China's Electric Vehicle Horizon:

Analyzing National, Provincial, and Top 20 City EV Policies Towards the 2025 Milestone

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CENTER FOR GLOBAL SUSTAINABILITY

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Executive Summary

China has emerged as the global leader in the adoption and production of New Energy Vehicles (NEVs), driven by a national strategy aligned with its dual carbon goals of peaking carbon emissions by 2030 and achieving carbon neutrality by 2060.

This report provides a comprehensive assessment of China's NEV development during the 14th Five-Year Plan (2021–2025), evaluating national and subnational policy implementation, market progress, and infrastructure readiness. Key findings include:

- **Rapid and resilient NEV market growth:** Despite the full phase-out of central government purchase subsidies in 2022, China's NEV market continued to expand, with the penetration rate rising from 25.6% in 2022 to 46% in 2024. Demand is increasingly driven by consumers rather than direct policy incentives.
- **Strong regional variation:** NEV development remains uneven. In 2024, the top eight provinces accounted for 60% of the national NEV stock. The eastern region leads due to mature supply chains and robust infrastructure, while central and western regions exhibit high growth potential. First-tier cities are nearing saturation, whereas second-tier cities and rural areas offer vast expansion opportunities.
- **Progress toward 2025 targets:** Most provinces and cities are on track to meet or exceed their 2025 NEV targets across key indicators, including vehicle stock, sales penetration, production, and public charging infrastructure. Notably, 16 provinces had already met the central government's 2027 sales penetration target (45%) by 2024.
- **Industrial development and innovation:** Both traditional automotive hubs and emerging provinces are contributing to the rise of globally competitive NEV clusters. While regions like Guangdong and Shanghai build on existing strengths, provinces such as Anhui have emerged through policy innovation and industrial upgrading.
- **Uneven charging infrastructure:** Although China has built the world's largest public charging network, infrastructure remains heavily concentrated in major eastern cities. Rural and suburban areas continue to face coverage gaps, posing a key barrier to equitable NEV access.
- **Limited progress in hydrogen fuel cell vehicles (FCEVs):** Despite technical readiness in specific sectors (e.g., short-range logistics), FCEVs remain cost-prohibitive and subsidy-dependent. Market adoption is largely limited to pilot city clusters due to high vehicle and infrastructure costs.

This report highlights both the successes and remaining challenges in China's NEV transition, offering key lessons for countries seeking to decarbonize their transport sectors while fostering domestic industrial growth.

Acronyms and Abbreviations

Battery-electric Heavy-duty Truck	BET
China Association of Automobile Manufacturers	CAAM
China Automotive Technology & Research Center	CATARC
China Electric Vehicle Charging Infrastructure Promotion Alliance	EVCIPA
Compound Annual Growth Rate	CAGR
Electric Vehicle	EV
European Union	EU
Five-Year Plan	FYP
Fuel Cell Electric Vehicle	FCEV
Hydrogen Fueling Station	HFS
International Institute of Green Finance	IIGF
Ministry of Industry and Information Technology of the People's Republic of China	MIIT
Ministry of Science and Technology of the People's Republic of China	MST
National Bureau of Statistics of China	NBS
National Development and Reform Commission	NDRC
National Energy Administration of the People's Republic of China	NEA
New Energy Vehicle	NEV
Penetration Rate of New Energy Vehicles	NEV%
Plug-In Hybrid Electric Vehicle	PHEV
United States	U.S.

1. Introduction

The broad adoption of Electric Vehicles (EVs), encompassing public transit buses, commercial logistics vehicles, and private passenger cars, has accelerated the decarbonization of the global transport sector (Cao et al., 2021). EVs play a significant role in reducing greenhouse gas emissions and promoting sustainable development (Wu & Zhang, 2017). Since the late 2000s, the Chinese government has actively implemented industrial policies to foster the growth of the EV market (Yang, 2023). By 2024, China accounted for 64% of global EV sales, solidifying its position as the world's largest EV market for the tenth consecutive year (Lim, 2024; Rho Motion, 2025). In the Chinese context, EVs are commonly referred to as New Energy Vehicles (NEVs) due to their utilization of various innovative energy technologies, namely battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) (MIIT, 2017b).

China has the world's largest transportation infrastructure, including extensive road and rail networks, which have contributed significantly to urbanization and industrialization (Xu & Xu, 2021). However, the growing demand for transportation has also led to a significant rise in carbon emissions (Xu & Xu, 2021). From 1990 to 2022, the annual growth rate of carbon emissions in China's transportation sector reached 7.3%, significantly higher than the global average of 1.7% (IEA, 2024b, 2024a). Vehicle emissions are the primary source of carbon emissions in the transportation sector, accounting for 80% of the sector's total and 8% of national carbon emissions in 2022 (China SAE & CATARC, 2023).

In response to the global climate agenda, major economies such as the European Union (EU), the United States (U.S.), and Japan have pledged to achieve carbon neutrality by 2050 (Energy & Climate Intelligence Unit, 2025), and have introduced strategic measures to promote the transition to zero-emission and low-carbon vehicles (IEA, 2021). China's ambitious dual carbon goals aim to peak carbon emissions by 2030 and achieve carbon neutrality by 2060 (NDRC, 2021), creating an urgent need to reduce carbon emissions from transportation. Therefore, the electrification and decarbonization of vehicles has become crucial for addressing the challenge of balancing the rapid growth of the automotive industry with high emission reduction targets.

While the EU and the U.S. have been prominent players in the global EV transition, China's leadership in EV manufacturing and deployment has become increasingly significant (IEA, 2022). China's forward-looking national strategy for the EV industry focuses on technological innovation, the deployment of a robust industry ecosystem, industrial integration, infrastructure improvement, and international cooperation (ICCT, 2021a). This comprehensive approach has had a profound impact on provincial and major city policies to adopt local

initiatives to promote EV deployment, boosting EV production and sales nationwide (IEA, 2023). As a result, the alignment of national and regional strategies has accelerated the transition towards green mobility, reinforcing China's commitment to its dual carbon targets.

This report provides an in-depth analysis of China's NEV policies at the national, provincial, and city levels. It examines the strategies and measures implemented to promote NEV adoption and analyze the gap between current NEV adoption levels and the 2025 target. This analysis provides valuable insights into the successes and challenges of China's NEV policy landscape, offering lessons for other countries seeking to advance sustainable transportation transitions.

2. From National Strategy to Local Action: A Comprehensive Overview of China's NEV Policy and Regional Impacts

2.1 How National and Subnational Policies Drive the Surge in NEVs Adoption

The development of China's NEV industry has been significantly driven by the continuous promotion of national policies over the years. In 2009, the State Council issued the *Plan on Adjusting and Revitalizing the Auto Industry* (State Council, 2009), marking the first large-scale national commitment to NEV development. That same year, the government launched the landmark "Ten Cities, Thousand Vehicles" program (Ministry of Finance, 2009), which aimed to promote NEVs in the public sector by deploying more than 30,000 NEVs within three years. In 2013, the government issued the *Notice on Continuing the Promotion and Application of New Energy Vehicles* (Ministry of Finance, 2013), shifting efforts toward the private sector. As a result, annual NEV sales in China surged from 18,000 units in 2013 to 330,000 units in 2015 (CAAM, 2014; NDRC, 2017), making China the world's largest NEV market, a status it has maintained ever since, with EV sales reaching 12.9 million in 2024 (State Council, 2025a). Building on the momentum generated by these early national efforts, a comprehensive system of fiscal and non-fiscal incentives emerged to drive NEV adoption (Table 1).

Fiscal subsidy policies have been key drivers in the rapid adoption of NEVs, including direct purchase subsidies and exemptions from vehicle purchase taxes (Y. Liu et al., 2023; T. Zhang et al., 2024; Zheng et al., 2022). Complementing these were non-fiscal incentives, such as purchase restriction exemptions, parking discounts, right-of-way priorities, free license plate acquisition, and charging discounts, each helping to lower the marginal cost of ownership and usage (Y. Liu et al., 2023; Tian et al., 2024; Zhao et al., 2024). At the same time, industrial policies, exemplified by the "dual credit" policy introduced in 2017, encouraged traditional automakers to transition toward NEV production (MIIT, 2017a). Through a combination of financial incentives and non-financial policies (Table 1), a multi-layered and systematic support framework has been established, enabling widespread NEV adoption, technological innovation and expansion of production capacity, thereby laying the foundation for long-term sustainable growth (B. Li et al., 2023).

Table 1. Incentive Policies for NEV Purchases at National and Subnational Levels.

NATIONAL			
Incentive Type	**Enforce Time**	**Policy Type**	**Content**
Financial	2009 - 2022	Purchase Subsidies	In 2009, subsidies were provided for the public service sector; in 2011, the subsidies were extended to private enterprises; from 2014 the amount of subsidies has been gradually slipping until it is withdrawn by the end of 2022 (Zhao et al., 2024).
	2014 - 2027	Vehicle Purchase Tax Exemption	The purchase tax exemption for NEVs began in September 2014 and will end in 2027 after four extensions. The vehicle purchase tax will be halved from 2026-2027 (Ministry of Finance, 2023a). Vehicle and vessel tax on NEVs and vessels are exempted (Ministry of Finance, 2018).
	2016 - 2020	Subsidy for Charging Infrastructure	Charging infrastructure subsidies were issued according to the number of NEVs promoted (MST, 2016).
	2024 - 2025	Vehicle Replacement Subsidy	Subsidy of ¥20,000 ($2900) for NEVs purchased by trade-in (State Council, 2024c). Subsidies are shared by the central and local governments at an overall 9:1 ratio, with regional variations (State Council, 2024c).
Non-Financial	2018 - now	Dual Credit Policy	Average fuel consumption credits and new energy vehicle credits are given to passenger car manufacturers, inducing traditional automakers to switch to NEVs (IIGF, 2022).
	2014 - 2030	Charging Discounts	Implementing preferential charging price to reduce the cost of NEVs usage (NDRC, 2014, 2023b).
	2012 - 2030	Charging Infrastructure Promotion	Improving technical standards; providing reasonable planning and layout; strengthening the charging network layout in rural areas, encouraging the participation of social capital et al (Y. Liu et al., 2023; NDRC, 2022a; State Council, 2023b).
	2020 - 2024	Promotion of NEVs in Rural Areas	Expanding the adoption of NEVs in rural areas, and driving the construction of charging infrastructure in rural areas (CAAM, 2020; State Council, 2021b, 2022, 2023d, 2024d).

