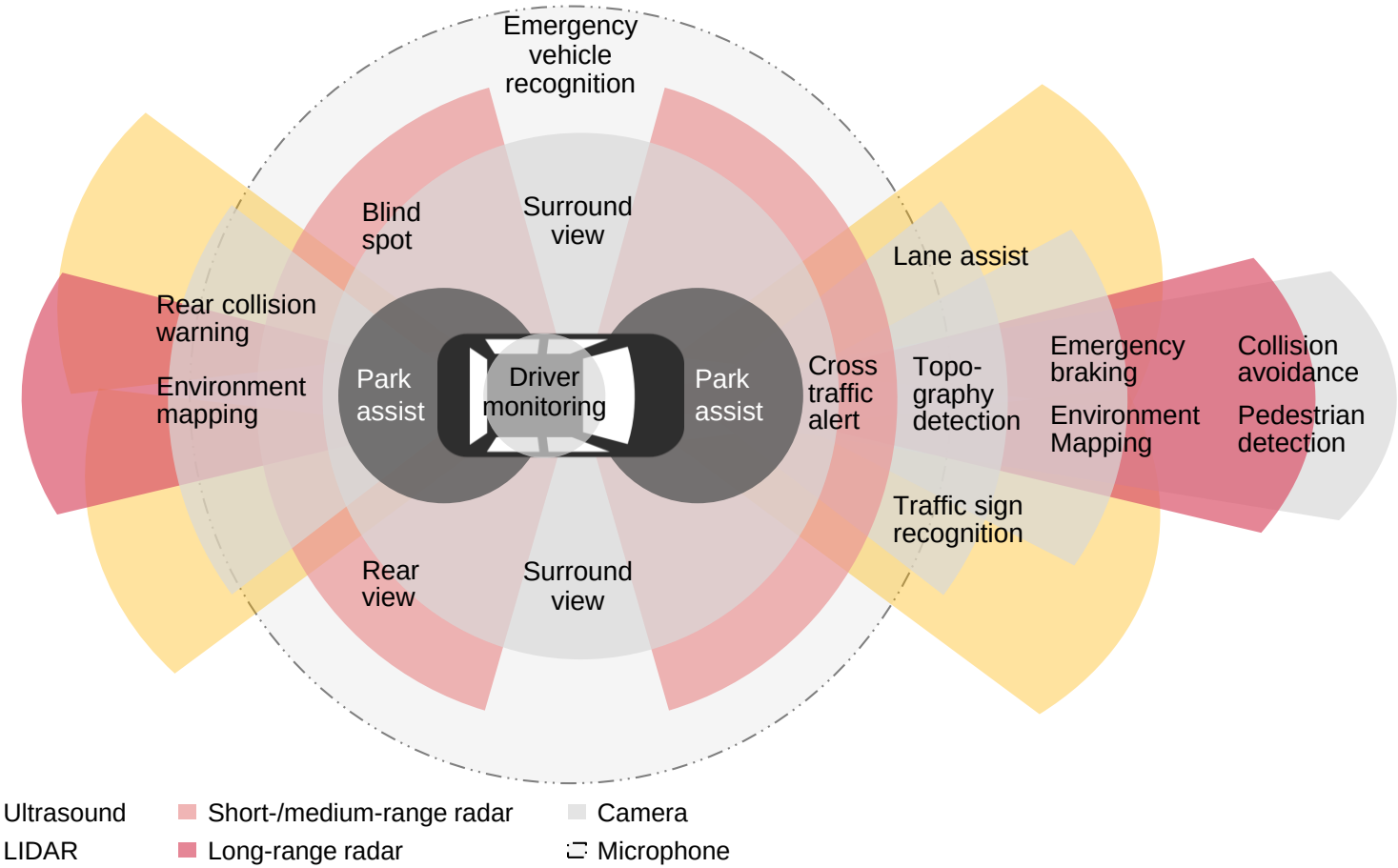
There is **no fixed point** in time **when battery electric vehicles** offer an operating **cost advantage over internal combustion engines** – it depends on factors such as the vehicle segment and range"

Main assumptions: electricity and fuel prices as for Germany 2020; H2 price 5€/kg; PHEV driving modes 40% EV mode/60% ICE mode; FCEV driving modes 40% EV mode/60% FC mode
One-time buying incentives not considered

Source: Strategy&

Hardware, software and infrastructure of automated driving are improving, but overall progress slower than expected

