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CIC Autonomous Driving Industry Blue Paper:

Urban NOA as an Inflection Point for Autonomous Driving Commercialization

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Research background and methodology (1/2)

Report background

- The autonomous driving industry has evolved from basic ADAS functions to more advanced NOA solutions. While traditional L2 ADAS focuses on single-point assistance, Urban NOA represents a more complex system-level capability, enabling continuous point-to-point assisted driving in open urban environments.
- Compared with highway scenarios, urban roads involve higher uncertainty as well as opportunities. As a result, Urban NOA has become a key benchmark for mass-production autonomous driving. Driven by rapid progress in both software and hardware, Urban NOA is moving from premium models to broader mass-market vehicle segments. This shift is accelerating the commercialization of autonomous driving and reshuffling the value pool among OEMs, Tier-1 suppliers and independent solution providers.
- This report focuses on Urban NOA as a key inflection point for autonomous driving at scale. It analyzes the technology evolution, commercialization path, competitive dynamics and future opportunities of Urban NOA, while also exploring how Urban NOA may pave the way for the next stage of L4 autonomous driving commercialization.

Report methodology

- In preparing this report, we adopted a rigorous research approach and combined multiple research methods to analyze the current status and future development trends of the Urban NOA industry. The key research methods are set out below:：
- **Methodology：**

  1. Information collection and research: We collected relevant first-hand and second-hand data across the Urban NOA value chain, covering market size, technology roadmap, commercialization progress, competitive landscape and policy environment

  - **Primary research:** We conducted in-depth interviews with industry experts across the autonomous driving value chain, including OEMs, independent solution providers, sensor suppliers, computing platform providers and other ecosystem participants. The interviews covered topics such as technology development, product deployment, customer demand, commercialization models and future market trends.
  - **Market landscape analysis：** We continuously tracked representative Urban NOA players and market participants to understand their product launches, OEM cooperation, deployment progress, market positioning and competitive advantages.
  - **Desk research:** We collected and analyzed public information, including industry reports, policy documents, company announcements, news releases and market data, to review the development history, growth drivers, competitive landscape and future trends of the Urban NOA industry.

Research background and methodology (2/2)

Methodology

- **Research methodology：**

  ***2.* Market sizing and estimation：**

  - **Modeling：** Based on the characteristics of the Urban NOA industry, we adopted a top-down and bottom-up approach to estimate market size and growth potential. We analyzed the industry from multiple dimensions, including vehicle sales, Urban NOA penetration, solution adoption, OEM deployment progress, hardware configuration and software monetization models. The analysis covers both demand-side factors, such as consumer acceptance and OEM product strategies, and supply-side factors, such as algorithm maturity, computing platform costs and sensor cost reduction.

  - **Calculation and estimation methodology：**

    - **Supply-side：** We reviewed the development status of major participants across the Urban NOA value chain, including OEMs, independent autonomous driving solution providers, sensor suppliers, computing platform providers and other ecosystem participants. The review focuses on product capabilities, technology roadmap, OEM cooperation, SOP progress, deployment scale, commercialization model and competitive positioning, in order to assess the competitive dynamics and future development direction of the Urban NOA market.

    - **Demand-side：** We conducted interviews with experts and practitioners across the autonomous driving value chain, including OEMs, Urban NOA solution providers, Tier-1 suppliers, sensor companies, computing platform providers and industry specialists. The interviews focused on technology evolution, product deployment, OEM procurement considerations, monetization models, cost trends, regulatory developments and future market opportunities.

    - **Model validation and cross-checking：** Throughout the research process, we validated key assumptions and conclusions through multiple sources and methods. Public information, expert interviews, company case studies and market observations were cross-checked to ensure the consistency and reasonableness of our analysis. We also reviewed representative Urban NOA deployment cases and market benchmarks to refine our assessment of market size, competitive landscape and future growth trajectory.

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At present, Level 2+ and Level 2++ represent the most commercially viable segment of the Autonomous Driving market, driven by the rapid rollout of Navigate on Autopilot (NOA) functions

Levels of vehicle automation, 2025

	ADAS(Advanced Driver-Assistance System)			AD（Autonomous Driving）			
	Level 0	**Level 1**	**Level 2**	**Level 2+**	**Level 2++**	**Level 3**	**Level 4 and above**
Feature functionality	Limited to warnings and momentary assistance	Provide steering **OR** brake/ acceleration support to the driver	Provide steering **AND** brake/ acceleration support to the driver	Highway NOA, supporting functions like lane changes and ramp handling with driver engaged	Urban NOA, supporting functions like end-to-end driving automation with driver engaged	System drives independently in specific, controlled situations; driver takes over when requested	System drives on its own within validated areas
Applicable Scenarios	N/A	Highways and Urban expressways with light traffic		Highways and selected structured roads with little human inputs	Complex urban roads with little human inputs	Drive vehicle under certain conditions and will not operate unless all required conditions are met	
Driving responsibility	Smart vehicle to provide assisted driving features while the drivers responsible for driving and supervising			Smart vehicle to drive under limited conditions with driver intervening when necessary			Drive without intervention from human drivers

- At the Level 2+ stage, commonly referred to as Highway NOA, vehicles can complete point-to-point highway driving by seamlessly coordinating automated lane changes, ramp navigation and speed control.
- Level 2++, often described as Urban NOA, further expands capability into city roads with more dynamic and less structured conditions, such as traffic lights, dense intersections and diverse road participants.
- Traditional ADAS (L1/L2) is valued as long as it can trigger and complete specific functions under set conditions, whereas urban NOA covers full driving tasks where any hard braking, hesitation, incorrect lane change, or unnatural yielding can quickly erode user trust. As a result, competition is shifting from feature availability to driving experience quality, which raises the bar for providers: systems must not only perceive but understand intent, not only plan but interact in human-like ways, and not only perform in test scenarios but remain consistent across cities, weather conditions, and driving styles.

Source: CIC

There are two business models in achieving AD: Mass-Production and Robo

Two business models in autonomous driving

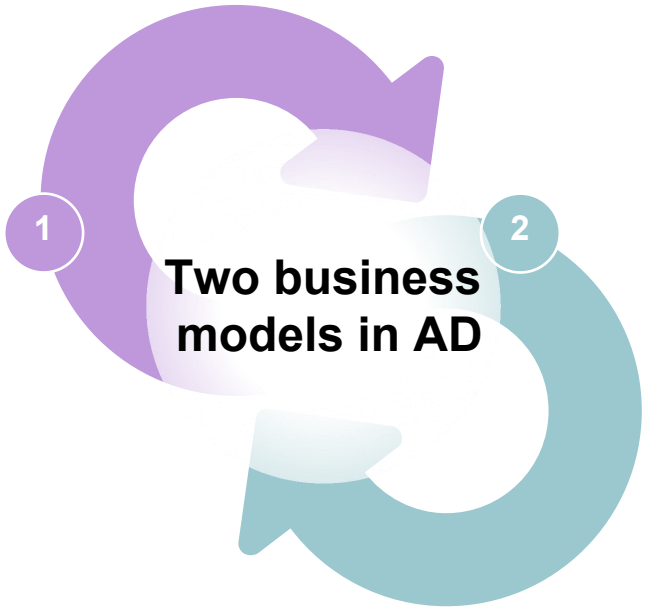
Mass Production model

Definition

- Scale AD technology in mass-produced passenger vehicles for end customers.

Development phase

- Urban NOA(L2++) is currently the highest level in this approach in mass-production, steadily advancing to L4 in future.



Robo model

Definition

- Advance AD technology in vehicles such as taxis, trucks, vans, among others.

Development phase

- Develop under evolving regulatory framwork through L4 Robotaxi, Robovan, Robotruck, and others.

Source: CIC

Urban NOA represents a key turning point in autonomous driving

Turning point

Comparable industries	Penetration growth roadmap		Key industry leaders
Smartphones	Global smartphone sales penetration rate, %	2009 ~15% 2010 ~21% 2011 ~32% 2023 ~80%	Key Drivers: Android's emergence as a new operating system drove rapid growth in work, education and entertainment applications.	Android Global smartphone operating system leaders US$4.7 trillion Market Cap（Google）
New energy vehicles	China new energy vehicle sales penetration rate, %	2021 ~13% 2022 ~30% 2023 ~38% 2025 ~54%	Key Drivers: Tesla's battery technology extended range, expanding charging infrastructure improved convenience, and growing vehicle intelligence enhanced the overall user experience.	TESLA Global NEV leaders US$1.5 trillion Market Cap
Urban NOA	China urban NOA solutions penetration rate, %	2025 ~11% 2026E ~22% 2028E ~42% 2030E ~62%	Key Drivers: Urban NOA enables point-to-point driving, as demonstrated by Tesla's FSD, giving users a direct sense of improved safety and stability.	Major opportunities for autonomous driving solution providers TESLA momenta HUAWEI

- For OEMs, urban NOA is shifting from an optional feature to a core part of product strategy. It is no longer limited to premium models; instead, the ability to consistently deliver urban NOA in mainstream segments now directly shapes perceptions of smart-driving capability, as well as pricing power and brand premium in the EV market. As a result, urban NOA is gradually shifting from an optional feature to a competitive threshold. As leading automakers begin to standardize or quasi-standardize urban NOA across more models, others will be forced to follow even if they are reluctant to invest in the short term. This process will push the market for advanced production-level intelligent driving from early-stage innovation diffusion into a rapid mass-adoption phase driven by OEM competition.

Source: CIC

Notes: Market capitalization data is as of May 29, 2026.