Note: All currency conversions from Chinese yuan (¥) and U.S. dollars ($) use the official 2020 exchange rate from the World Bank (¥6.9 = $1), which is applied consistently throughout the report.

SUBNATIONAL (PARTIAL)[1]			
Incentive Type	**Enforce Time**	**Policy Type**	**Content**
Financial	End in 2019	Local Purchase Subsidies	Over 40 provinces and cities implemented local subsidies, with funding shared between the national and local governments at ratios ranging from 1:1 to 1:0.1 (Gasgoo, 2017). However, these local subsidies were discontinued in 2019 (Ministry of Finance, 2019).
	2022 - 2023	Vehicle Replacement Subsidy	Shenzhen introduced subsidies of ¥5,000 to ¥10,000 ($725 to $1,450) for replacing old vehicles with NEVs as early as 2022 (Shenzhen Government, 2022). In 2023, Shanghai also offered a ¥10,000 ($1,450) subsidy for similar replacements (Shanghai Municipal Commission of Commerce, 2023).
	2021 - 2025	Subsidy for Private Pile Installation	Henan provides tiered rewards of up to millions for residential charging pile installations during 2021-2025 (Government of Henan Province, 2020). Xi'an offers a ¥10,000 ($1,450) subsidy for individuals installing charging piles in 2023 (Xi'an Municipal Government, 2023).
	2016 - now	Subsidy for Charging Infrastructure Construction	Subsidies for charging infrastructure in provincial and municipal level commonly include total investment subsidies, construction subsidies, operation subsidies, and charging subsidies (Chen et al., 2023). Since 2016, 32 provinces and cities across the country have introduced incentive policies for charging Infrastructure construction (Chen et al., 2023).
	–	Charging Subsidy	Shanghai provides tiered electricity subsidies for charging at public charging stations (Shanghai Municipal Development and Reform Commission, 2022). Hainan provides annual subsidies of ¥1,350 to ¥1,800 ($200 to $260) for charging NEVs (Hainan provincial industry and Information Technology Department, 2024).
Non-Financial	2014 - now	NEV License Plate Acquisition	Megacities offer registration privileges to EV consumers to promote adoption. For example, Beijing, Tianjin, Shenzhen, and Guangzhou exempt NEV consumers from the license plate lottery, allowing them to obtain plates through direct application (Beijing Municipal People's Government, 2020; Guangzhou Municipal People's Government, 2019; Shenzhen Municipal People's Government, 2024b; Tianjin Municipal People's Government, 2019).
	2016 - now	Exemption from Traffic Restrictions	Cities like Beijing, Shanghai, Wuhan, and Tianjin exempt NEVs from traffic restrictions, such as exemption from license plate-based restrictions, unrestricted access during peak hours, or waivers on specific area and time restrictions (Beijing Traffic Management Bureau, 2025; Shanghai Municipal People's Government, 2023; Tianjin Public Security Bureau, 2024; Wuhan Municipal People's Government, 2019).

1. Each policy type includes content from only a subset of provinces and cities.

Non-Financial	2016 - now	**Parking Fee Benefits**	Many cities offer free or discounted parking for NEVs. Cities like Qingdao, Xi'an, and Chengdu offer up to two hours of free parking daily for NEVs in public parking lots. Suzhou, Nantong, and Shenzhen provide half-price or free roadside parking. Qingdao has also designated "NEV-only parking zones" with partial fee waivers (Zhao et al., 2024).
	-	**Toll Exemption**	Waiving tolls for NEVs on specific roads, such as highways. Currently, this measure primarily targets FCEVs. Regions such as Shaanxi, Shandong, Jilin, Sichuan, and Ordos in Inner Mongolia have introduced policies exempting FCEVs from highway tolls (Fuel Cells Works, 2024).

In the early stages, NEV development relied heavily on central government subsidies and tax exemptions. Beginning in 2009, the central government offered substantial financial support to both manufacturers and consumers, significantly reducing purchase costs and accelerating market expansion (Ehsan et al., 2024). From 2009 to 2020, China issued over ¥140 billion ($20.3 billion) in NEV purchase subsidies (The Economic Observer, 2021). These subsidies were tied to performance metrics such as battery capacity and energy density, encouraging continuous technological advancement (ICCT, 2021b). As a result, the average battery capacity of China's BEVs increased by 60% between 2012 and 2021 (ICCT, 2023).

Over time, however, per-vehicle subsidy levels gradually declined in response to rising technical standards and more stringent eligibility thresholds (Zhao et al., 2024). For example, the maximum subsidy for BEVs, dropped from ¥60,000 ($8,700) in 2009 to ¥12,600 ($1,800) in 2022 (Zhao et al., 2024). While direct purchase subsidies have been gradually phased out, tax exemptions remain in place as a more stable and less distortionary policy tool to support NEV adoption, helping to ease the transition toward a fully market-driven model. Between 2014 and 2022, NEV purchase tax exemptions exceeded ¥200 billion ($29 billion), with projections reaching ¥520 billion ($75.4 billion) by 2027 (NDRC, 2023a). These incentives have stimulated market demand, with NEV production and sales growing from fewer than 6,000 units in 2009 to 12.8 million units in 2024 (CAAM, 2025; Zhao et al., 2024).

A major policy reflecting China's strategic shift toward a market-oriented approach was the introduction of the dual credit policy in 2017, which requires traditional automakers to meet NEV production quotas or purchase credits to avoid penalties (MIIT, 2017a). In 2018, China further promoted competition in the sector by relaxing foreign investment restrictions in the automotive industry, attracting international automakers to invest in NEVs development (China Automotive News, 2024b; NDRC, 2018).

At the subnational level, local governments have played a pivotal role by formulating and implementing region-specific policies tailored to their local contexts. First-tier cities[2] like Beijing, Shanghai, and Shenzhen have adopted measures such as free license plate quotas, purchase subsidies, and preferential traffic policies to attract NEV buyers. In Shanghai, for example, NEV owners are exempted from license plate auction fees, which can amount to nearly ¥95,000 ($13,770), significantly lowering the total cost of ownership (G. Li et al., 2023). Second- and third-tier cities[3] have focused on charging infrastructure development and improving user convenience to promote NEV adoption. Cities like Suzhou, Xi'an, and Qingdao have invested heavily in public charging networks and introduced measures such as parking fee reductions and toll exemptions to enhance the overall NEV user experience (Table 1). In rural areas, the "New Energy Vehicle Going to the Countryside" initiative, launched in 2020 by the central government and implemented locally, aims to expand NEV access in less-populous regions (CAAM, 2020). By collaborating with NEV automakers and introducing preferential financial policies, local governments have tapped into the consumption potential of rural markets (Xinhua Net, 2024a). To address the limited availability of charging facilities, the central government has provided funding to support charging infrastructure in county-level areas (State Council, 2024b). Zhejiang took an early lead by proactively expanding NEV infrastructure in rural areas. For example, through county-level surveys, urban charging data analysis, and assessments of charging demand and site selection[4], Zhejiang has laid a solid foundation for the diffusion of NEVs in the countryside (Farmers' Daily, 2024). As a result, the rural NEV penetration rate increased from 4% in 2022 to 17% in 2023 (China Energy News, 2024a). By 2024, about 15 million NEVs had been sold through this initiative, driving the widespread adoption and fostering a broader market transition (OFweek, 2025).

In addition, the central government provides policy support for battery technology R&D and industry chain upgrades, making EV manufacturing more cost-competitive and driving the rapid growth of the NEV market (Tian et al., 2024). At the same time, local governments have fostered the development of local NEV industry chains by establishing industry funds and supporting leading enterprises, resulting in the formation of region-specific industrial clusters (Chongqing Municipal People's Government, 2024; Huizhou Municipal People's Government, 2024).

As a result, China's NEV industry is undergoing a strategic transition from heavy subsidy dependence to a more market-driven model (NEA, 2020), guided by the top-level planning from the central government and proactive implementation by local governments. At the national level, policies offer broad strategic guidance—setting long-term development goals, designing fiscal subsidy frameworks, formulating technical standards, and coordinating cross-regional efforts. At the local level, provincial and municipal governments operationalize this vision through more targeted and context-specific measures, such as regional subsidies, infrastructure development, industrial cluster promotion, and talent recruitment.

2. We categorize cities based on the classification standards of the National Bureau of Statistics. First-tier cities refer to Beijing, Shanghai, Guangzhou, and Shenzhen.
3. According to the classification standards of the National Bureau of Statistics, second- and third-tier cities include provincial capitals and other economically developed cities.
4. Key measures of Zhejiang include: a) identified rural charging needs through surveys and inter-department consultations; b) piloted stations in central villages and along main roads based on charging data analysis; c) site selection considered population size, demographics, distance to cities, traffic access, and NEV ownership.

2.2 Incentive Policy and Overall Performance during 14th Five Years Period

During the 14th Five-Year Plan (FYP) period (2021-2025), China's NEV policies have become increasingly systematic and comprehensive, signaling a strategic shift from a "policy-driven" to a more "market-led" development model. In 2020, the State Council issued the *New Energy Vehicle Industry Development Plan (2021-2035)*, which established the foundation for both near- to long-term development of the NEV industry (State Council, 2020b). This plan focuses on enhancing technological innovation, fostering a new industrial ecosystem, promoting industry integration, improving infrastructure systems, and deepening international cooperation (State Council, 2020a).

From 2020 to 2024, a series of national policies (Figure 1) were introduced to support the strategic implementation and development of the NEV market. These policies focused on key areas including NEV adoption in the public sector and rural regions, the expansion of a high-quality charging infrastructure network, the advancement of hydrogen FCEVs, and the promotion of NEV consumption. To promote comprehensive development of the NEV market, each policy initiative set short-term targets related to NEV adoption, infrastructure, FCEVs promotion, and NEV production (Table 2), providing clear guidance for provincial and municipal governments to align with their local strategies accordingly. Although the national targets for NEV production are qualitative, subnational governments have proposed specific quantitative production targets.