Automated driving technology developments



Current status and limitations

Hardware
e.g. sensors

- **Radar and camera sensors** are developed with a **good cost position**
- **Cheap LiDAR systems** do **not** yet have the necessary **performance**
- **New ADAS computers** based on low power tech are **under development**
- **Different driver assistant systems mandatory** beginning **2022** in **EU**

Software
e.g. smart data usage

- **Test and validation not** yet **mature**
- **Motion prediction** still **not** completely **solved**
- Very **large amounts** of **test data complicate** traditional **analytics**

Infrastructure
e.g. 5G

- So far, there are only a **few test tracks** that are fully developed for automated driving
- **Expansion of 4G** by 2022 for motorways in DE as basis for 5G
- For the time being **only pseudo 5G** based on 4G (non stand-alone)

Source: Strategy&

While L3 enables various attractive use cases, user experience and system complexity breakthrough is happening at L4

Automated driving SAE levels and AD function mapping

HIGH

AUTOMATION

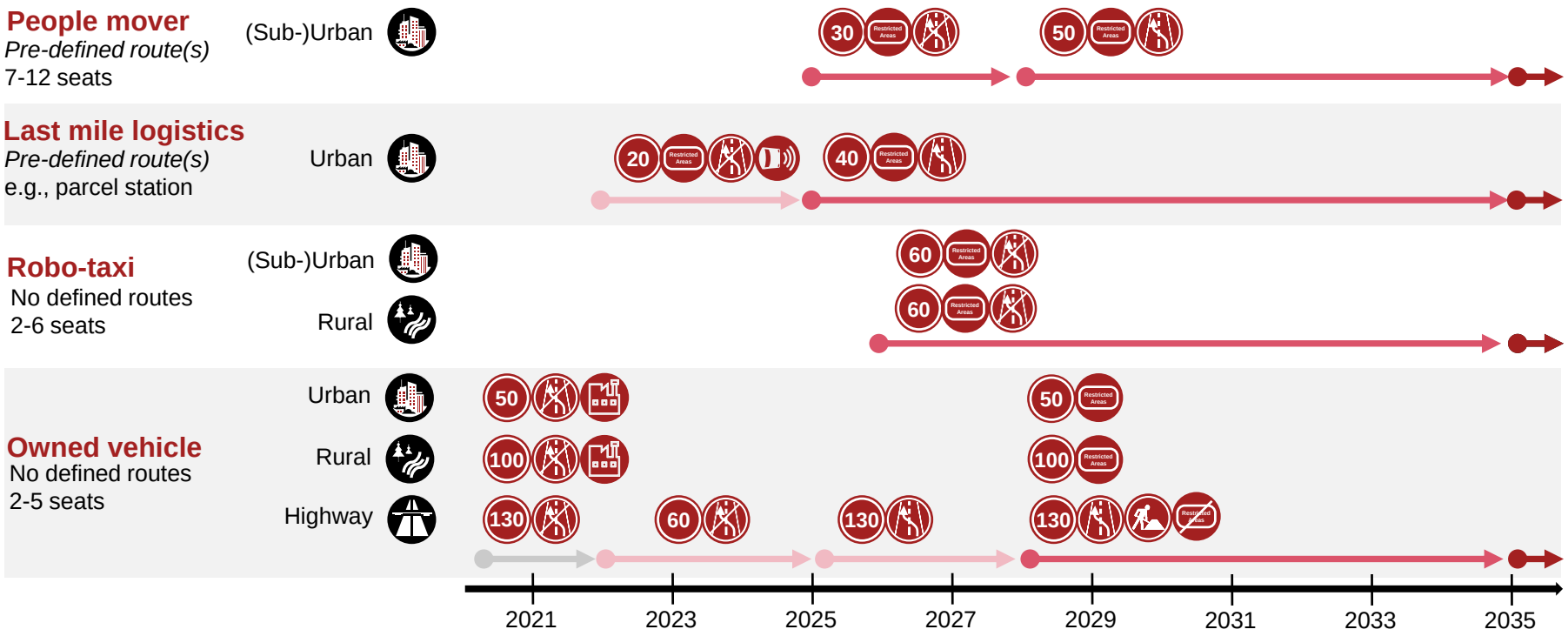
LOW

SAE level	Narrative definition		Vehicle control	Environment monitoring and user interface	Fallback for dynamic driving task	System capability	Exemplary AD functionalities
5 Full automation	The **system performs all aspects of dynamic driving** (driving-mode specific)…	…under **all environmental and road conditions** that can be managed by a human driver	System	System	System	All driving modes	• Universal pilot (full autonomy) • Interactive pilot driving (control via touch/gesture UI) • Robo-taxi and automated people-mover (all conditions)
4 High automation		…even **if a human driver does not respond** appropriately to a request to intervene		Alternative or conventional user interface		Most driving modes	• Urban/rural/highway pilot with multi-lane change • Robo-taxi and automated people-mover • Urban last-mile delivery • Automated valet parking
3 Conditional automation		…**expecting the human driver to respond appropriately** to an intervention request			Human	Some driving modes	• Urban/rural/highway assistant (e.g. hands-off traffic jam, intersection movement, single lane change) • Parking chauffeur • Assisted fleet operations (on-site, off-highway)