Urban NOA serve as a stress test of technological maturity for autonomous driving

	Highway NOA (L2+)	Urban NOA (L2++)
Scenarios	**Highly standardized line-haul** • Well-paved roads • Clear signs and warnings	**Complex and diverse city open roads** • Mixed motorized and non-motorized traffic • Narrow residential lanes • Diverse township roads etc.
Road condition	**Relatively low and standardized** • Mainly motor vehicles traveling at high speeds • No non-motor vehicles or pedestrians	**Highly complex** • High-speed motor vehicles & low-speed non-motor vehicles • Pedestrians and pets • Road obstructions (parked vehicles, displaced facilities, etc.)
Road participants	**Standard** • Mainly vehicle-vehicle interaction	**Various** • High human-vehicle interaction • High vehicle-vehicle interaction
Tasks	**Relatively few and regulated** • Mainly straight driving, car following, and lane changing	**Vary and Complicated** • Traffic signal response & intersection navigation • Obstacle avoidance, roundabout, unattended left turn and U-turns • Interaction with pedestrians and crossing traffic

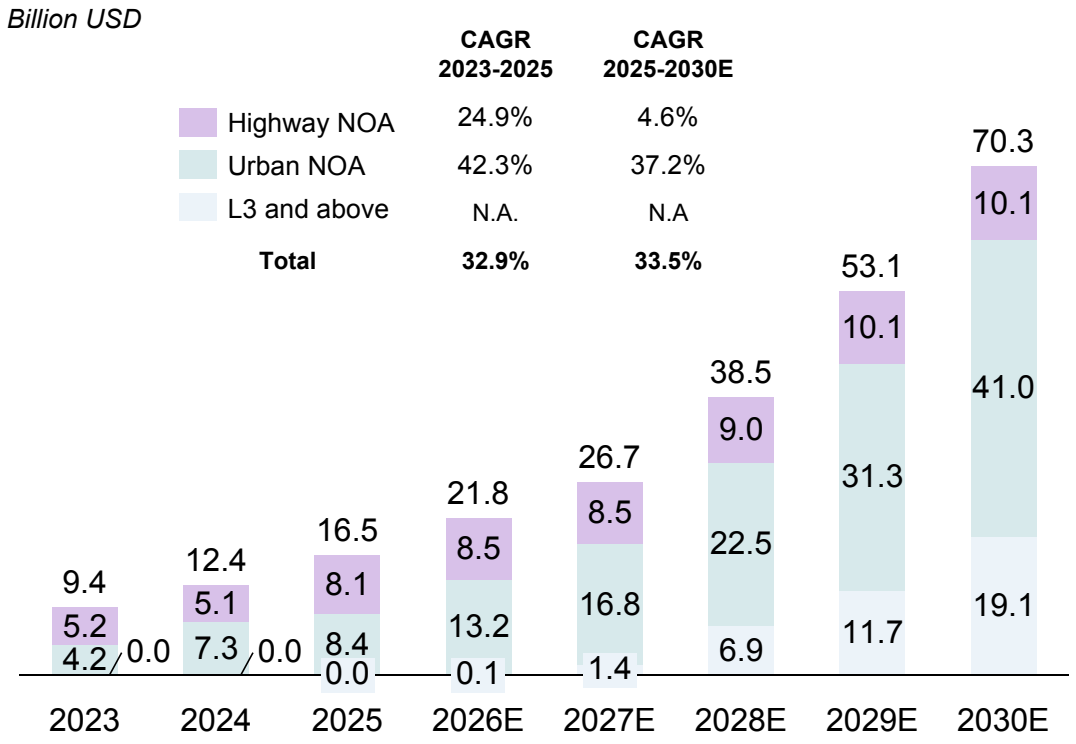
- Urban roads are a key stress test for autonomous driving systems. Performance limited to fixed routes or a small number of cities may indicate reliance on scenario-specific customization. Stable operation across different cities, road environments and vehicle hardware configurations is therefore a stronger indication of a replicable technology architecture. For industry research and investment analysis, urban NOA provides a validation environment closer to real-world commercialization.

Source: CIC

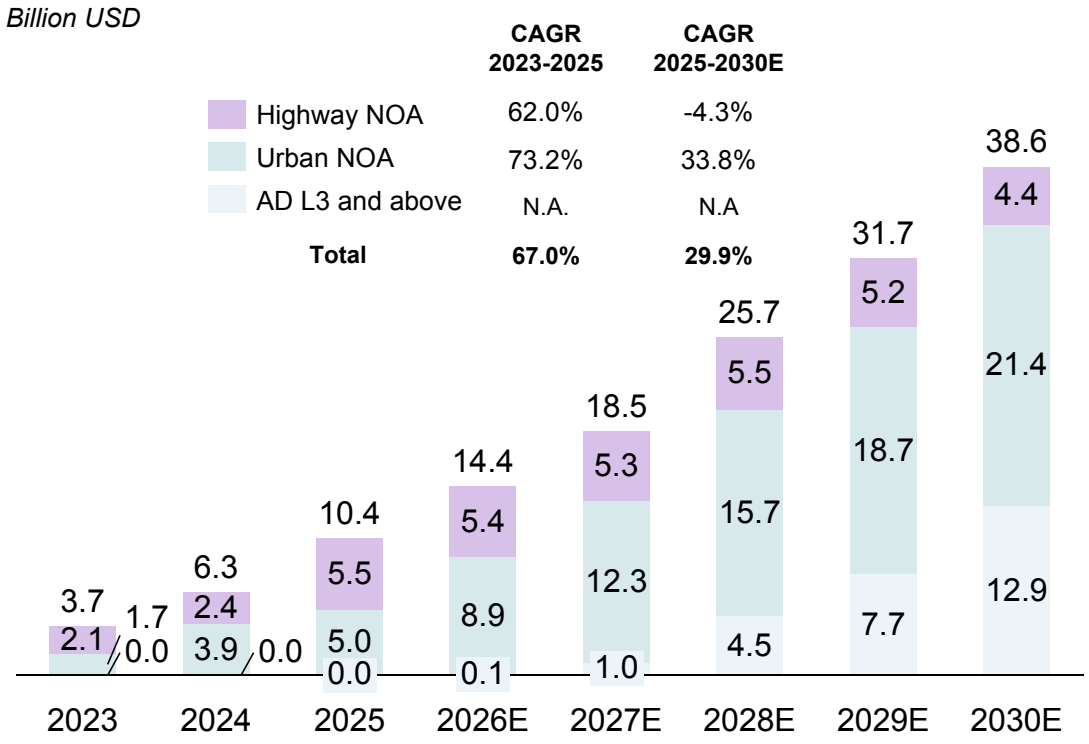
Rapid penetration of mass-production autonomous driving has been driven by the rapid adoption of Urban NOA functionality (1/3)

Market size of Global and China's vehicle, by Highway NOA, Urban NOA, L3 and above, 2023-2030E

Global market size of vehicle, by Highway NOA, Urban NOA, L3 and above, 2023-2030E



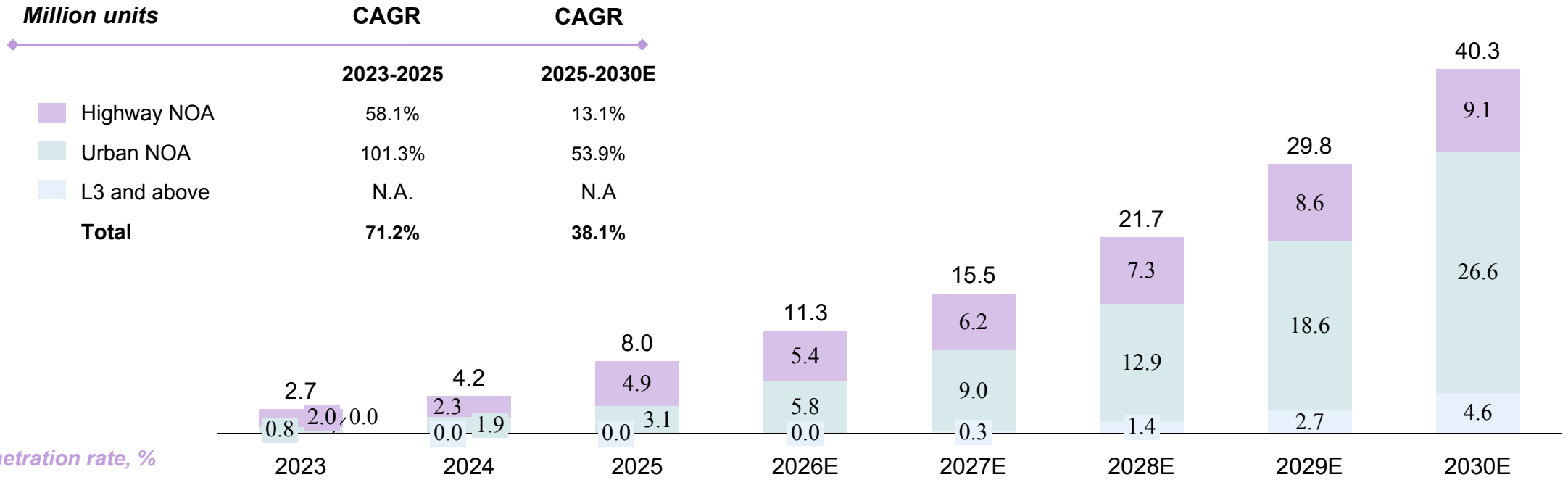
China market size of vehicle, by Highway NOA, Urban NOA, L3 and above, 2023-2030E



Source: CIC

Rapid penetration of mass-production autonomous driving has been driven by the rapid adoption of Urban NOA functionality (2/3)

Global Sales Volume of Vehicle, by Highway NOA, Urban NOA, L3 and above, 2023-2030E



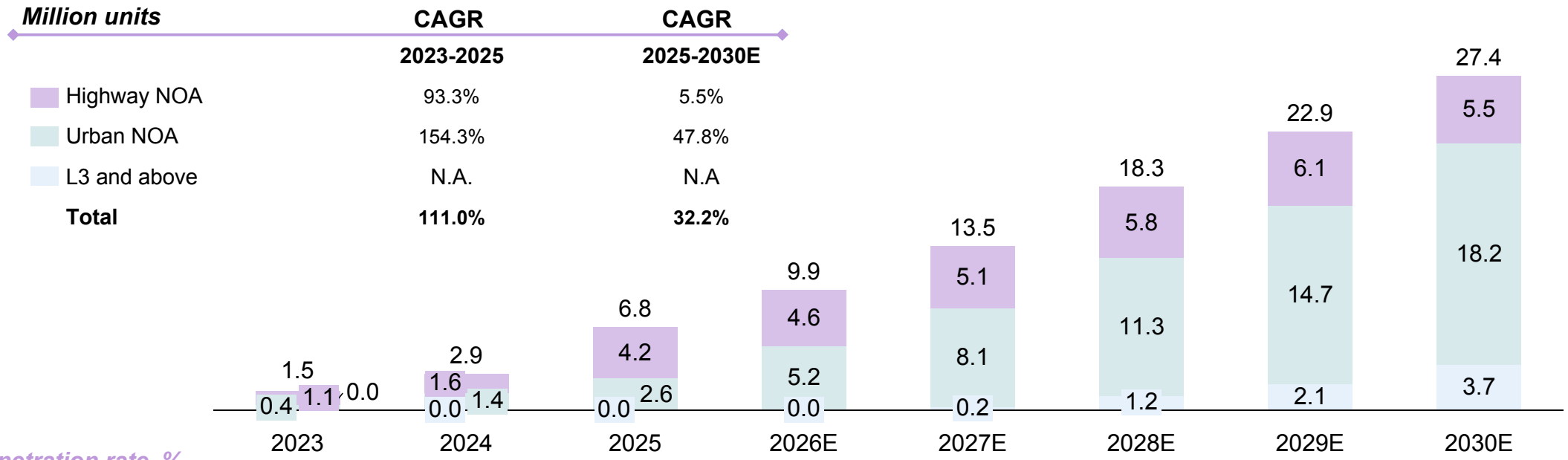
Penetration rate, %	2023	2024	2025	2026E	2027E	2028E	2029E	2030E
Highway NOA （L2+）	**3.2%**	**3.7%**	**7.6%**	**8.2%**	**9.1%**	**10.4%**	**11.8%**	**12.2%**
Urban NOA（L2++）	**1.2%**	**3.0%**	**4.8%**	**8.8%**	**13.1%**	**18.3%**	**25.6%**	**35.7%**
L3 and above	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.4%**	**2.0%**	**3.7%**	**6.1%**

Note: Tesla’s data only includes the number of vehicles with FSD activated.