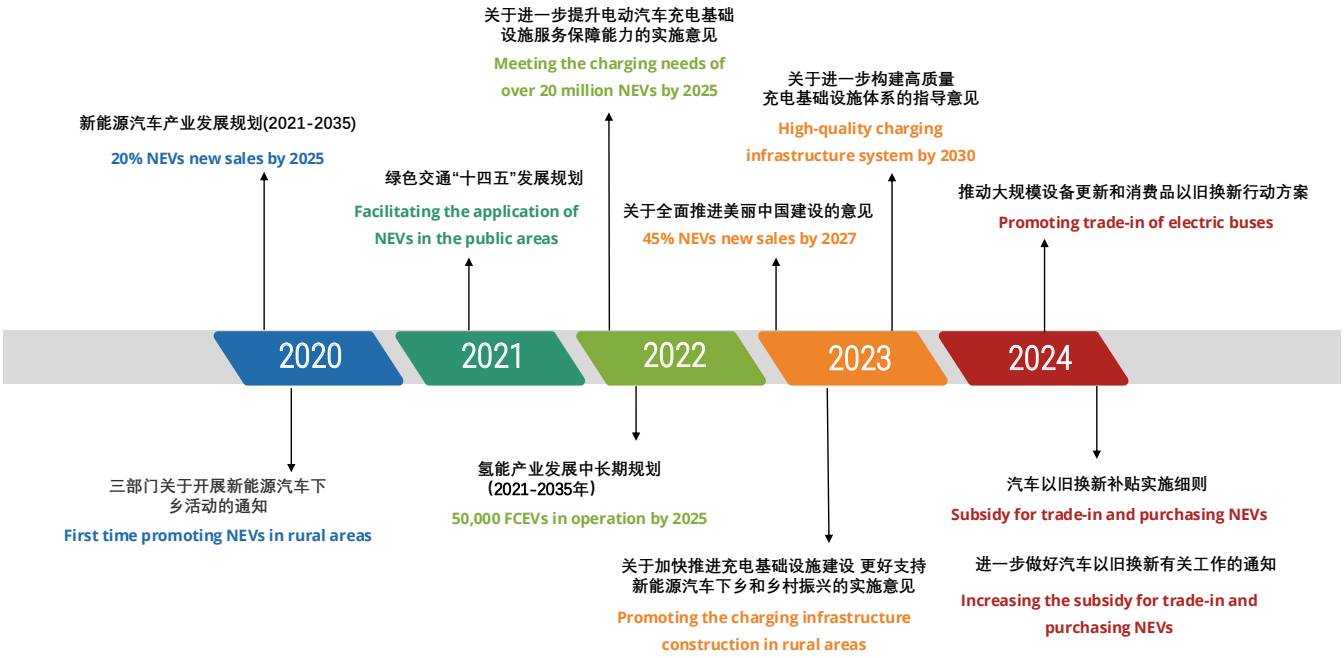

Figure 1. Timeline of National Policies for China's NEVs in 2020-2024. Source: Official policies from the State Council, Ministry of Transport, Ministry of Industry and Information Technology, and National Development and Reform Commission, see Appendix for detailed information.

In general, subnational targets are consistent with national objectives. However, in some cases, subnational targets have significantly exceeded national benchmarks. For example, Hainan Province has announced a 60% NEV annual sales rate target by 2025 (Table 2) and plans to completely ban the sale of internal combustion engine vehicles by 2030 (Hainan New Energy Vehicle Promotion Center, 2023; Hainan Provincial People's Government, 2019), while the national target is only 20% in 2025. Shanghai has set a target of achieving a 2:1 vehicle-to-charging-pile ratio by 2025 (Shanghai Municipal People's Government, 2022), while the current national ratio is 2.4:1. Additionally, eight provinces and cities, including Beijing, Guangdong, and Hebei, have proposed promoting 10,000 hydrogen fuel cell vehicles by 2025, even though no specific target has been set at the national level.

Table 2. Selected subnational targets that exceed national 2025 goals across four key categories.

	National	Provinces (Partial)
NEV Adoption	20% NEV annual sales	Hainan: 60% NEV annual sales
		Shanghai: 50% NEV annual sales
		Shandong: 45% NEV annual sales
	Public fleets: 72% NEV in buses, 35% NEV in taxi, 20% NEV in logistic vehicles	Henan & Fujian: 100% NEV in Public fleets
		Hainan: 100% NEV in new and renewed public fleets
Charging Infrastructure	Meeting the charging needs of more than 20 million NEVs[5]	Shanghai: 2:1(Ratio of NEV to piles)
		Guangxi: 2.3:1(Ratio of NEV to piles)
		Hainan: 2.5:1 (Ratio of NEV to piles)
		Zhejiang: 2,300 thousand charging piles, including 250 thousand public charging piles
		Hubei: 600 thousand charging piles, including 250 thousand public charging piles
FCEV	50,000 stock	Beijing & Guangdong & Hebei & Inner Mongolia & Shanxi & Shaanxi & Shandong & Shanghai: 10 thousand stock

Note: *No qualitative or quantitative targets have been proposed for NEV consumption or promotion in rural areas according to the national/subnational targets, so we replace it with the production targets here. Source: official policies from the central government and provincial governments, see Appendix for detailed information.

5. By 2024, China's NEV stock has surpassed 30 million, with a NEV-to-pile ratio reaching 2.4:1, exceeding this number from a 2022 policy.

NEV Production*	Strong competitiveness; breakthroughs in key technology; higher safety level (though described qualitatively without specific quantitative targets)	Guangdong: 3 million NEV annual production
		Henan: 1.5 million annual NEV production
		Shanghai & Zhejiang: 1.2 million NEV annual production

China has faced significant gaps in meeting the demand for NEV charging infrastructure, but recent years have seen substantial improvements. In 2017, China had 446,000 charging piles, with an NEV-to-pile ratio of 3.5 (Figure 2). Due to the high concentration of charging infrastructure in certain areas, charging difficulties were widespread (NEA, 2018). Since 2017, NEV stock has grown at an average annual rate of 54%. By 2024, the total NEV stock reached 31.4 million, accounting for 9% of the nation's total vehicles, with 70% being BEVs (State Council, 2025c). China now leads the world in NEV stock, representing over 50% of the global total (IEA, 2025). To meet the surging demand for charging, the number of charging piles has expanded rapidly. By 2024, China had installed 12.8 million charging piles, 28 times the number available in 2017 (EVCIPA, 2025; NEA, 2018). In recent years, the growth rate of charging piles has outpaced that of NEV adoption, helping to ease the infrastructure gap. The NEV-to-pile ratio declined from 3.5 in 2017 to 2.4 in 2024 (Figure 2) (EVCIPA, 2025). This improvement suggests that the supply-demand imbalance in charging infrastructure has begun to ease. With continued growth in NEVs and further expansion of charging infrastructure, the ratio is expected to decline further to 2:1 in 2025 (B. Li et al., 2024).

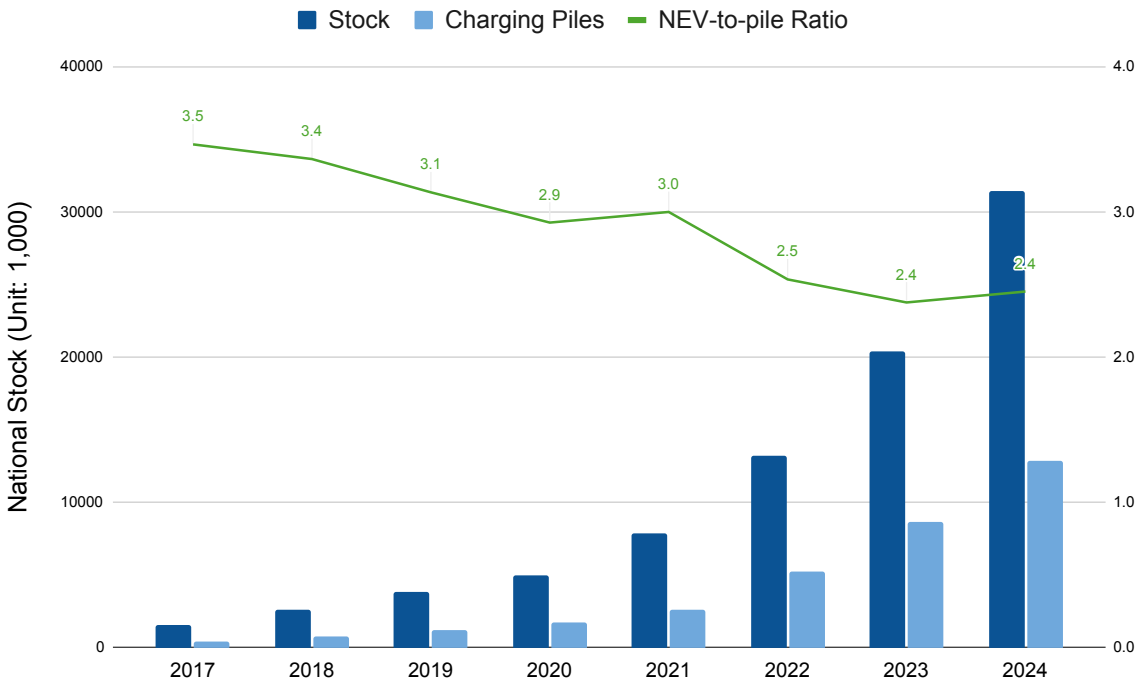

Figure 2. National Trend of Stock and the NEV-to-pile Ratio. The NEV-to-pile ratio is calculated by the numbers of the stock and charging piles. Source: Ministry of Public Security; China Electric Vehicle Charging Infrastructure Promotion Alliance.

Despite overall national progress, the adoption of NEVs exhibits significant regional disparities in China. From a temporal perspective, nearly all provinces have experienced consistent year-over-year growth in NEV stock since 2017 (showed in Figure 3), aligning with the national growth trend, with a rapid acceleration after 2020. However, geographically, NEV adoption remains heavily concentrated in key economic hubs such as the Beijing-Tianjin-Hebei region, the Jiangsu-Zhejiang-Shanghai Area (Yangtze River Delta)[6], the Pearl River Delta[7], and the Sichuan-Chongqing area.