2 Partial automation	The **human driver performs remaining aspects** of dynamic driving, **while the system**…	…executes both **steering and acceleration/deceleration** (driving-mode specific)…		Human			• Adaptive cruise control • Remote/key parking assistant • Lane change assistant
1 Driver assistance		…executes **either steering or acceleration/deceleration** (driving-mode specific)	Human and System	Conventional user interface			• Adaptive cruise control • Driver assisted parking assistant • Lane keeping assistant (system steers) • Blind spot monitoring rear/side (system steers)
0 No automation	The **human driver performs all aspects** of dynamic driving, potentially "enhanced" by warning or intervention systems		Human			n/a	• Pre-/forward- collision braking • Front/rear cross-traffic alert with braking

Source: "SAE International Standard J3016", SAE; Strategy&

Commercially viable automated driving applications at L3 and beyond will start becoming available for specific use cases first

Automated driving timeline of commercial road availability



Commercial availability (beyond pilot projects)[1)]

Level 2+ · Level 3 · Level 4 · Level 5

Max. speed · Area restriction · Construction area capable · Automated lane changes · Closed compounds · Vehicle follows user

Urban: *Traffic situations with many traffic interactions and low speeds*
Sub-Urban: *Traffic situations with moderate traffic interactions and moderate speeds*
Rural: *Traffic situations with few traffic interactions and higher speeds*

Current developments

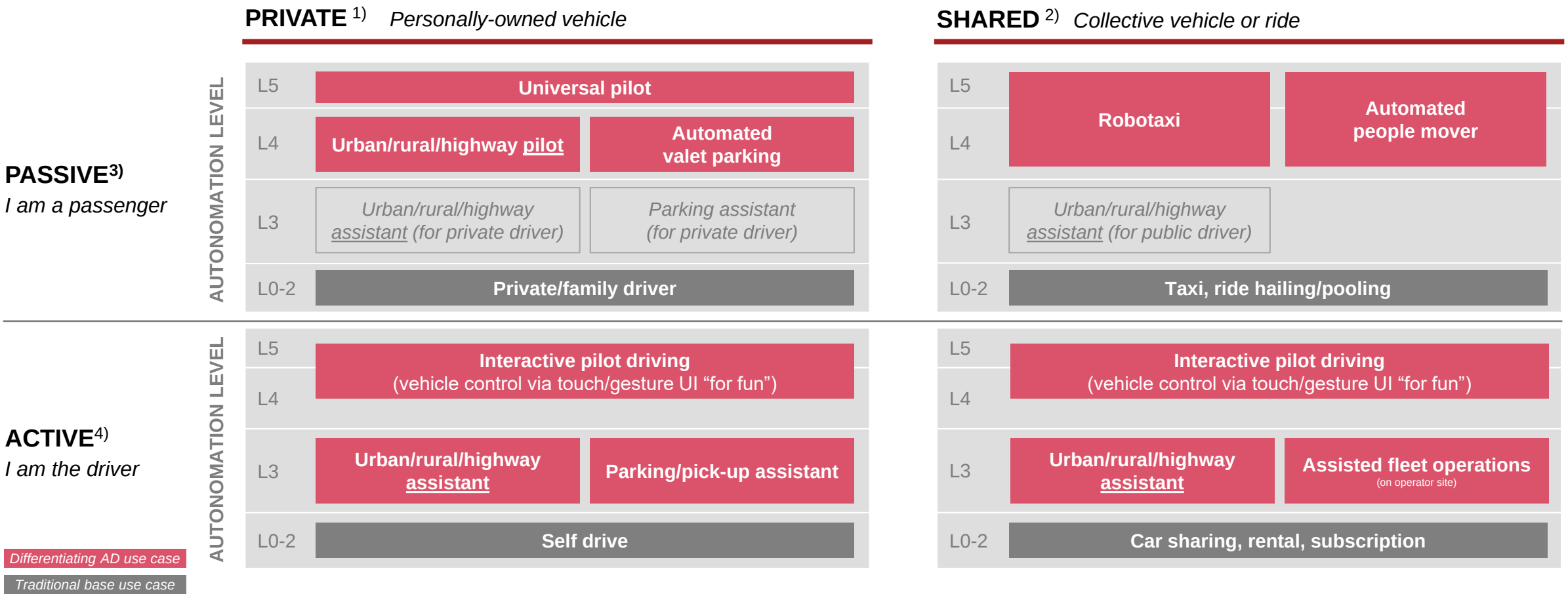
- ADAS technologies require **higher development cost** and efforts than anticipated
- ADAS **sensors** still far **above target cost**, due to small production volumes and sensor fusion/ recognition challenges
- **Regulation** still **uncertain** with the UN/ECE technical framework and national rules not yet fully in place
- While first **L3 vehicles** expected for **2021/22**, first **L4 road applications** beyond pilot projects expected for **~2025**