Source: CIC

Rapid penetration of mass-production autonomous driving has been driven by the rapid adoption of Urban NOA functionality (3/3)

China Sales Volume of Vehicle, by Highway NOA, Urban NOA, L3 and above, 2023-2030E



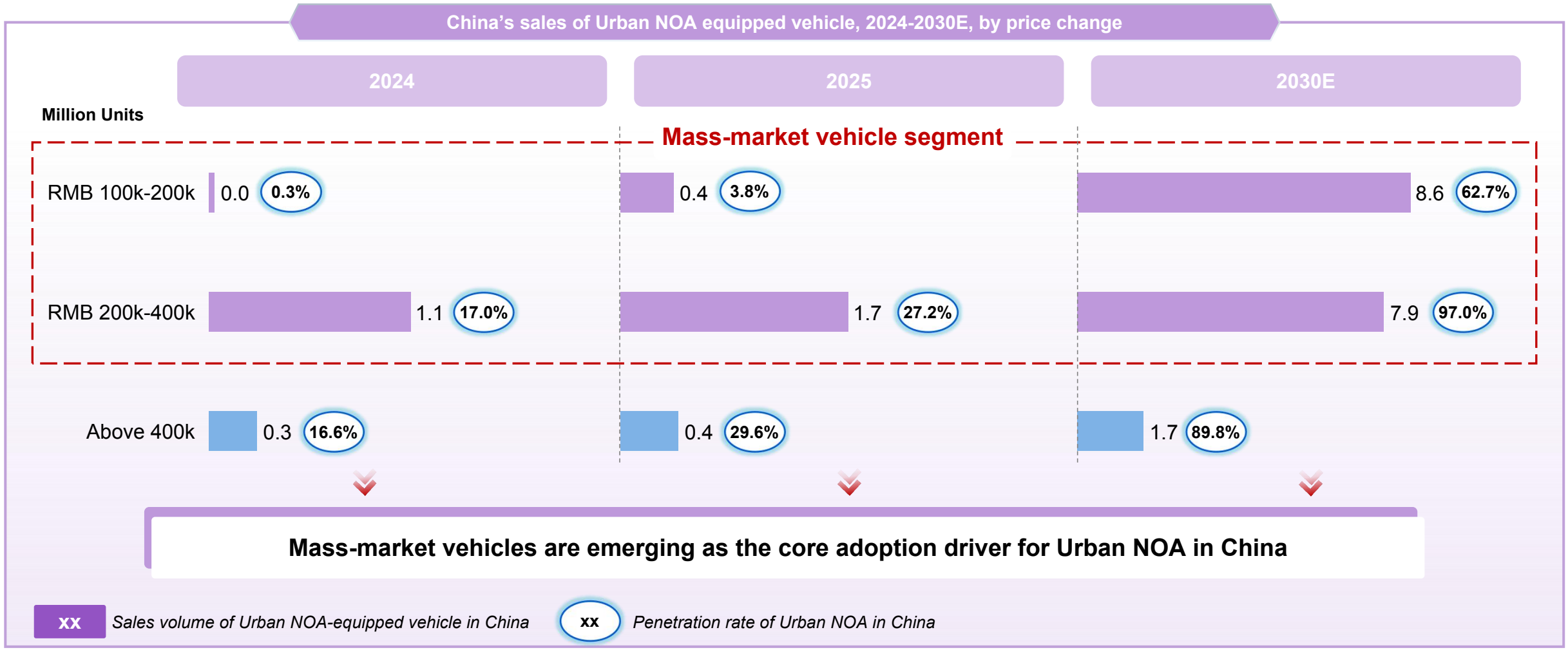
Penetration rate, %

	2023	2024	2025	2026E	2027E	2028E	2029E	2030E
Highway NOA （L2+）	5.2%	6.9%	18.3%	18.9%	19.8%	21.7%	21.5%	18.8%
Urban NOA（L2++）	1.8%	6.0%	11.3%	21.5%	31.7%	41.9%	52.2%	62.4%
L3 and above	0.0%	0.0%	0.0%	0.1%	0.9%	4.4%	7.6%	12.7%

Note: Tesla’s data only includes the number of vehicles with FSD activated.

Source: CIC

Urban NOA is penetrating into mass-market for sizable growth in future



Source: CIC

China is becoming a testing ground for high-level mass-production autonomous driving

1

Competitive NEV Market Drives Intelligent Differentiation

- Highly competitive NEV market drives OEMs to differentiate through intelligent features
- Urban NOA serves as a highly perceivable technology label, rapidly adopted in new models
- Emerging EV makers and domestic brands use urban NOA to strengthen tech-oriented brand recognition
- Joint-venture brands increasingly adopt urban NOA to narrow intelligent driving gaps in China

2

Complex Road Scenarios Strengthen Algorithm Training

- Roads feature dense non-motor vehicles, pedestrians, delivery riders and complex intersections
- Tidal traffic flows, temporary roadside obstacles and mixed traffic scenarios increase R&D difficulty
- Systems proven in China's complex environment are expected to show stronger generalization and global adaptability

3

Rapid Supply Chain and Vehicle Development Enable Faster Rollout

- NEV companies and local suppliers iterate rapidly across E/E architecture, domain controllers, sensors and OTA mechanisms
- Higher-level driving functions can be introduced into mass-produced vehicles more quickly
- Consumer demand for intelligent features further accelerates OEM adoption

4

Policy Support and Demonstration Applications Underpin Scaled Deployment

- China supports NEVs, intelligent connected vehicles, demonstration-zone testing and vehicle-road-cloud integration
- Demonstration applications for higher-level assisted driving continue to advance
- Policy support extends beyond subsidies to pilot programs, market access, data frameworks, infrastructure and safety management systems

Source: CIC

The globalization of urban NOA is propelled by China's Urban NOA solution providers

Globalization of Urban NOA

- Urban NOA globalization is unlikely to follow a single path, but rather three parallel phases: **In China for China, In China for Global and In Global for Global**. Suppliers first refine technologies and validate commercialization in China's complex urban scenarios; then expand mature solutions overseas with Chinese OEMs and localize them; and ultimately enter global OEM programs with global delivery capabilities.
- China's complex urban roads provide a "high-difficulty training ground," but globalization is not simple replication. Differences in road markings, driving habits, regulatory responsibilities, data compliance and vehicle architectures require transferable algorithms, engineering processes and validation systems. These capabilities will determine whether Chinese suppliers can move from domestic leadership to global leadership.

Source: CIC

Due to the gaining momentum of Urban NOA, China's L3 regulatory framework is moving from road testing to commercial deployment

China's L3 Regulations Shift from Testing to Deployment

Timeline	Guideline	Issuer	Highlights
Feb 2020	Strategy for innovation and Development of intelligent Vehicles	11 ministries & commissions	■ Set **clear short-term goals** for AD development by 2025 ■ Aims to establish a **systematic AD regulatory framework** by 2025(e.g., for technology, industry ecosystems, infrastructure, regulations, cyber security) ■ Aims to achieve L3 mass production and L4 commercialization **in select scenarios** by 2025
Nov 2023	Notice on Launching the Pilot Program for the Access and On-road Operation of Intelligent Connected Vehicles	MIIT, MPS, MOHURD, MOT	■ **Select qualified** L3/L4 ICV models for access and on-road operation pilots. Marks a key step from road testing to regulated commercial deployment.
Dec 2023	Safety Service Guidelines for Autonomous Vehicle Transportation (Trial)	MOT	■ Applies to L3 and above autonomous vehicles used in transport services. ■ Sets requirements on operating areas, safety personnel, vehicle monitoring and emergency response.
Dec 2023	Guidelines for Testing Internet-Connected Vehicles on Public Roads in Pilot Cities	MIIT,MOT,MPS，MOHORD	■ **Selecting Internet-connected vehicles** equipped with autonomous driving functionality that meet the conditions for mass production to initiate pilot testing for access ■ Conducting pilot projects of on-road operation in **designated areas for Internet-connected vehicles that have obtained access.**
Sep 2024	Intelligent and Connected Vehicle — General Technical Requirements for Automated Driving System	SAMR, SAC	■ Establishes general technical requirements for automated driving systems. ■ Covers dynamic driving tasks, takeover requests, human-machine interaction and minimum risk maneuvers.
Nov 2024	Effective Plan to Reduce Logistics Costs Across Society	GOCCCPC, GOSC	■ **Encourage the development of new logistics models that integrate autonomous driving**, and promote technologies and equipment like autonomous vehicles.
Dec 2025	First Conditional Access Approval for L3 Automated Driving Vehicle Products	MIIT	■ Granted conditional access approval for China's first L3 automated driving vehicle products. ■ Beijing issued dedicated L3 pilot licenses, allowing approved vehicles to conduct L3 on-road pilots within designated ODD, road sections and speed limits.
Jan 2026	Implementation Guidelines for Pilot Programs on Market Access and Road Use of Intelligent Connected Vehicles	MIIT, MPS, MOHURD, MOT	■ Clarified the operating conditions and liability allocation framework for Level 3 autonomous vehicles in China.

Leading players have secured L3-related production nominations

AD Solution Providers

momenta

HUAWEI

...