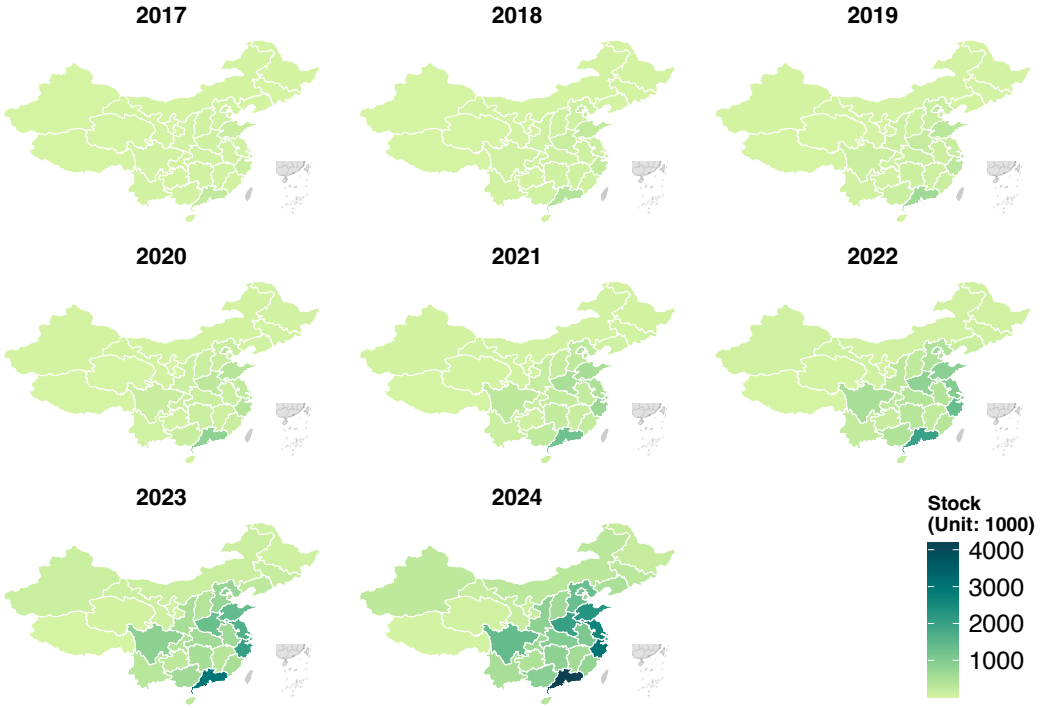

Figure 3. National Stock Trend Map with Regional Disparities. Note: Due to data limitations, the 2024 stock data does not include the growth data for new energy commercial vehicles. Source: Ministry of Public Security of China.

6. An economic hub in eastern China, including Shanghai, Jiangsu, Zhejiang, and selected cities in Anhui.
7. A major economic region in southern China, centered in Guangdong Povince.

Several factors contribute to these regional variations:

Economic and Socio-demographic Factors: Regions with stronger economies are better positioned to stimulate demand for NEVs, invest in charging infrastructure, and support advancements in EV technology (Shao & Mišić, 2023; Westin et al., 2018). Coastal provinces with higher GDP per capita, particularly in eastern China, exhibit higher production and adoption rates of NEVs and better-developed infrastructure, such as Guangdong and Jiangsu (Shao & Mišić, 2023).

Automotive Industry Base: Regions with established automotive manufacturing industries benefit from supply chain advantages and expertise, facilitating the transition to NEVs (Borgstedt et al., 2017), such as the Yangtze River Delta (Shanghai-Jiangsu-Zhejiang) and Guangdong.

Local Policy Support: Provinces with robust NEV policies provide greater incentives and support for adoption, addressing specific regional challenges and promoting local industry growth, such as Anhui, which has built an emerging NEV industrial ecosystem through strong policy support and industrial upgrading (Shao & Mišić, 2023; Zhao et al., 2024). Jilin, by contrast, presents the opposite case of Anhui, as excessive local economic protectionism has hindered the development of EV-friendly policies (Shao & Mišić, 2023).

Weather Conditions: Regional temperatures influence EV performance, with extreme cold posing challenges to battery efficiency and driving range, leading to slower adoption in colder areas, such as northwest and northeast regions (X. Li et al., 2022).

3. Provincial and City-Level NEV Landscape 2025: An Analysis of Adoption Trends

3.1 Provincial and City-Level NEV Stock and 2025 Targets

The stock of NEV in China has continued to grow over the past 8 years, reflecting a significant national shift toward transportation electrification and green development goals (Tao, 2024). However, NEV adoption remains uneven across regions, with economically developed provinces and major cities showing particularly strong growth momentum.

Since 2017, all provinces have recorded consistent year-on-year increase in NEV stock, with 75% achieving annual growth rates exceeding 50%. By 2024, NEV stock is predominantly concentrated in southern and eastern provinces, such as Guangdong, Zhejiang, Jiangsu, Beijing, Shanghai, Shandong. Notably, Guangdong leads the country, accounting for 13% of the national NEV stock, followed closely by Zhejiang at 9.6%. Jiangsu ranks third, with Shanghai, Shandong, and Henan each contributing over 5%, and Sichuan and Hebei each exceeding 4%. Collectively, these top 8 provinces account for approximately 60% of China's total NEV stocks. An additional 16 provinces each hold between 1% and 4% of the national share, amounting to over 35% combined, while the remaining 7 provinces in the northeast and northwest together represent just 3% of the total. However, since the beginning of the 14th FYP period, NEV stock in these less-represented provinces has grown at an accelerated pace, with several northeastern and northwestern provinces (Inner Mongolia, Jilin, Liaoning, Ningxia, and Xinjiang) experiencing increases of approximately 100% (Figure S1).

By the end of 2024, 19 provinces have set short-term targets for NEV stock, most of which align with the 14th FYP period (2021-2025). However, NEVs development during this period has outpaced the expectations of many local governments. The majority of provinces had already surpassed their 2025 targets (see the light blue bars in Figure 4), with Anhui even surpassing its 2027 goal. Among the provinces that have not yet surpassed their short-term targets, Zhejiang and Beijing appear to have set more ambitious targets for 2025, with their 2024 NEV stock still falling significantly short of those goals, whereas Shanxi, Chongqing, Guizhou, and Hainan have adopted more moderate and attainable targets.

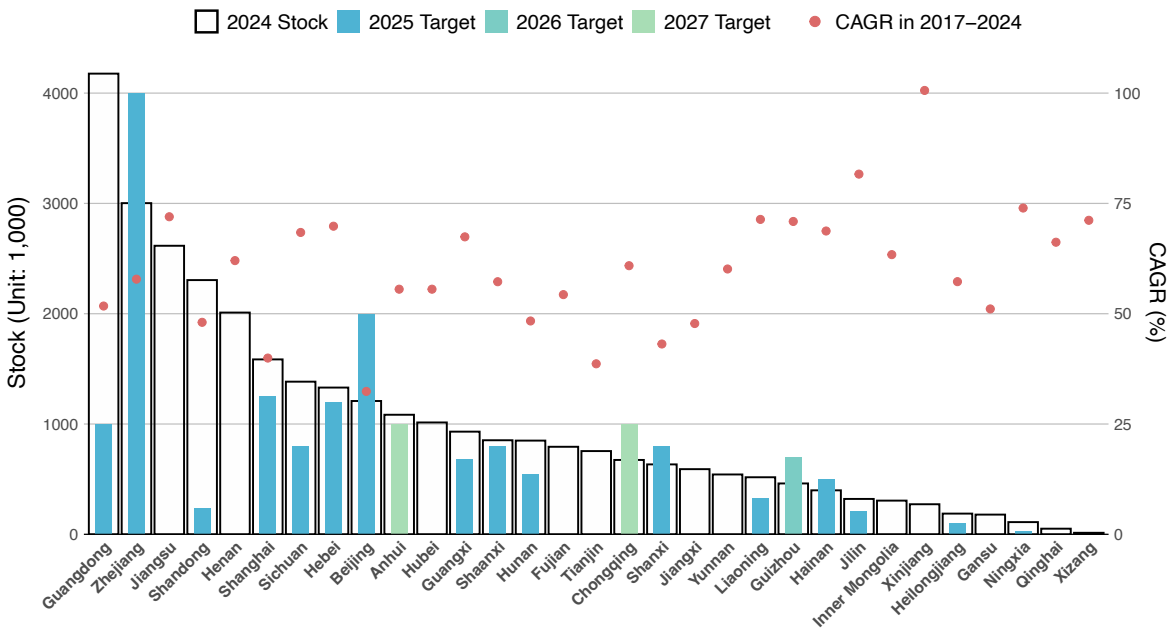

Figure 4. Stocks Trend for Provinces. Ranked by Stock in 2024, excluding Hong Kong, Macau and Taiwan. For provinces that did not specify concrete stock targets, projections related to meeting NEV charging demand were used as substitutes. Note: Due to data limitations, the 2024 stock data does not include growth data for new energy commercial vehicles. Source: Ministry of Public Security of China.

Similar to the provincial situation, most of the top 20 cities have already achieved their 2025 targets by 2024. The top 20 cities[8] include first-tier cities, several provincial capitals, and other cities in economically developed provinces. Excluding centrally-administered municipalities, Shenzhen, Guangzhou, Hangzhou, and Chengdu each surpassed a million NEVs in stock by 2024, maintaining their leading positions, with Chengdu recording the fastest growth rate at 80%. In contrast, lower-ranked cities such as Suzhou, Wenzhou, Dongguan, Foshan, and Wuxi, despite having relatively low NEV stocks, achieved growth rates exceeding 100%, significantly higher than the 75% growth rates observed in other cities. Wuxi ranks first in growth rate since the start of the 14th FYP period, with a 115% increase (Figure S2). This pattern suggests that while first-tier cities demonstrate a "slower but steady" growth pattern, late-developing regions are accelerating to close the gap with early adopters. However, Ningbo's 2025 target remains significantly higher than its current stock, reflecting strong policy ambitions. Zhengzhou has proposed an even more ambitious long-term goal of reaching 2.7 million NEVs by 2035 (Zhengzhou Municipal People's Government, 2024a). Overall, coastal first-tier cities continue to lead the market, while inland cities like Chengdu, Zhengzhou and Xi'an are emerging as strong contenders with high growth rates and ambitious targets.