ADAS = Advanced Driver Assistance Systems UN/ECE = United Nations Economic Commission for Europe
1) Indicating start of availability. Tipping points of significant adoption expected significantly later in certain fields

Source: Strategy&

Individual mobility splits into four modes of private vs. shared and active vs. passive driving, each with increasing automation

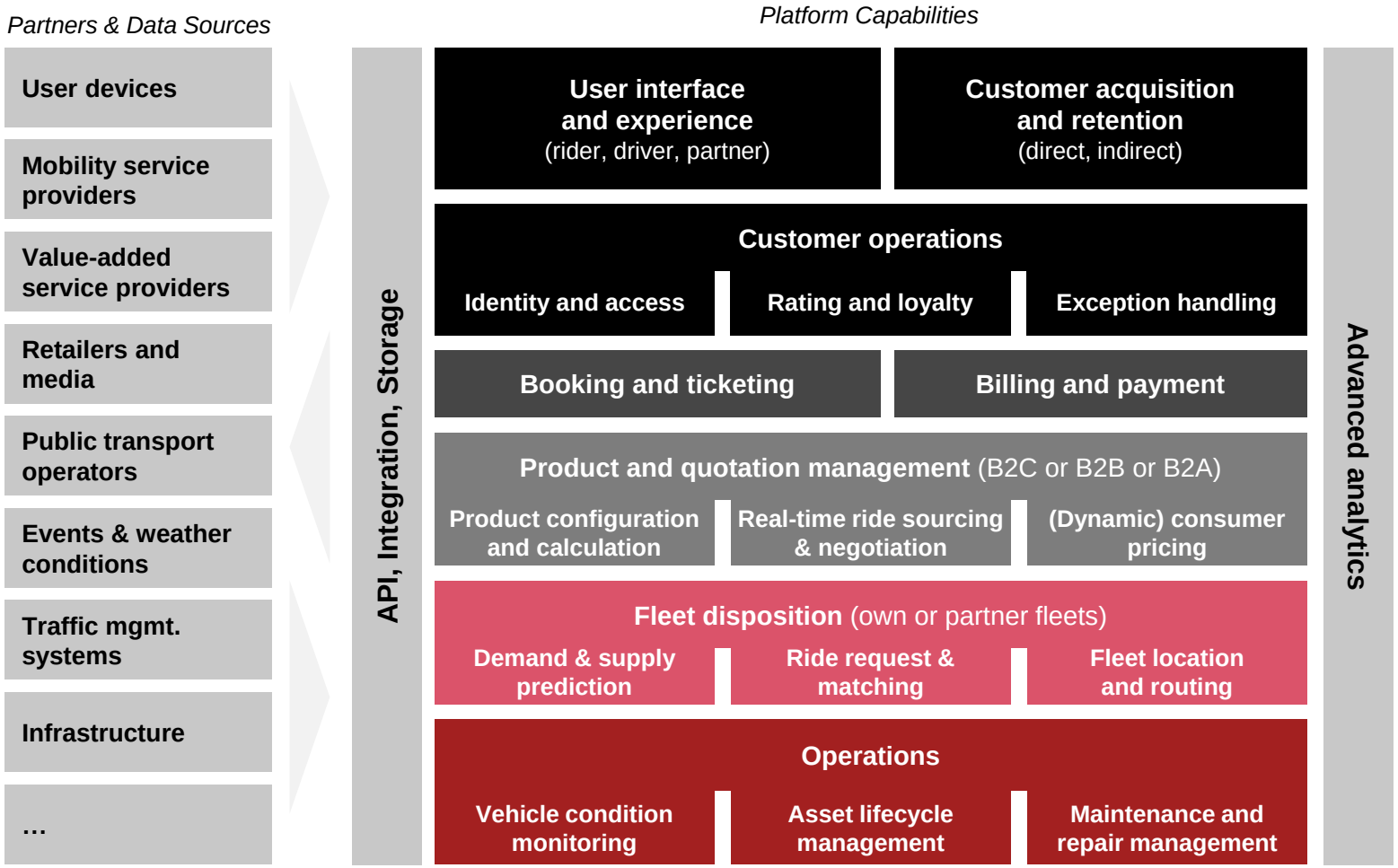
Private / shared mobility modes with selected automated driving use cases