OEMs

BYD

XPENG

NIO

SAIC

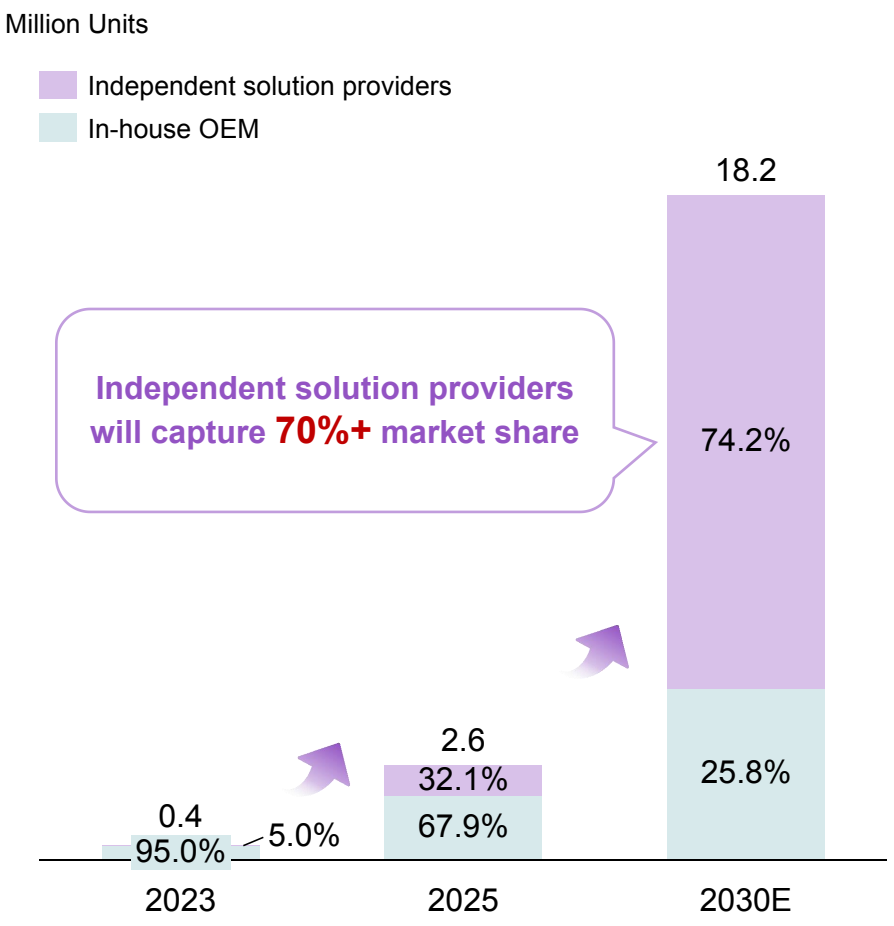
AUDI

- China is accelerating this process through policies promoting L3 vehicle access, road safety, liability allocation and insurance mechanisms, while local pilot zones provide clearer deployment space. The significance of these policies lies not only in enabling deployment, but also in reducing commercialization uncertainty for OEMs and consumers.
- For the industry, L3 pilot programs are expected to further drive the evolution of urban NOA. On one hand, L3 requires higher levels of safety redundancy and clearer ODD definitions, which will continue to push L2++ systems toward stronger safety validation and more defined functional boundaries. On the other hand, L3 commercialization is expected to increase the software value per vehicle, providing suppliers with access to higher-value product tiers.

Source: CIC

Independent solution providers are expected to accelerate growth momentum

China sales of vehicle with Urban NOA feature



Independent solution providers enable scalable autonomous driving commercialization

	OEM pain points	Independent solution provider capabilities	Value created by Independent solution providers
Cross-platform Development Capability	• Diverse vehicle models and price segments make repeated development for each platform inefficient	• Standardized software modules and cross-platform adaptation capabilities	• Shortened development cycles and reduced delivery risks
Data Closed-loop Capability	• Urban driving involves long-tail scenarios, while a single OEM fleet's data remains limited.	• Cross-OEM, cross-city and cross-vehicle-model data closed-loop capabilities	• Improved model generalization and driving safety performance
R&D & Delivery Capability	• Accelerating vehicle launch cycles constrain internal R&D resources	• Mature project management, on-site support and SOP delivery experience	• Supports rapid rollout of advanced intelligent driving functions
Core Technical Capabilities	• Intensifying pricing competition increases pressure on R&D efficiency and cost control	• Hardware ecosystem collaboration and algorithm optimization capabilities	• Enables deployment of advanced functions at mass-market price points
Organizational Agility	• Operating with a manufacturing culture, limited talent reserve and slow response to the market.	• Having an engineering AI culture with more data points, higher organizational efficiency, and faster response capabilities.	• Quicker response to market demands and faster product iteration

Source: CIC

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Source: CIC

Urban NOA competition is increasingly shaped by scalable mass-production delivery capabilities

Four Core Indicators for Urban NOA Competition

	Representative metrics	*Importance*
Commercialization scale	• Sales volume of equipped vehicles • Cumulative installations	• Determines data scale and revenue foundation • The larger the scale, the stronger the advantages in data closed-loop iteration and unit cost efficiency
Mass-production certainty	• Number of nominations • Number of SOP launches • Number of mass-produced vehicle models	• Reflects OEM recognition and future revenue visibility • Nominations represent the project pipeline, SOP demonstrates delivery and monetization capability
Customer coverage	• Number of OEM customers • Coverage of international OEMs	• Reflects the replicability and globalization potential of the solution • High-quality OEMs enhance long-term project opportunities
System performance	• Takeover frequency • False AEB activation rate • Success rate of complex maneuvers	• Reflects real-world user experience, safety and system stability • Higher performance stability, greater potential for standard adoption

- Urban NOA exhibits clear economies of scale and experience curve effects. First, data scale translates into model advantages. Road data generated by a large fleet of real-world vehicles can continuously enhance a system's ability to handle long-tail scenarios. Second, a larger number of vehicle models supports engineering reuse. As more models reach SOP, suppliers are better positioned to establish standardized interfaces, testing procedures and delivery templates, thereby reducing the marginal cost of new projects. Third, OEM partnerships provide commercial validation. Collaboration with a broader base of leading OEMs helps suppliers secure higher-quality projects and gain more opportunities in the course of globalization.
- Therefore, competition in the urban NOA market is not simply determined by "who has the best algorithm," but by "who can translate algorithms into a scalable product delivery system." The competitive advantages of leading players are reflected across multiple dimensions, including technology, delivery capabilities, customer coverage, cost efficiency and data scale. Together, these factors create compound barriers that are difficult for later entrants to replicate within a short period of time.

Source: CIC

China's Urban NOA market is increasingly led by two major players, each following a distinct strategy

Key players of Urban NOA in China

Momenta Huawei HI Others

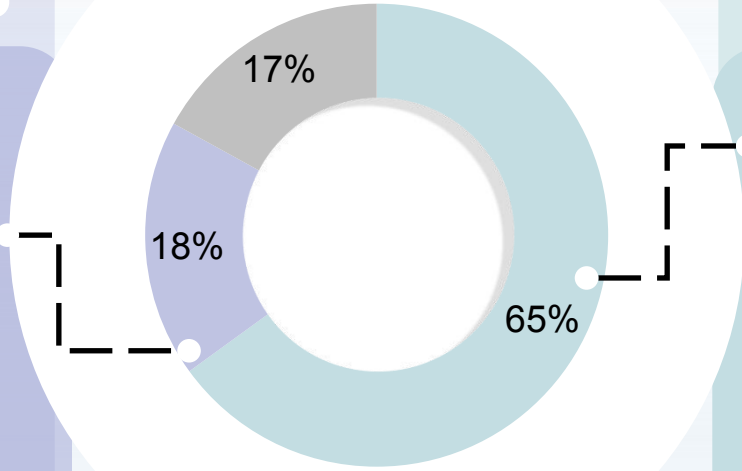
HUAWEI HI

Full-stack solution provider

OEM Coverage

AVATR, Audi, ARCFOX, JETOUR, BAOJUN, 广汽昊铂 HYPTEC, ...

Market share of Independent Urban NOA providers in China[1]



momenta

Hardware-agnostic Android-like platform

OEM Coverage

gm, BUICK, Ford, AUDI, BYD, CHERY, LOTUS, LYNK&CO, MG, ROEWE 荣威, NISSAN, AION, 广汽昊铂 HYPTEC, ...

Notes: (1) bases on sales volume from March in 2025 to February in 2026

Source: CIC

Huawei operates both the HI and HIMA modes, providing a full-stack intelligent vehicle solution

Company Profile

HUAWEI

Founded in 1987, Huawei is a leading technology company with a presence in the intelligent vehicle sector, possessing leading in-vehicle chip and autonomous driving technologies.

- **2024** The business matured, forming five major solutions: ADS, vehicle control, vehicle cloud, in-vehicle optics, and Harmony cockpit.
- **2021** The HI model took shape, releasing Seres Huawei SF5 and AITO.
- **2020** Launched the HI (Huawei Inside) full-stack smart vehicle solution, entering the automotive sector.
- **2018** Released in-vehicle chips and an internet of vehicles cloud platform.
- **2014** Launched solutions across device, network, and cloud, and partnered with leading OEMs in China.
- **2013** Established its automotive business unit and expanded into autonomous driving.
- **2009** Initiated development of in-vehicle modules and entered the automotive industry.

Comparison of Huawei HI & Huawei HIMA

	Huawei HI	Huawei HIMA
Product definition	• **OEMs lead product definition and Huawei provide full-stack intelligent solution**	• **Huawei leads product definition and key decisions throughout full process**
Delivery mode	• Turnkey AD solutions to OEMs	• Participates more deeply in product definition, marketing and channel sales
Sales channel	• Sold through OEMs' own channels	• Sold through Huawei's own channels
OEM coverage	**7 OEMs** VOYAH AVATR 方程豹	**5 OEMs** AITO
Sales share within Huawei[1]	~30%	~70%