8. Top 20 cities tier classifications follow the standards of the National Bureau of Statistics. First-tier cities refer to Beijing, Shanghai, Guangzhou, and Shenzhen. Second-tier cities include 11 provincial capitals, Tianjin, Chongqing, and Ningbo; third-tier cities include Wuxi and Wenzhou. Suzhou, Foshan, and Dongguan, though not officially classified, are treated as third-tier cities in this report due to their economic significance.

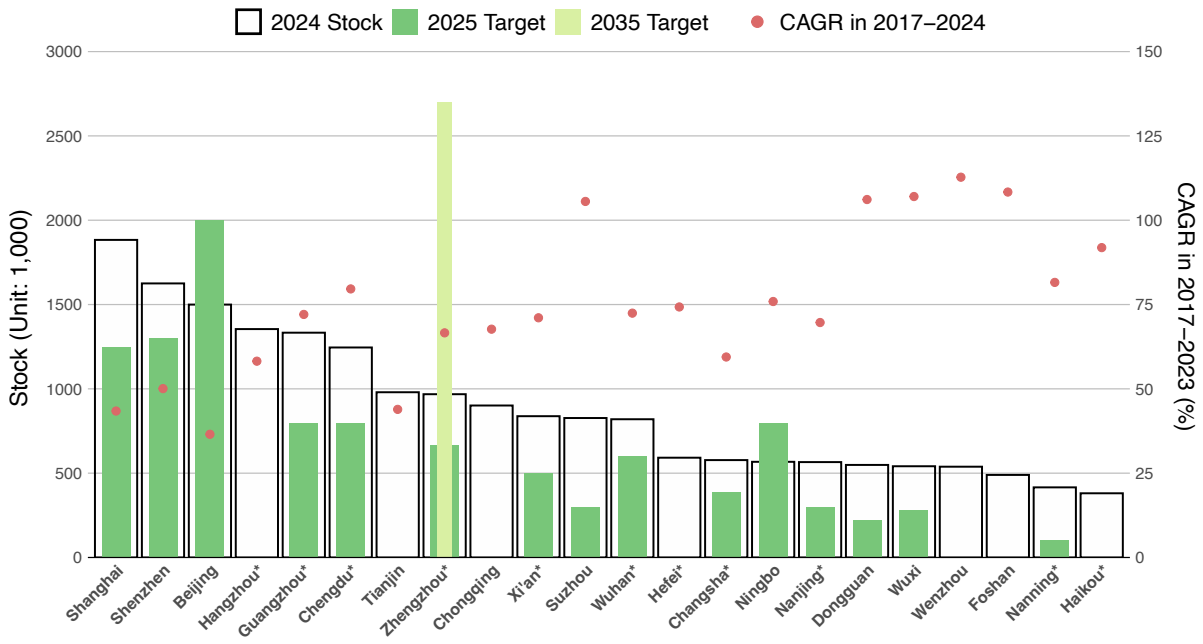

Figure 5. Stocks Trend for Top20 Cities (Ranked by Stock in 2024). The Top 20 Cities consist of 22 cities, selected based on a comprehensive evaluation of the cities that ranked among the top 20 in annual NEV sales in recent years. Note: Due to data limitations, the 2024 stock data does not include the growth data for new energy commercial vehicles. "*" indicates the provincial capital city; the same applies hereafter. Source: Ministry of Public Security of China.

3.2 Provincial and City-Level NEV New Sales and 2025 Targets (Passenger Car)

China's NEV market displays a clear pattern of "mature leadership in the east, rapid rise in the central region, and emerging potential in the west and northeast," with significant regional differences in sales volumes and growth rates. According to 2024 sales data (Figure 6), provinces can be grouped into four tiers based on NEV sales volume[9]. The top-performing group includes Guangdong, Zhejiang, Jiangsu, and Shandong, which lead the market thanks to their advanced economies, well-developed infrastructure, and strong policy support. In 2024, these four provinces collectively accounted for 37% of national NEV sales. Guangdong, ranked first, achieved an impressive sales volume of 1.22 million units in 2024, while Zhejiang, Jiangsu and Shandong each surpassed 800,000 units. The second group comprises Henan, Hebei, Sichuan, and Anhui, with sales between 400,000 and 700,000 units, reflecting rapid market

9. The four tiers of sales volumes are divided as follows: above 800,000 units, 400,000–800,000 units, 200,000–400,000 units, and below 200,000 units.

expansion. The third group includes 12 provinces with sales ranging from 200,000 to 400,000 units, indicating moderate development. The fourth group includes less-developed regions such as Xinjiang, Ningxia, and Xizang, with sales under 200,000 units. Despite their lower sales volumes, these regions are experiencing high growth rates, highlighting significant development potential.

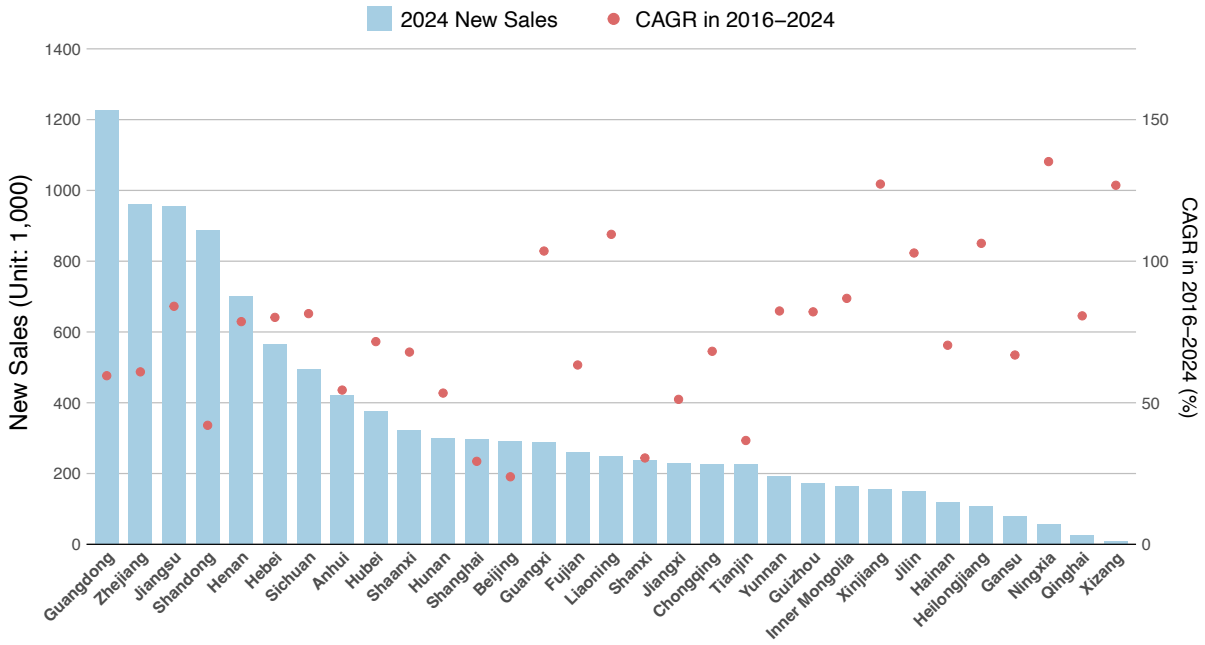

Figure 6. New Sales Trend for Provinces (Ranked by Numbers in 2024). Source: National Financial Regulatory Administration of China (non-public data).

From 2016 to 2024, most regions experienced rapid growth in annual NEV sales, with average growth rates ranging from 50% to 125%. Among the three central-administered municipalities, Shanghai, Beijing, and Tianjin had average growth rates below 40%. This relatively slower pace can be attributed to their early market entry and already high baseline sales volumes, signaling a transition toward market saturation and maturity. Similar to the trend in stock growth, western and northeastern regions, such as Xinjiang, Jilin, Heilongjiang, Ningxia, and Xizang, showed more significant growth due to their lower sales base, achieving annual growth rates exceeding 100%. Moreover, northwest provinces such as Inner Mongolia, Jilin, Ningxia, Qinghai, and Xizang have experienced annual growth rates exceeding 130% from 2021-2024 (Figure

S3), showcasing the remarkable development potential of NEVs. Inner Mongolia and Qinghai, in particular, have demonstrated exceptionally rapid growth — with growth rates rising from 30% during 2016–2020 to 145% and 130%, respectively, in 2021–2024 (Figure S3). This growth is likely driven by policy support, late market entry, and the low-base effect.

In 2020 and 2021, the Chinese government set targets for NEV penetration rates to reach 20% by 2025 and 40% by 2030 (State Council, 2020b, 2021a). However, this relatively modest 20% target was surpassed as early as 2022, when the national NEV penetration rate reached 25.6% (State Council, 2023a), demonstrating exceptional progress early in the 14th FYP period. By the end of 2023, the government further raised its ambitions, announcing a new goal of achieving a 45% penetration rate by 2027 (State Council, 2023e). This adjustment reflects strong confidence in the NEV market's growth potential and highlights its strategic significance in achieving China's "dual carbon" goals. Remarkably, by 2024, the national penetration rate soared to 46%, exceeding the 2027 goal three years ahead of schedule (Figure 7).