1) Includes self-owned, family-owned, credit-financed, long-term leased, personal company car 2) Includes rental, subscription (up to 1 year), ride-hailing, ride-sharing, car sharing, pool car, car club
3) “Passenger” determines mobility purpose and target, passenger selects means of transport and expected time of arrival, mobility system determines detailed routing and actual time/place of arrival
4) “Driver” determines mobility purpose and target, driver determines means of transport and plans arrival time, driver determines detailed routing and actual time and place of arrival through user interface (UI)
Source: PwC AutoFacts®, Strategy&

Seamless smart mobility services require a modular, open API-based technology architecture and platform approach

Smart mobility technology platform building blocks



Current developments

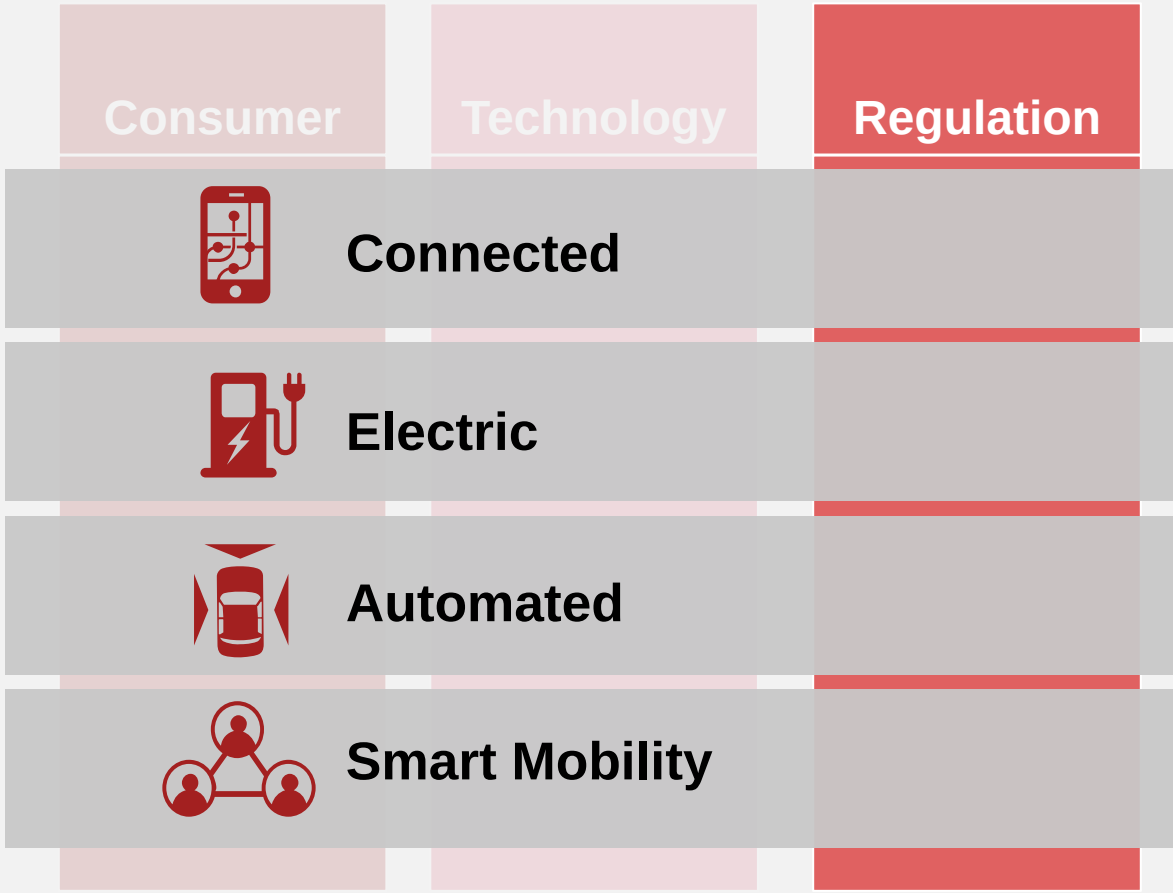
In contrast to individual mobility, providing smart mobility requires a **modular technology and system architecture**, capable of **integrating various partners** across the ecosystem with focus on