Notes: (1) bases on sales volume from March in 2025 to February in 2026

Source: CIC

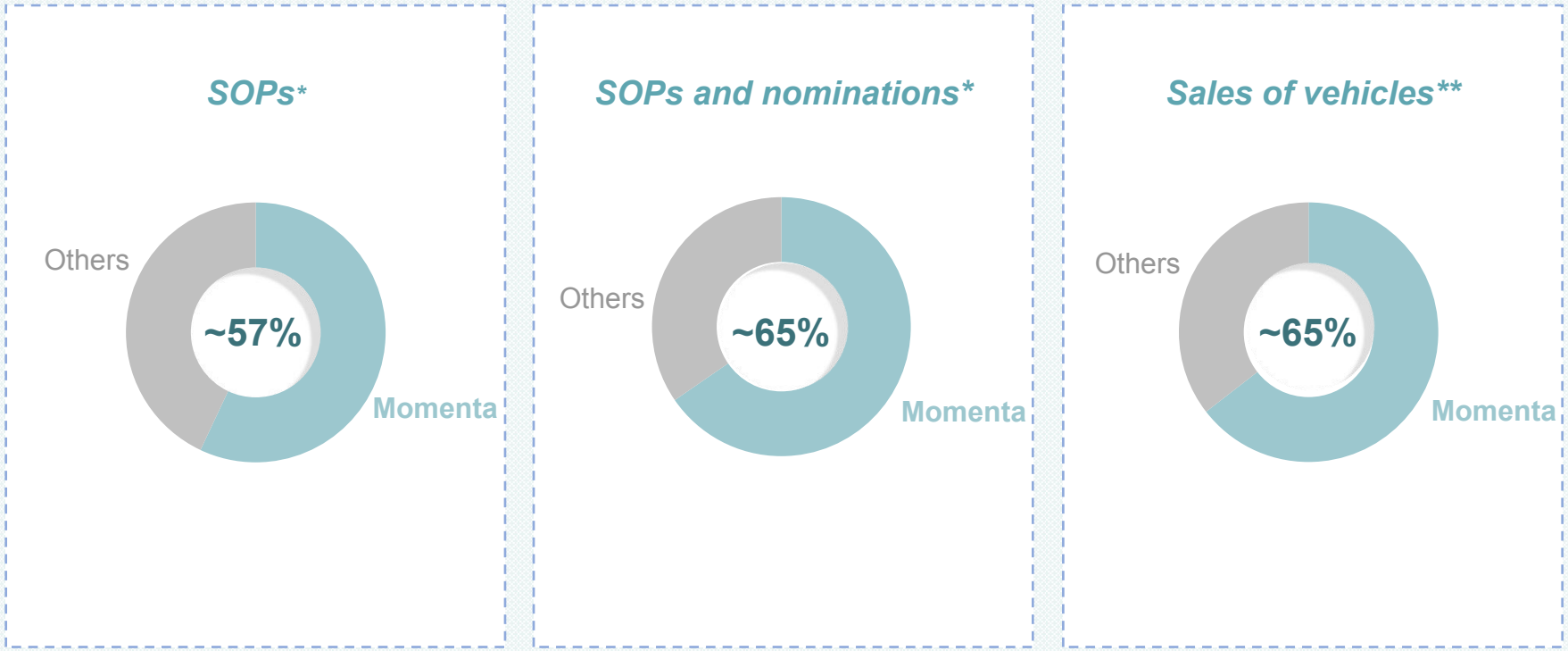
Momenta demonstrates strong commercial traction across OEM partnerships and deployment metrics

Company Profile

Founded in 2016, Momenta is a leading autonomous driving company focusing on AD solutions for mass-produced vehicles and scalable driverless AD mobility and logistics solutions.

- **2025** Released the industry-leading R6 Reinforcement Learning Large Model and pioneered the commercialization of reinforcement learning in autonomous driving.
- **2024** First to bring Urban NOA and end-to-end models into mass-production globally.
- **2023** Global first mass-production of Deep Learning Planning technology.
- **2022** Start of production of our first driving automation solution.
- **2020** Launched Robotaxi operations in Suzhou with the first-in-Suzhou demonstrative application license.
- **2019** First to implement Transformer architecture in driving automation perception.

Market Share of SOPs, SOPs and Nominations, and Sales of Vehicles Among Independent Urban NOA Solution Providers



*Notes: (1) * As of February 28, 2026; (2) ** From March in 2025 to February in 2026*

Source: CIC

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The L4 autonomous driving covers a wide range of scenarios, and Robotaxi and Robovan may emerge as the dual key engines of the industry

Definition of L4 autonomous driving

	Robotaxi	Robovan	Robotruck	Robobus	Robosweeper	Others
Application scenarios	• **Public open road**	• **Public open road**	• Semi-enclosed highway	• Public open road	• Public open road	• Enclosed area such as ports, mines, etc
Business model	• **Mostly operation**	• **Vehicle sales** • **Vehicle lease** • **Operation**	• Vehicle Operation	• Vehicle sales	• Vehicle sales • Vehicle operation	• Vehicle sales • Vehicle Operation
Global market size in 2030E (USD billion)	82	85	33	15	17	11
Global installed base in 2030E (thousand units)	Penetration rate 5.7% 1,625	6.9% 6,552	0.6% 138	0.4% 61	N/A[1] 534	57.8%[2] 117
Key players	WAYMO, TESLA, WeRide, pony.ai, momenta	九识 ZELOS, NEOLIX, momenta	pony.ai, KARGOBOT	WeRide, 轻舟智航 QCRAFT	WeRide, COWAROBOT 酷哇机器人	CiDi 希迪智驾, EACON 易控智驾, BOONRAY 伯镭科技

Notes: (1) Penetration rate is not applicable for robosweepers, as the market includes cleaning vehicle deployed in parks, campuses, buildings which do not have a clear replacement base; (2) penetration for autonomous mining trucks.

Source: CIC

L4 commercialization remains constrained by high safety, cost, operational and regulatory barriers, limiting near-term scalability

Key barriers to L4 commercialization at scale

1	**Higher safety validation threshold than L2++**	• Urban NOA still operates under driver supervision, with relatively clear system boundaries. By contrast, L4 systems must perform driving tasks independently within their defined ODD. Without real-time human fallback, they face much stricter safety assurance requirements. As long-tail scenarios increase, validation costs rise, making commercialization rollout more cautious.
2	**Vehicle cost constraints on scalability**	• L4 vehicles require greater sensor redundancy, higher computing power, redundant braking and steering systems, as well as remote assistance and fleet operation capabilities. Although core hardware costs continue to decline, total system cost remains well above that of mass-produced intelligent vehicles. Unit economics are unlikely to improve until vehicle costs fall, utilization rises and operating areas expand.
3	**Operations-heavy business model**	• Robotaxi and unmanned logistics require end-to-end fleet operations, including vehicle procurement, dispatching, insurance, cleaning, maintenance, charging, remote assistance, accident handling and customer service. As a result, L4 companies need both autonomous driving R&D capabilities and operational management capabilities. Compared with selling software solutions to OEMs, the model is heavier and more cash-intensive.
4	**Evolving regulatory framework**	• L4 commercialization involves road access, accident liability, insurance, data security, remote operation standards and vehicle admission requirements. Regulatory openness varies by city and country, so expansion often needs to proceed city by city. Regulation is not only a constraint, but also a prerequisite for commercialization certainty. Clear liability boundaries are essential for L4 to move from pilot operations to scaled deployment.

Source: CIC

Urban NOA builds a scalable real-world foundation for L4 across data, models, engineering and market readiness

Urban NOA as a real-world training ground for L4

1 Urban NOA provides real-world data at scale

- L4 must handle extensive long-tail scenarios, while robotaxi-only data accumulation is constrained by fleet size, operating coverage and regulatory approvals. Deployed in mass-produced vehicles, Urban NOA can capture broader real-world data across cities, road types, driving styles and traffic behaviors.

2 Urban NOA improves model generalization

- Complex intersections, unprotected turns, non-motorized vehicle cut-ins, temporary parking and construction detours are all key scenarios for L4. Continuous Urban NOA operation in these environments helps models learn real traffic interactions and improve perception, prediction, planning and control.

3 Urban NOA builds automotive-grade engineering capabilities

- L4 requires not only algorithms, but also automotive-grade software, vehicle control interfaces, functional safety, OTA, sensor fusion and quality management. Mass-production Urban NOA deployment helps companies accumulate OEM co-development, vehicle validation, SOP delivery and post-launch iteration experience, part of which can be transferred to L4 platforms.

4 Urban NOA builds user trust and regulatory familiarity

- Trust in autonomous driving develops gradually. Urban NOA helps consumers understand assisted driving capabilities, functional boundaries and takeover mechanisms, while giving regulators early exposure to real-road performance. This supports future liability allocation, insurance mechanisms and road access policies for L3/L4.

Source: CIC

L4 autonomous driving is evolving along two distinct technology approaches

Comparison of two technology approaches

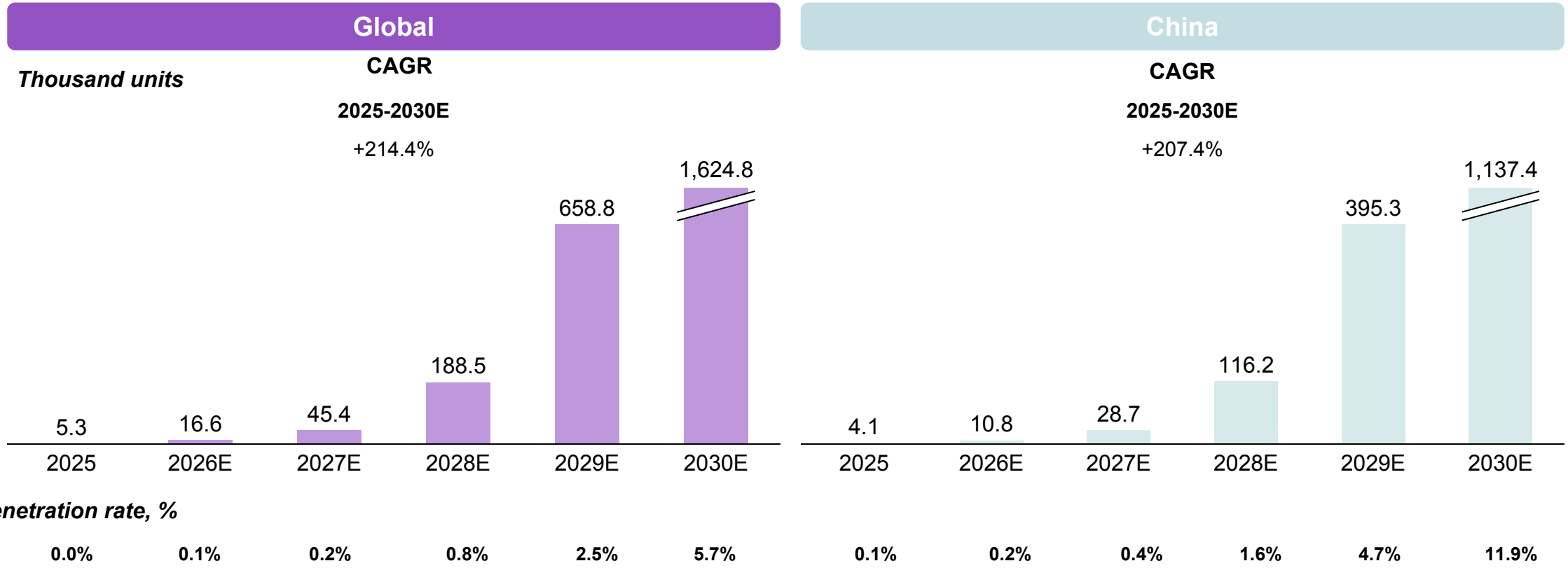
Technology Roadmap	Methodology	Algorithm Model	Map Solution
1 Data-driven Approach (TESLA, momenta)	To improve AD safety and precision by training models with data and corner cases from mass-produced vehicles.	Self reinforcement one-stage end-to-end model	Do not rely on HD map
2 Hybrid Approach (WeRide, pony.ai, NEOLIX, ZELOS)	To deploy L4 fleets (such as robotaxi, robovan, etc.) in licensed cities, adapt algorithms to local road conditions, and gradually expand into more cities.	End-to-end perception + rule-based planning hybrid model	Mostly rely on HD map

- **The data-driven approach** possesses greater scalability and enables faster, lower-cost expansion through continuous collection of real-world data and rapid algorithm iteration.