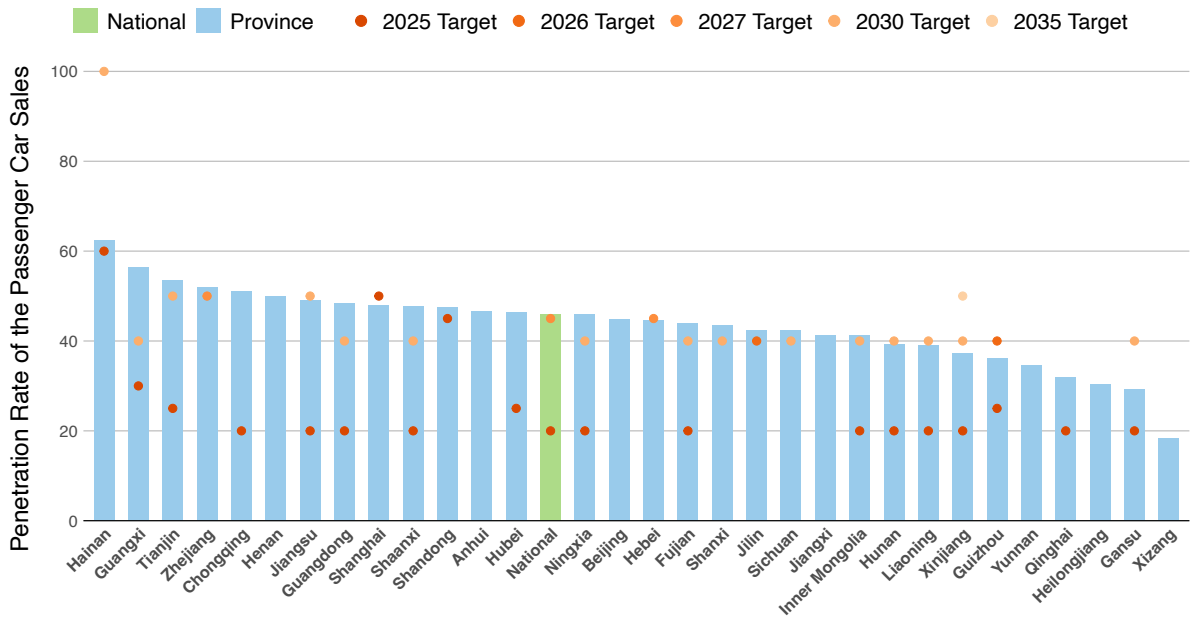

Figure 7. 2024 Provincial Penetration Rate and Near-term Target. Source: official policies, see Appendix for detailed information.

To align with national targets, many provinces adopted local targets of a 20% NEV penetration rate by 2025 and 40% by 2030 (Figure 7). Additionally, some provinces adopted even more ambitious targets exceeding the national benchmarks. Hainan, Shanghai, and Shandong stand out, setting 2025 of 60%, 50%, and 45%, respectively. Hainan's aggressive target is driven by its unique policy environment as a provincial-level NEV promotion demonstration zone and ambitious plan to phase out fossil fuel vehicles entirely by 2030 (Hainan Provincial People's Government, 2021). Additionally, Hainan proposed a NEV leasing plan in 2024 to promote the adoption of NEVs (Hainan Provincial People's Government, 2024). Provinces such as Guangxi, Tianjin, Hubei, and Guizhou have proposed slightly higher-than-national targets, but these goals appear relatively conservative, as their current penetration rates have already exceeded early expectations. Provinces like Zhejiang, Hebei, Jilin, and Guizhou have shown flexibility by adjusting their plans and introducing interim targets for 2026 or 2027 based on their current development status, while Xinjiang has set a long-term target of reaching a 50% penetration rate by 2035.

By 2024, 22 provinces had surpassed the national NEV penetration target of 40%, and 13 of them exceeded 45%. Notably, Hainan, Guangxi, Tianjin, Zhejiang, Chongqing, and Henan all achieved rates above 50%. Hainan achieved a penetration rate of 62%, exceeding its 60% target, underscoring the effectiveness of its proactive policies and establishing the province as a leading example for NEV adoption. Guangxi ranked second with a 56% penetration rate. Despite being a less-developed region in Southwest China, Guangxi has taken the lead by promoting localized micro NEVs tailored to local needs. Provinces such as Hebei, Zhejiang, and Tianjin have already exceeded their 45–50% short-term targets in 2024. Xizang remains the only province below the 20% threshold.

Overall, southern and eastern provinces led the market, with significantly higher NEV penetration rates compared to northern and western regions. Economically advanced provinces like Guangdong and Jiangsu have leveraged robust economic foundations, well-developed infrastructure, and supportive policies. In contrast, less developed provinces like Qinghai and Xinjiang face challenges such as limited charging infrastructure, lower consumer purchasing power, and delayed market entry. Nonetheless, the rapid progress across most provinces underscores the accelerating momentum and widespread regional commitment to NEV adoption.

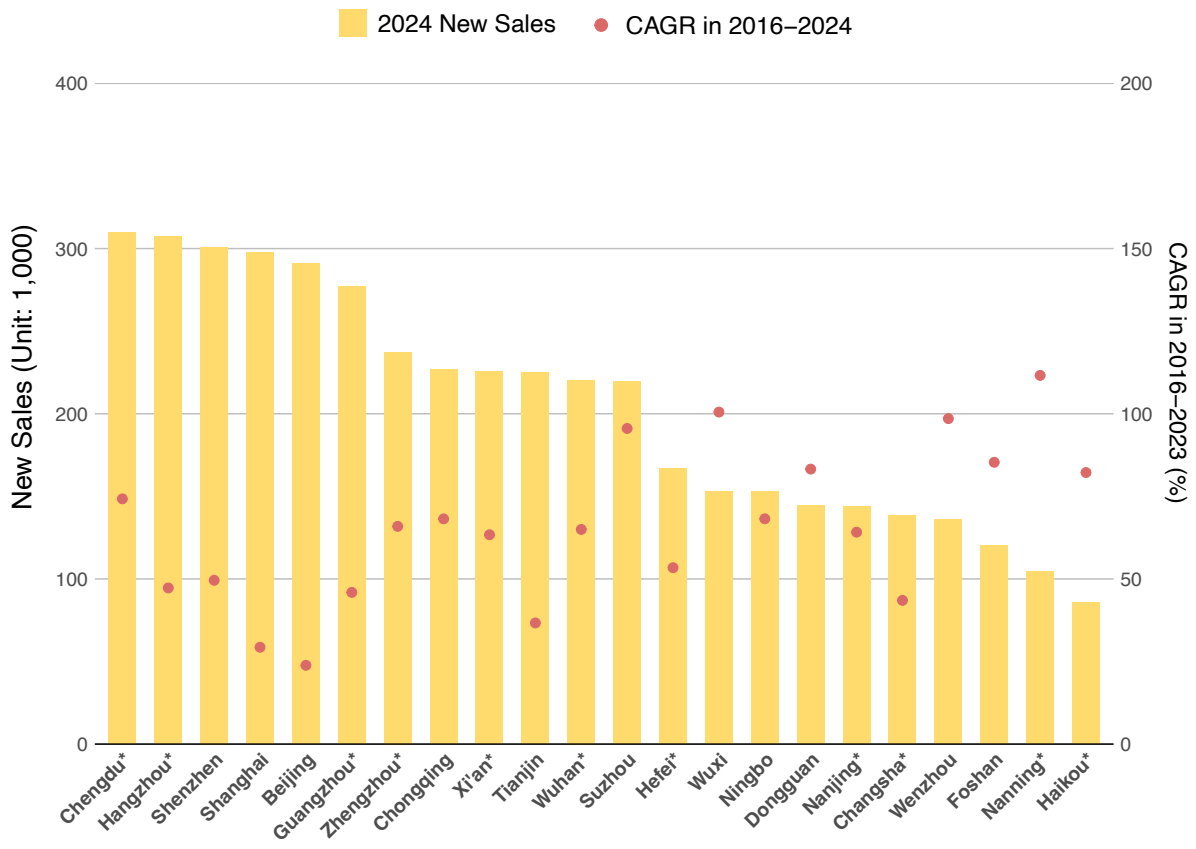

Figure 8. New Sales Trend for Top 20 Cities (Ranked by Numbers in 2024). * indicates provincial capital cities. Source: National Financial Regulatory Administration of China (non-public data).

Among the top 20 cities (Figure 8), six cities—Chengdu, Hangzhou, Shenzhen, Shanghai, Beijing, and Guangzhou—make up the top sales group, each recording NEV sales between 2.9 and 3.1 million units in 2024. Chengdu led the nation in NEV sales in 2024, reaching nearly 3.1 million units with an average annual growth rate of 74%. Hangzhou and Shenzhen also surpassed 3 million. The NEV penetration rates in these three cities stood at 47%, 59%, and 61%, respectively (Figure 9), highlighting their remarkable success in NEV adoption. Shanghai was the only city among the top 20 to record a decline in NEV sales in 2024, falling by 18% to 2.97 million units compared to 2023. This city had long led the nation in NEV sales due to its robust charging infrastructure, comprehensive industrial supply chain, and strong policy support (Shao & Mišić, 2023). In its early push for NEV adoption, Shanghai's electric vehicle license plate policy proved more effective than direct subsidies (G. Li et al., 2023), as it addressed the dual challenges of limited license plate availability and high vehicle demand. However, policy tightening in 2024 introduced stricter eligibility criteria for free NEV plates[10] in Shanghai (Shanghai Municipal People's Government, 2023), potentially contributing to the recent drop in sales.

10. Shanghai's free NEV license plate policy was adjusted from requiring 24 months of social security contributions or 12 months of personal income tax to 36 months of social security or personal income tax contributions, with eligibility limited to individuals without a registered NEV or fuel vehicle.

The mid-high sales group, comprising 6 cities, recorded NEV sales between 2.2 million and 2.4 million in 2024. This group includes major provincial capitals and centrally-administered municipalities. Notably, Suzhou, the only non-provincial capital in this group, sold 2.19 million NEVs with an impressive annual growth rate of nearly 100%. Regional policies have played a crucial role in this surge—Suzhou's government allocated ¥100 million ($14.5 million) in 2024 to subsidize vehicle trade-ins, significantly boosting local NEV adoption (Suzhou Municipal People's Government, 2024). The remaining 10 cities fall into the emerging sales group, with annual NEV sales between 0.8 million and 1.7 million units. Consistent with trends in NEV stock, cities in this group tend to exhibit higher average annual growth rates in annual sales, signaling substantial development potential.