- **Flexibility to integrate multiple modalities** and mobility service providers (with different brands)
- **Cross-platform customer acquisition** and seamless sign-up/-in
- Region-specific/ **local mobility product configuration** and partner management, incl. ride request/ offering brokerage
- **Real-time environment / asset condition-based routing**
- Predictive **maintenance scheduling**
- **Predictive** asset **lifecycle management**

Source: Strategy&

“

Regulation aims to accelerate the mobility transformation – but following very different approaches across regions”



Source: Strategy&

Dynamic regulatory discussions shape CASE trends – impacting EV penetration and speed of AV testing rollout in particular

Latest regulatory initiatives and discussions

USA

AUTOMATED Announcement to unify AV policies across 38 federal departments enforcing a consistent regulatory approach (01/2020)

AUTOMATED NHTSA with plan to introduce upgrades to NCAP, involving new safety technologies and test procedures (10/2019)

ELECTRIC Limited national support (i.e. plans to terminate EV subsidies)

Heterogeneous regulatory dynamics; focus on commercial dimension, less on sustainability

GLOBAL

CONNECTED **Internationally harmonized** and **binding UN norms** on **cybersecurity and software requirements** for **OEMs** (06/2020, UNECE's World Forum for Harmonization of Vehicle Regulation, WP.29)

AUTOMATED **First binding global regulation** on **level 3 vehicle automation** with **focus** on **advancing safety** (UNECE's World Forum for Harmonization of Vehicle Regulations)[2)]

AUTOMATED **Updated standards** for **on-road testing of level 3, 4 and 5 prototype ADS promoting a standardized groundwork** for **AV tech** (09/2019)[3)]

Recently introduced **regulations** at UN level with **positive impact** on **CASE adoption**, further **steps** still **required**

EU

CONNECTED **New guidelines** on the **processing** of **personal data** (EDPB, 02/2020)

AUTOMATED Addition of new advanced **test scenarios** to rate **AEB technology** (2020 EU NCAP update)

AUTOMATED **Updated guidelines** to enforce **advanced safety features** (01/2020)

ELECTRIC New **EU CO_2 emission targets**, applying as of 01/2020[1)]

SHARED **New governmental regulations** promoting **shared mobility** (e.g. free parking)

EU states with a **siloed / bottom-up approach** towards **CASE regulation**

China

AUTOMATED **Release** of the **"Strategies for Innovation and Development of Intelligent Vehicles"** with focus on creating an **ecosystem** for **AVs** in **China** (02/2020)

AUTOMATED Plans for **new changes to the NCAP test program** with new **safety additions** (following the Euro model)

ELECTRIC **New national guidelines on safety requirements** and **standards** for **EVs** (coming into force by January 1st 2021)

Top-down approach based on long-term **strategy with positive impact** on **CASE**

Positive expert sentiment **Neutral** expert sentiment **Negative** expert sentiment

Note: (1) the regulation targets a 15% reduction for passenger cars from 2025 onwards and 37.5% reduction from 2030 on. (2) e.g. establishes strict requirements for Automated Lane Keeping Systems. (3) incorporates "lessons-learned based on accumulated field experience in testing prototype ADS-operated vehicles on public roads". (4) general regulatory sentiment derived from various expert opinions across politics and industry, e.g. automotive associations. AEB = Automated Emergency Braking; AV = Automated vehicle; NCAP = New Car Assessment Program; NHTSA = National Highway Traffic Safety Administration; UNECE = United Nations Economic Commission for Europe

Source: Strategy&

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