Source: CIC

Robotaxi is shifting from pilot to scaled commercialization, with China being expected to lead global adoption (1/2)

Number of Robotaxi Operating Fleet, 2025-2030E

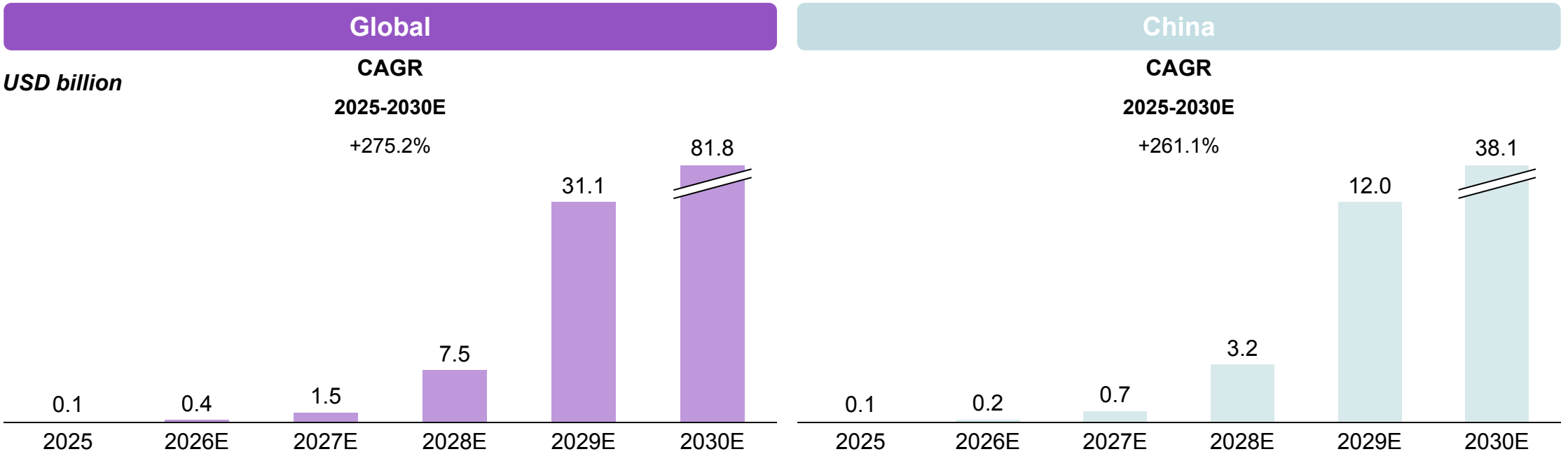


- Although still at an early stage of large-scale deployment, robotaxi services are approaching broader commercial use as system performance improves and regulatory frameworks continue to evolve. Though the global and China robotaxi operations markets were around US$ 0.1 billion in 2025, they are expected to expand to approximately US$81.8 billion globally and US$38.1 billion in China by 2030, reflecting the transition from pilot programs to scaled commercial networks. Meanwhile, by 2030, robotaxi penetration is projected to reach approximately 5.7% globally and 11.9% in China.

Source: CIC

Robotaxi is shifting from pilot to scaled commercialization, with China being expected to lead global adoption (2/2)

Market Size of Robotaxi Service, 2025-2030E

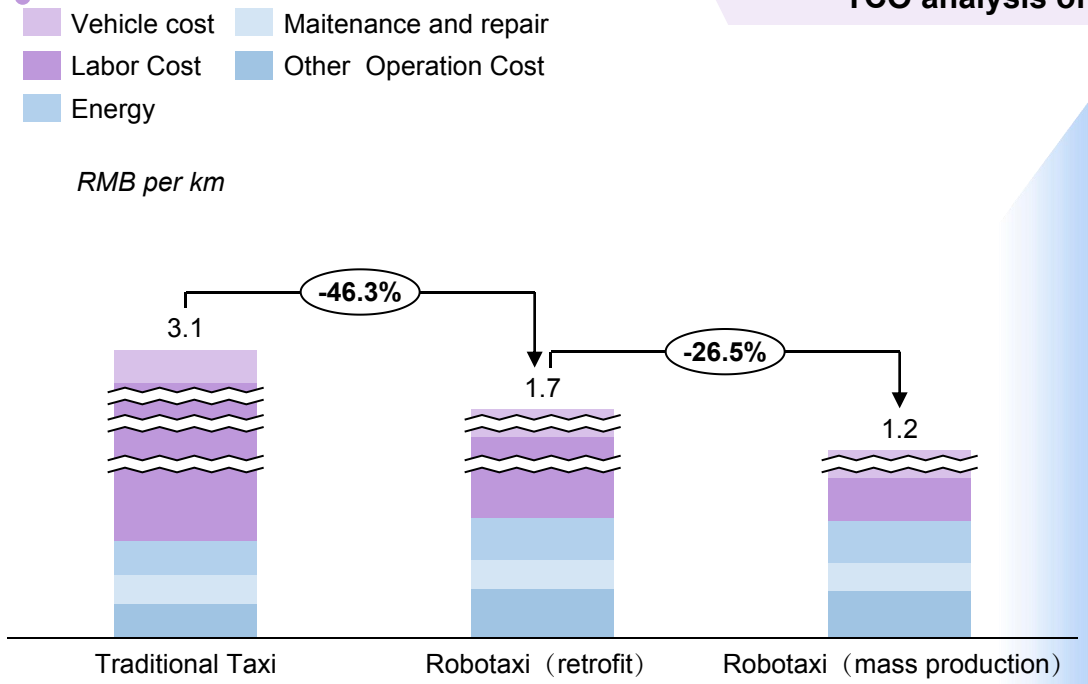


- From a commercial perspective, robotaxis address high-frequency urban mobility demand in a market with trillion-RMB long-term revenue potential. Urban ride-hailing is one of the largest and most repetitive transportation use cases globally, with massive daily transaction volume and highly standardized service demand. As autonomous systems reach commercial reliability in these high-density operating environments, robotaxis gain access to a market large enough to support scaled, platform-level businesses rather than isolated pilot programs.
- The core driver of robotaxi economics is structural cost reduction. By removing the human driver, robotaxi operations eliminate what is typically the single largest expense in traditional ride-hailing: labor cost. In many markets, driver compensation accounts for the overwhelming majority of per-trip operating costs. In parallel, the industry is moving from retrofitted autonomous vehicles to factory-integrated autonomous platforms, which is expected to reduce upfront vehicle costs, improve hardware consistency and enhance system reliability.
- Once deployed at scale, robotaxi operations are expected to achieve substantial margin expansion. By 2030, profit margins are projected to reach up to 60% in China and can be furthered to 80% in higher labor cost markets such as the UAE, the United States and Europe, as supervisory models improve and economies of scale take effect.

Source: CIC

Robotaxi delivers a structural cost advantage over traditional taxis, and mass production is about to unlock the larger savings

TCO analysis of Robotaxi and traditional taxi



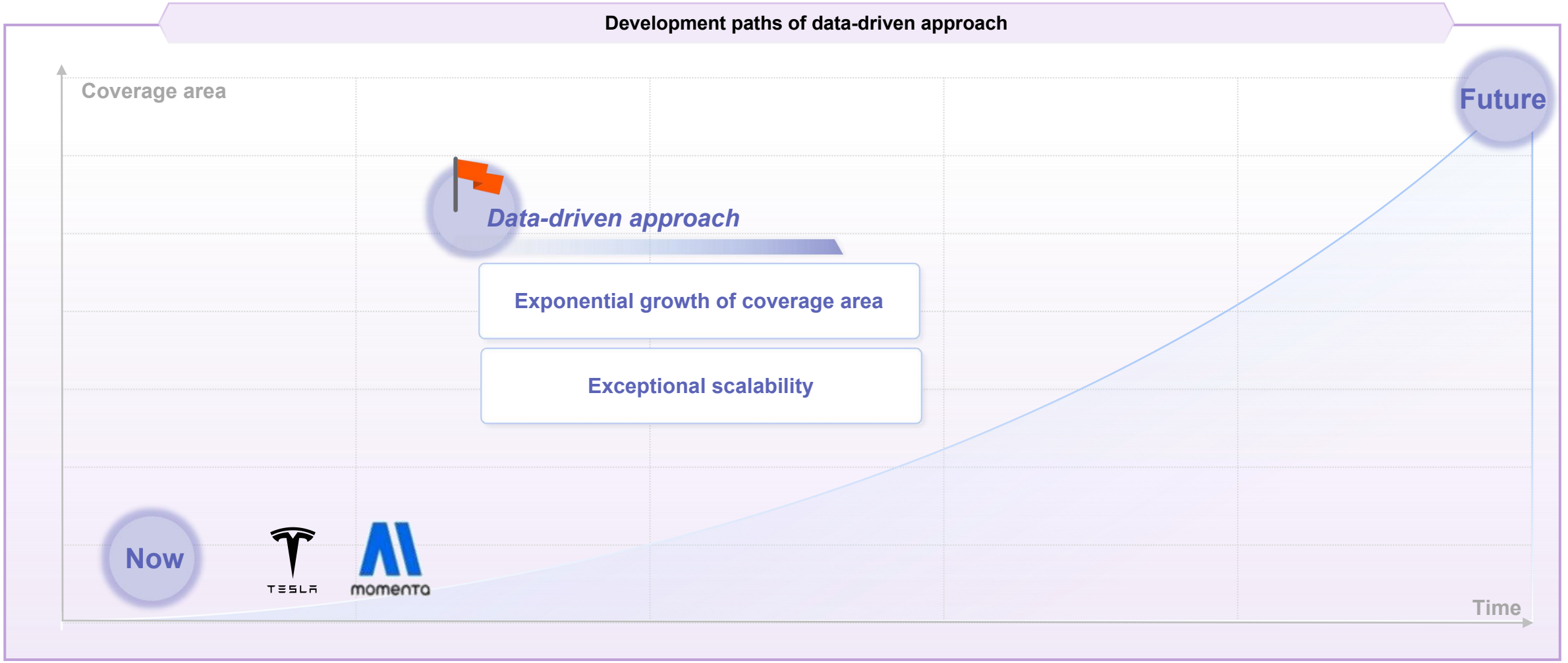
Cost Component	Unit	Traditional taxi	Robotaxi (retrofit)	Robotaxi (mass production)
Vehicle cost	RMB per km	0.2	0.4	0.3
Labor Cost	RMB per km	2.3	0.6	0.3
Energy	RMB per km	0.2	0.3	0.3
Maitenance and repair	RMB per km	0.2	0.2	0.2
Operation Cost	RMB per km	0.2	0.3	0.3
Total		**3.1**	**1.7**	**1.2**