NEV penetration rates among the top 20 cities were relatively high, ranging between 40% and 60%, with most cities already approaching or surpassing their near-term targets (Figure 9). Haikou leads with a 62% penetration rate and has set ambitious targets of 80% by 2025 and 100% by 2030, making it one of the most progressive cities in NEV adoption. Shenzhen followed closely with 61%, progressing steadily toward its 70% target for 2025.

Several high-penetration cities, including Wenzhou, Hangzhou, and Ningbo, are located in Zhejiang Province, where NEV penetration ranges between 50% and 60%. Beyond its strong economic foundation, Zhejiang's widespread investment in charging infrastructure across both urban and rural areas has significantly contributed to this success (Zhejiang Provincial People's Government, 2023). As of 2023, public charging stations covered 85.26% of townships in Zhejiang, providing accessible and affordable charging options for NEV users (Xinhua Net, 2024c).

Shanghai, Guangzhou, and Xi'an have each set a 50% penetration target for 2025. While Guangzhou and Xi'an surpassed this threshold in 2024, Shanghai reached 47%, slightly below the target. Despite the decline in NEV sales in 2024, its penetration rate remained roughly consistent with 2023. Notably, Xi'an aims for 100% NEV sales by 2030, demonstrating its long-term commitment to electrification. Tianjin has also exceeded its 50% penetration target set for 2030.

Overall, by 2024, most major cities have already met or are on track to surpass their short- and medium-term NEV penetration targets. However, with the gradual phase-out of NEV purchase tax incentives and subsidies, it remains uncertain whether these cities can sustain or further accelerate their NEV adoption in the coming years.

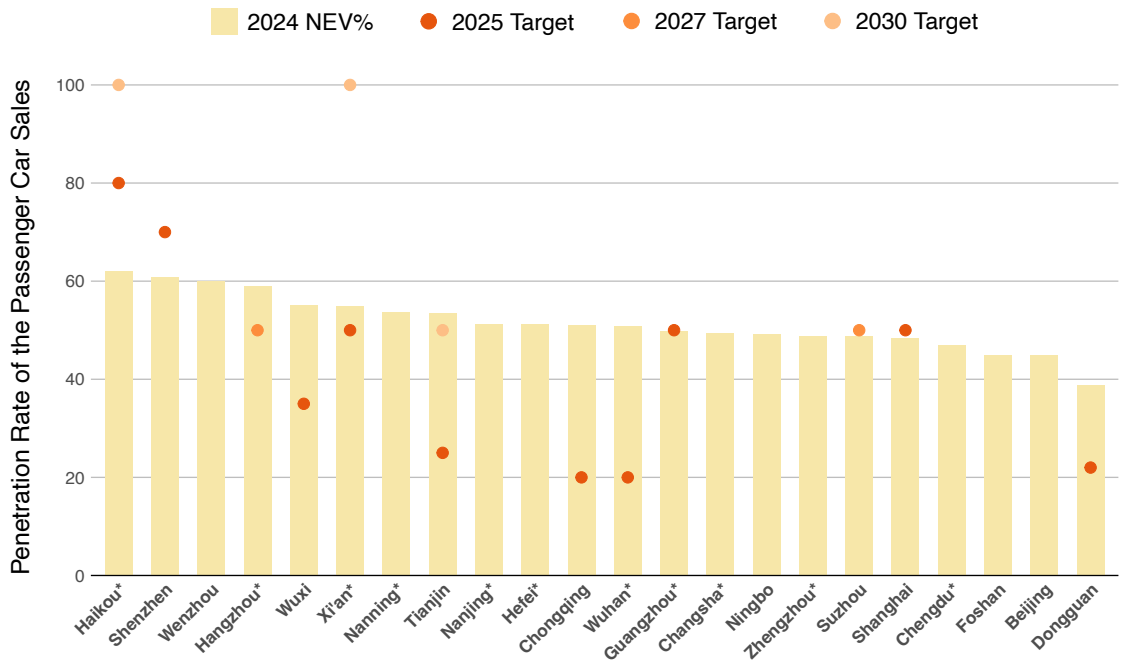

Figure 9. 2024 Top 20 Cities' Penetration Rate and Near-term Target. * indicates provincial capital cities. Source: official policies, see Appendix for detailed information.

NEV sales as a proportion of total vehicle sales have shown a downward trend in most provincial capitals (Figure10), indicating a broader diffusion of NEV adoption beyond the major cities. The most significant declines were observed in Xi'an, Chengdu, Wuhan, Changsha, Zhengzhou, Hangzhou, Shenzhen, Guangzhou and Nanjing, corresponding to rising NEV sales share in other cities within the same provinces, such as Wuxi, Ningbo, and Dongguan. Moreover, within Jiangsu Province, both Suzhou and Wuxi have surpassed the provincial capital Nanjing in terms of NEV city share. Despite this shift, provincial capitals like Haikou, Xi'an, Chengdu, and Wuhan still account for over 50% of NEV sales within their provinces, while others, including Changsha, Hefei, Nanning, Zhengzhou, and Hangzhou, maintain shares between 25% and 50%. Notably, Nanning stands out as the only provincial capital among the top 20 cities where the proportion of NEV sales continues to rise. As Guangxi's two most economically developed cities, Nanning and Liuzhou dominate the province's NEV market, accounting for 55% of sales and 58% of public charging infrastructure, while all other cities remain below 10%. Nanning has actively promoted infrastructure development through dedicated municipal financial planning, which may be challenging for other cities in the province (People's Daily, 2024). This concentration of resources limits NEV expansion to other cities, highlighting the uneven development of the NEV market within Guangxi. Guangxi ranks 19th in China's GDP as of 2024, making it a relatively less developed region (NBS, 2025). This imbalance in NEV adoption may reflect broader trends in other economically underdeveloped areas, suggesting that lower-tier cities and even rural regions hold significant potential for future NEV growth.

Overall, the growth momentum of NEVs is transitioning from traditional provincial capitals to economically dynamic second- and third-tier cities, reflecting a more balanced and diversified regional development in NEV adoption.

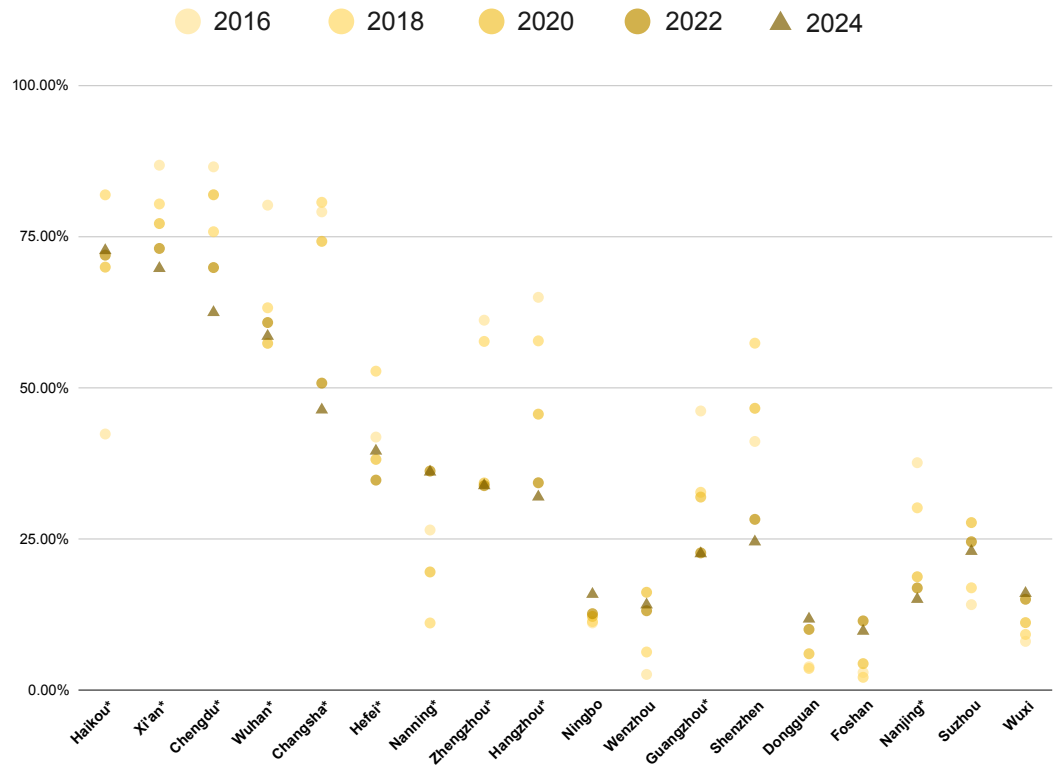

Figure 10. City Share of Provincial New Sales from 2016-2024. The four centrally administered municipalities are excluded from this figure. Cities within the same province are placed immediately after their respective provincial capitals. * indicates provincial capital cities.

3.3 Provincial NEV Production and 2025 Targets

In recent years, China's NEV industry has maintained rapid growth. In 2024, China's NEV production reaches 13 million units, ~4.5 times of the production in 2021, while the penetration rate of NEV production also rises from 14% in 2021 to 41% in 2024. The development of NEV production relies on the foundation of the traditional automobile industry as well as the rise of emerging industries, presenting significant regional characteristics and differentiated development patterns. Most provinces in China produce NEVs. As shown in Figure 11, 75% of China's NEVs are produced in provinces in Group A, with Guangdong, Shanghai, Shaanxi, Jiangsu leading production, all exceeding 1 million units. In 2024, Guangdong, ranked first, produced 3.61 million new energy vehicles, accounting for 25% of the national total. In contrast, the production in Groups B and C accounted for 20% and 5% of the national total, respectively, indicating that while regional disparities exist, NEV production in China remains relatively concentrated.