Assumption

1. *Retrofit Robotaxi refers to standard passenger vehicles modified post-production with add-on autonomous driving hardware and software, while Mass-produced Robotaxi refers to vehicles with autonomous driving systems integrated directly during the OEM's standardized manufacturing process.*
2. *Operational Metrics: The TCO calculation assumes a daily mileage of 400 km, 20 operating hours per day, and 360 operating days per year.*
3. *Other Operation Cost: Primarily include expenses such as cloud services, parking fees, data traffic, and vehicle licensing fees.*
4. *Safety Personnel Ratios: The assumed safety personnel-to-vehicle ratio is 1:10 for retrofitted robotaxis and 1:20 for mass-produced robotaxis.*

Source: CIC

Robotaxi companies with data-driven approach demonstrating more scalability and the potential for exponential growth



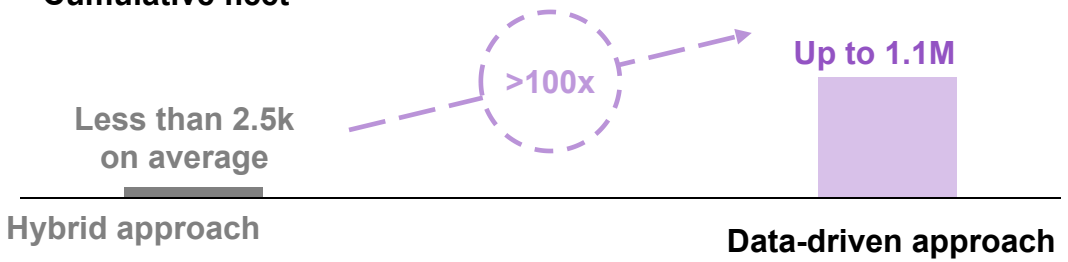
Source: CIC

Data-driven approach is better positioned and provides necessary foundation for full autonomy

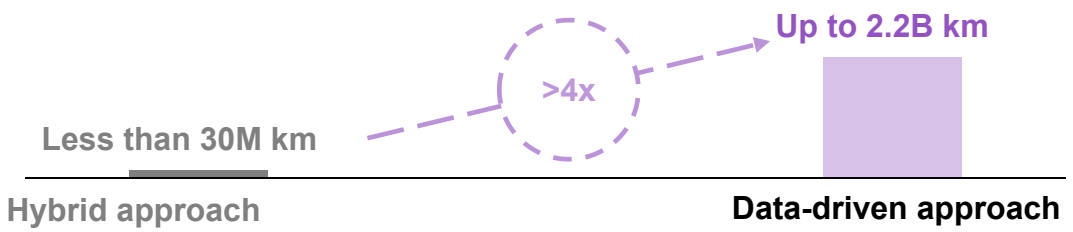
Key advantages for Data-driven approach

Data scale creates unmatched compounding advantages

Extensive vehicle fleet over L4-dedicated players

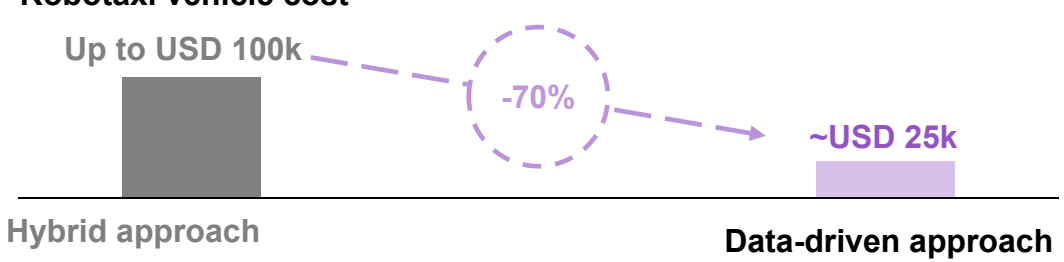


Wealth of real-world corner cases for rapid iteration

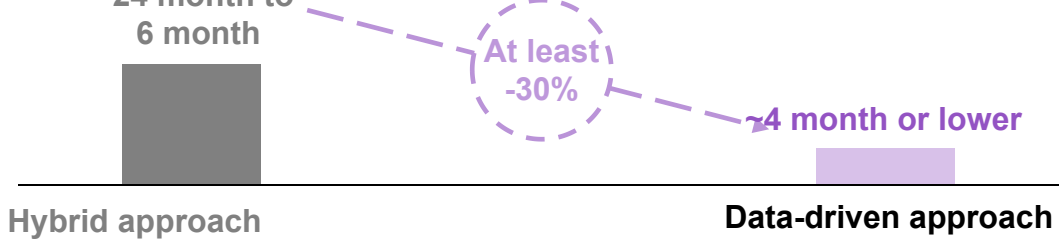


Mass-production capability accelerate the advance of full autonomy

Mass-produced experience to reduce solution cost



Mass-produced experience to help scale development



Source: CIC

The mass-production approach offers superior advantages for scalable autonomous driving deployment

Defining characteristics of mass-production model

Extensive vehicle scale to accumulate corner cases with lower cost

- **Leverages mass-produced vehicle sales instead of dedicated fleets for rapid data accumulation:** For example, Tesla has built a user base of over one million FSD users, compared with fewer than 3,000 vehicles operated by leading robotaxi fleets.
- **Lower marginal cost per vehicle, broader geographic and operational coverage**: Enables data gathering across vast regions and diverse driving conditions at substantially reduced per-vehicle cost.

Rapid algorithm iteration to enable smarter AD system

- **Rapid training and iteration**: Continuous exposure to diverse conditions and high-value corner cases accelerates AD system development.
- **More human-like driving at scale**: Over time, this yields more natural and stable behavior across an expanding range of scenarios.

Strengthened generalization capability enabling broader deployment

- **Stronger generalization through broad validation**: : HD map-free solution to demonstrate strong cross-region generalization capability
- **Scalable deployment across OEMs:** Enables reliable rollout across a wide range of vehicle models and platforms.

Extensive validation of scalable safety

- **Safety validated at million-mile scale:** Growing real-world operating data enables broad testing and refinement of safety performance.
- **Continuous gains across the stack:** Continuous improvements in perception, planning, decision-making speed, and control steadily reduce accident risk as the system matures.

A financially sustainable path to autonomy

- **Each vehicle compounds both data and capital:** Every mass-produced car generates new training data, validates safety and boosts generalization, while delivering recurring revenue and cash flow.
- **Sustainable road to full autonomy:** re-invested earnings sustain the continuous, highly capital-intensive R&D needed to reach full autonomy.

Source: CIC

Robovan and Robotruck are also high-potential scalable Robo applications

- Beyond robotaxi, several other autonomous mobility segments—including robovan and robotruck—are gaining momentum and are expected to commercialize progressively in the near future.

Robovan

- Robovan vehicles have been deployed in commercial operations in China since 2022. These vehicles typically operate on fixed routes between urban distribution centers and customer locations, where traffic patterns and operating environments are relatively structured. By replacing human couriers on repetitive routes, robovan solutions have reduced operating costs by approximately 70.0%. The global and China robovan markets were both valued at approximately US$0.2 billion in 2025, and are projected to expand rapidly to approximately US$85.0 billion and US$ 53.5 billion by 2030, with penetration rates reaching 6.9% and 14.0%, respectively.

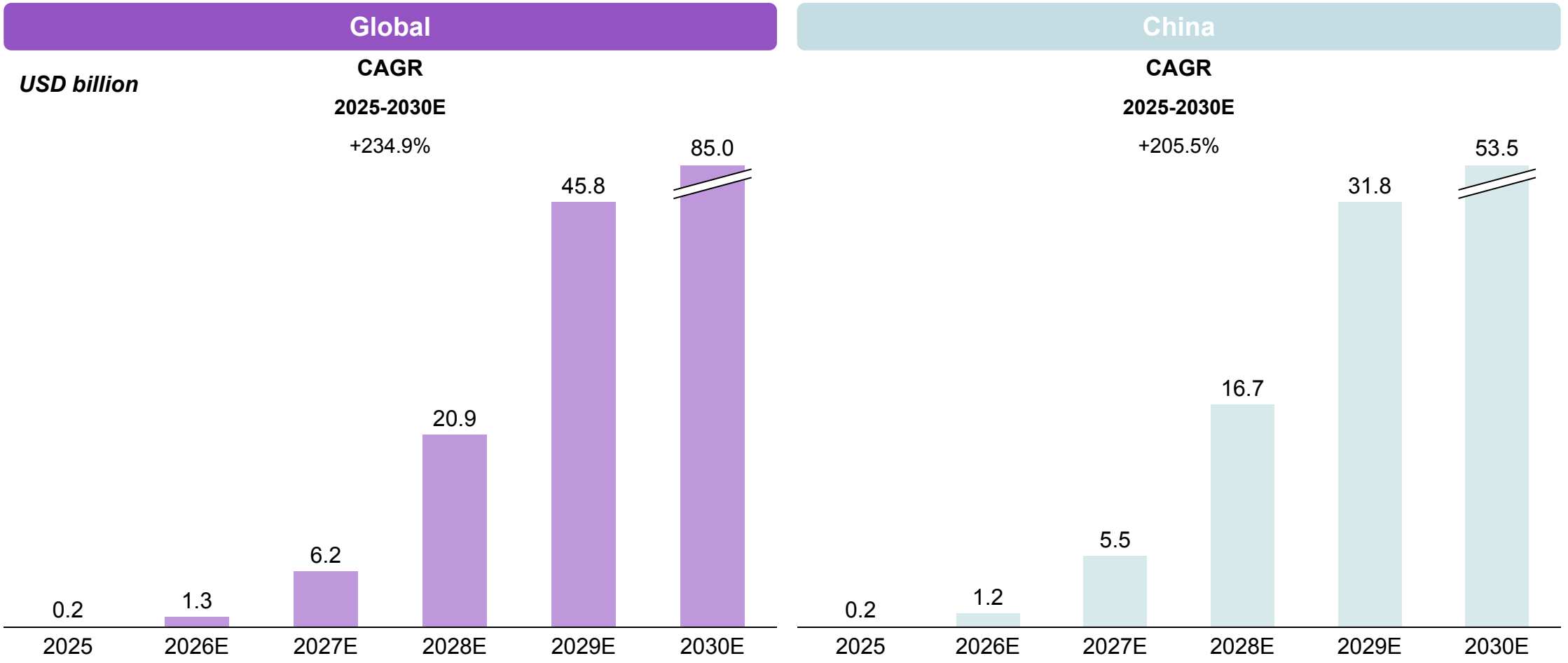
Robotruck

- Robotruck segment is poised for broader adoption. Driven by demands for improved road safety, lower emissions, and greater operational efficiency, the market reached approximately US$0.1 billion globally and US$0.1 billion in China in 2025, and is projected to grow to approximately US$33.0 billion and US$16.5 billion, respectively, by 2030, with penetration of robotrucks expected to reaching approximately 0.6% globally and 1.2% in China by 2030.

Source: CIC

Robovan is also one of the most promising use cases for full autonomy today (1/3)

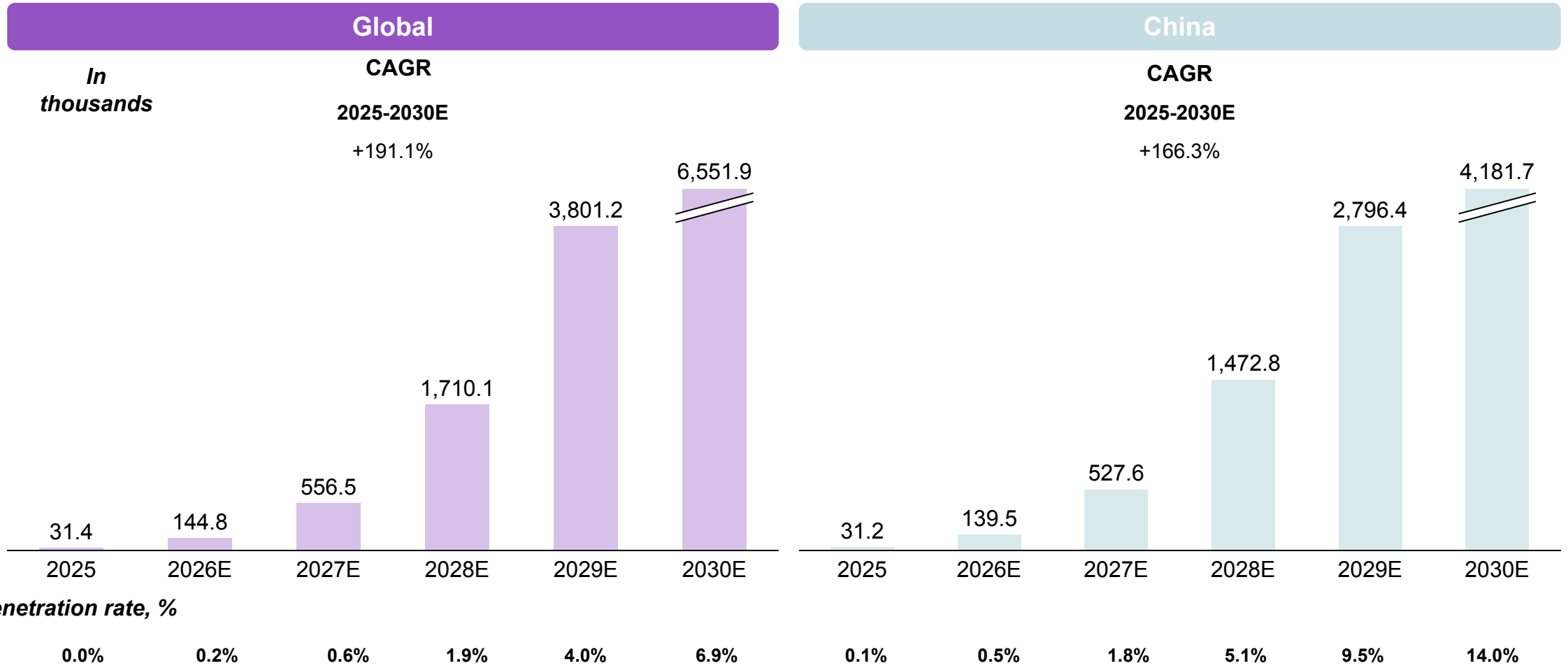
Market Size of Robovan Service, 2025-2030E



Source: CIC

Robovan is also one of the most promising use cases for full autonomy today (2/3)

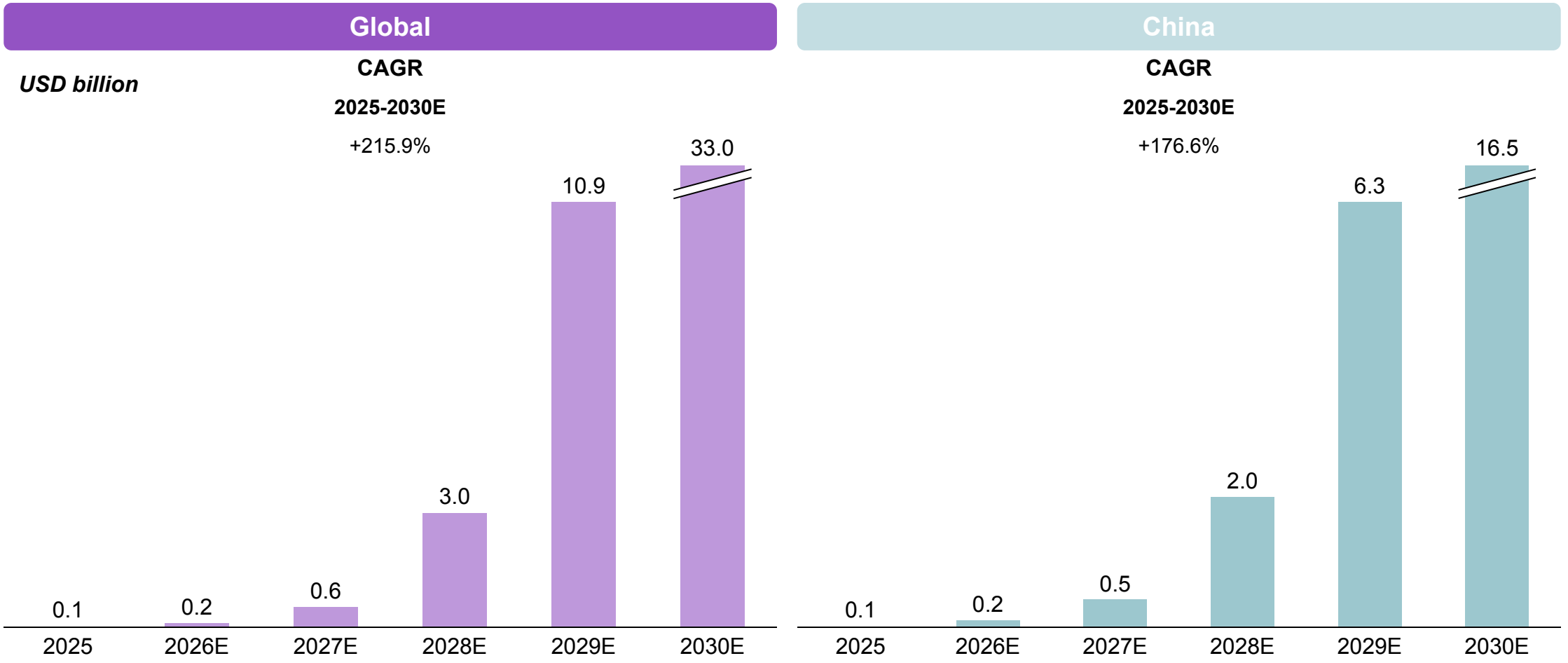
Number of Robovan Operating Fleet, 2025-2030E



Source: CIC

Robotruck is also one of the most promising use cases for full autonomy today (1/2)

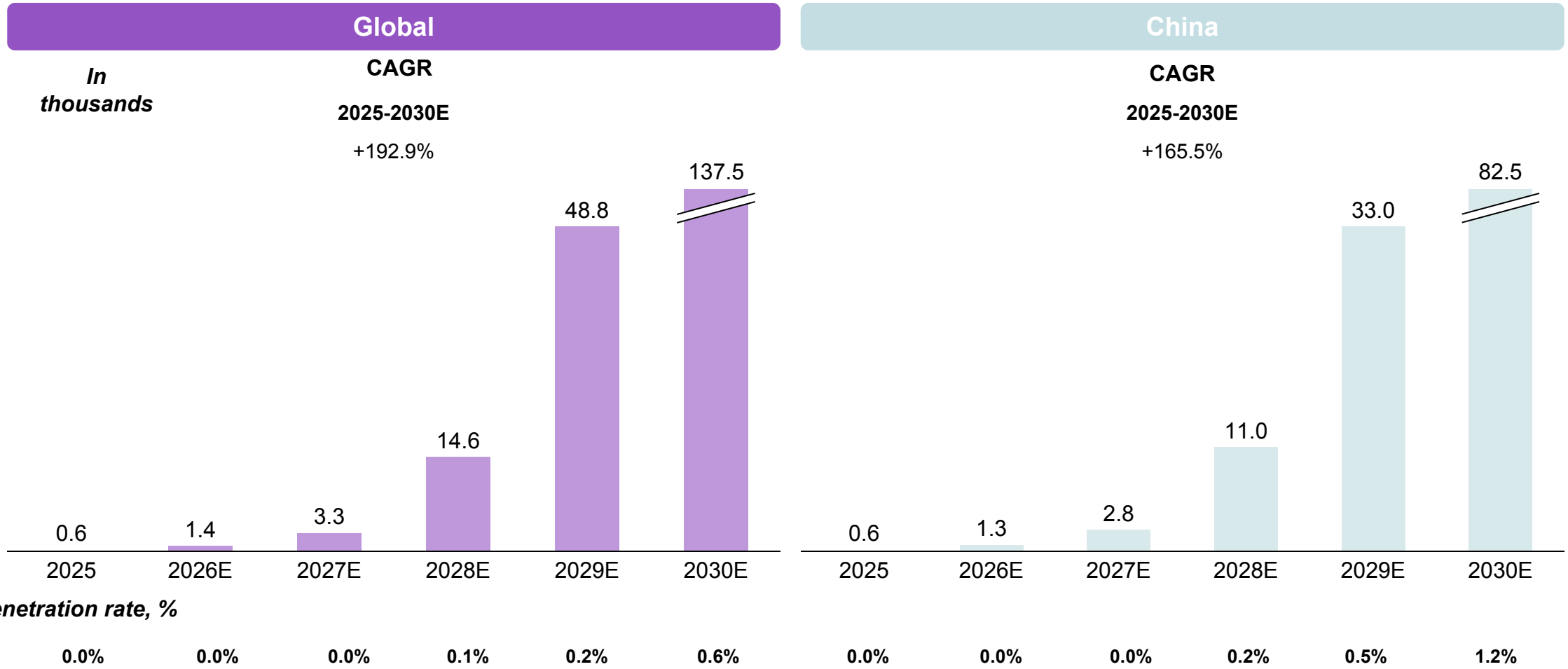
Market Size of Robotruck Service, 2025-2030E



Source: CIC

Robotruck is also one of the most promising use cases for full autonomy today (2/2)

Number of Robotruck Operating Fleet, 2025-2030E



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