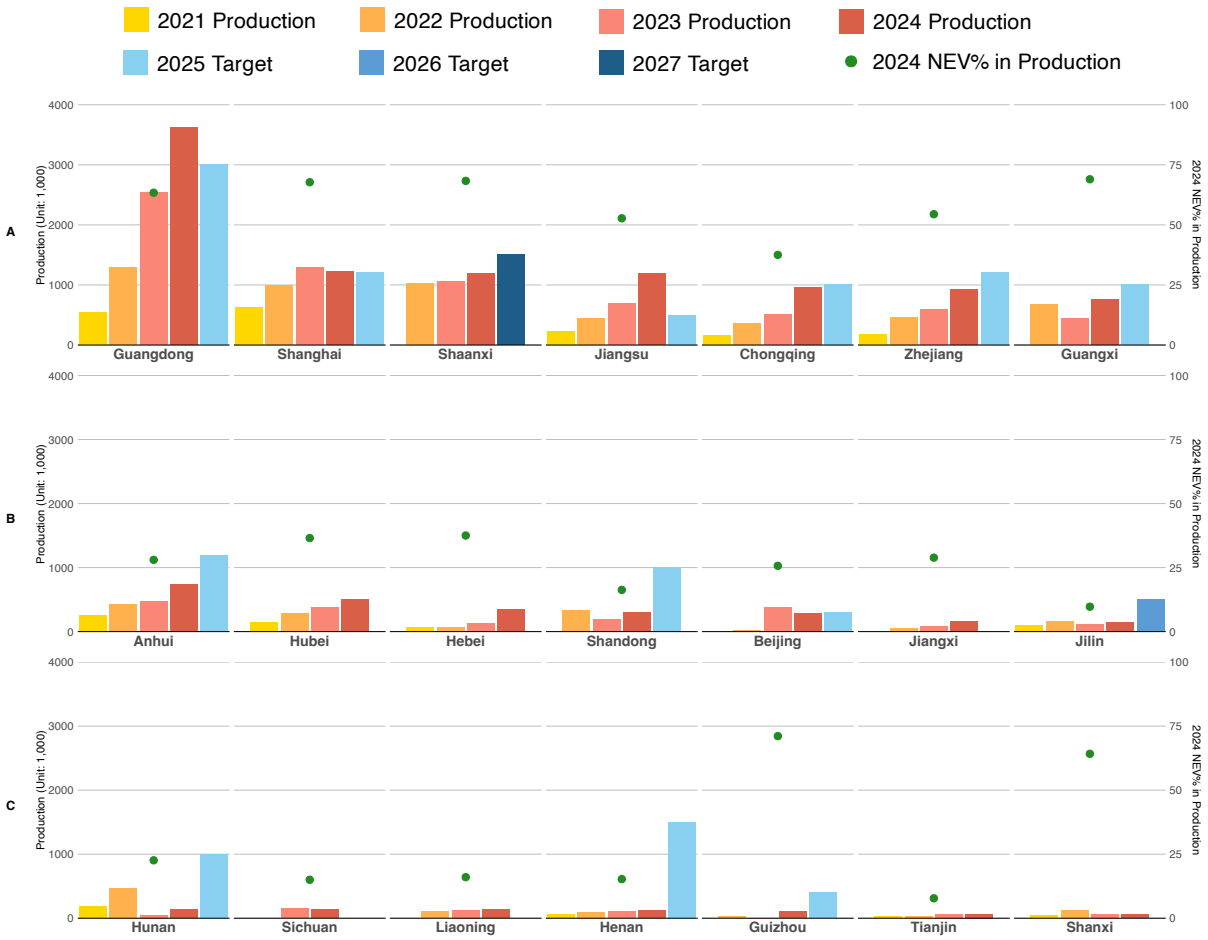

Figure 11. Comparison with Provincial Production Trend and Near-term Targets. In this figure, we list the provinces from the 1st to the 21st in terms of NEV production in 2024, which are categorized into three groups, A, B, and C, in order of production from high to low. The production data from local government/automobile offices in Anhui, Hunan, Shandong, and Beijing differ significantly from the National Bureau of Statistics (NBS) data in 2024, likely due to inconsistencies in statistical criteria for vehicle manufacturers. Here, we adopt the NBS data. Source: Provincial annual statistical bulletins; NBS.

NEV production in China demonstrates a diversified pattern of "path dependence alongside breakthrough opportunities" (Li X. et al., 2023). On the one hand, traditional automobile manufacturing hubs (such as Guangdong, Shanghai, Jiangsu, Hubei, and Chongqing) have leveraged their mature automotive industry chains to rapidly transition and expand NEV production, showcasing immense potential for growth. On the other hand, provinces with weaker traditional automotive (such as Anhui, Jiangxi, and Sichuan) foundations have achieved breakthroughs in the NEV sector through policy support and industrial upgrades. Guizhou and Shanxi, despite their late start and relatively low NEV production, have achieved a production penetration rate of over 50%. Meanwhile, Anhui has established 15 subsidiary funds to support the NEV industrial chain (People's Daily, 2025), driving the rapid growth of its NEV sector and a significant increase in production.

To achieve the "dual carbon" goals, provinces and municipalities have set NEV production targets for 2025–2027. For instance, Guangdong, Shanghai, Jiangsu and Beijing have already surpassed their 2025 targets, demonstrating their leadership in NEV production and market expansion. Shaanxi, Chongqing, Zhejiang, and Guangxi, which have relatively high NEV production, are also on track to achieve their near-term production targets. However, Henan has set an ambitious goal of producing 1.5 million NEVs by 2025. Given its output of only 123,000 units in 2024, achieving this goal poses significant challenges.

As China emerges as a global hub for NEV manufacturing, the country has formed four distinct industrial clusters driven by policies, markets, and technological advancements:

1. **Yangtze River Delta Cluster:** Covering Shanghai, Jiangsu, Zhejiang, and Anhui, this region accounted for 30% of China's total NEV production in 2024. Leveraging the well-developed industrial base of the Yangtze River Delta, Shanghai has collaborated with Jiangsu, Zhejiang, and Anhui to establish a world-class NEV industry cluster, integrating the entire supply chain from design and R&D to manufacturing (NDRC, 2024). This has resulted in a highly efficient and comprehensive local supply network (Xinhua Net, 2023): Shanghai specializes in core technologies such as chips and software, Jiangsu supplies power batteries, Zhejiang provides integrated die-casting machines, and Anhui focuses on vehicle assembly. Additionally, Anhui has strengthened a competitive edge in vehicle manufacturing and battery production through policy support and investment in a full industrial chain layout (Anhui Provincial Department of Industry and Information Technology, 2023). The region's "4-hour industrial zone" enables NEV manufacturers to source essential components within a four-hour drive, reducing transportation costs and enhancing supply chain flexibility (People's Daily, 2023a). With its strong production capacity, the Yangtze River Delta has emerged as a key driver of China's NEV exports. In 2022, the region accounted for over 70% of China's total NEV exports, with an export growth rate significantly outpacing the national average (Shanghai Automotive Parts Industry Association, 2023). The combination of a complete industrial chain, strong market demand, and export advantages has provided a powerful engine for NEV industry growth and vast opportunities for further expansion.

2 **Pearl River Delta Cluster:** In 2024, this region accounted for 27% of China's total NEV production. Leveraging Guangdong's strong automotive industry foundation and its leadership in the electronics sector, Guangzhou and Shenzhen have collaborated with surrounding cities to establish a comprehensive NEV industrial chain. This ecosystem integrates upstream raw materials, midstream component manufacturing, and downstream NEV production, with full coordination across three-electric (battery, motor, and electronic control) systems R&D and intelligent connected vehicle (ICV) technologies (Nanfang Daily, 2023; Yuan, 2022). Guangzhou and Shenzhen serve as hubs for vehicle manufacturing, intelligent driving algorithms, and software development, while Huizhou and Dongguan focus on automotive electronics (Guangdong Provincial Department of Science and Technology, 2025). Foshan and Zhongshan, meanwhile, specialize in both traditional and NEV components (Guangdong Provincial Department of Science and Technology, 2025). To further support NEV development, Guangdong has established dozens of R&D institutions and launched the Greater Bay Area NEV Industry Technology Innovation Alliance, creating a robust technology platform that spans fundamental research, applied research, and commercialization (Nanfang Daily, 2023). In 2022, Guangdong ranked first nationwide in patents related to NEVs and ICVs (DearAuto, 2023). With a strong industrial base and cutting-edge technological advancements, the province continues to drive rapid innovation and expansion in the NEV sector.

3 **Beijing-Tianjin-Hebei Cluster:** In 2024, the Beijing-Tianjin-Hebei (BTH) region produced 710,000 NEVs, accounting for 5% of the national total. Although current production remains relatively low, the region has experienced rapid growth during the 14th FYP period, with production increasing more than sevenfold from fewer than 100,000 units in 2020. A key challenge for the region's NEV industry is the low integration between vehicle manufacturers and component suppliers (Beijing Municipal Science and Technology Commission, 2025). In recent years, the whole vehicle-to-component coordination ratio in the BTH region has remained at approximately 25%, significantly lower than 90% in the Yangtze River Delta and 45% in the Greater Bay Area (Beijing Municipal Science and Technology Commission, 2025). This weak industrial linkage has hindered the development of a robust automotive supply chain. To address this issue and accelerate the growth of an intelligent connected NEV cluster, Beijing, Tianjin, and Hebei jointly launched the BTH Intelligent Connected NEV Technology Eco-Port in 2024. This initiative aims to attract automakers, key component manufacturers, and advanced technology enterprises, fostering the development of a comprehensive NEV supply chain hub that serves northern China (Beijing Municipal People's Government, 2024b). Additionally, it will establish a nationally leading center for automotive parts testing, validation, and production. By creating a "two-hour industrial cluster" for NEV manufacturing, this strategic layout is expected to enhance supply chain efficiency, strengthen industrial resilience, and drive the structural transformation of the region's automotive sector (Beijing Municipal People's Government, 2024b).

4 **Central and Western Cluster:** Focused on Sichuan, Chongqing and Shaanxi, this cluster accounted for 17% of China's total NEV production in 2024. This region specializes in power batteries, electric drive systems, and plug-in hybrid technologies (Gasgoo, 2024). Chongqing boasts a well-developed auto parts supply system, with leading capabilities in NEV intelligence and electrification (Xinhua Net, 2024b). Sichuan benefits from abundant lithium resources and a fully integrated power battery industry, contributing approximately 20% of the country's total battery production (Sichuan Economy, 2024). However, the vehicle-to-component coordination ratio remains relatively low in both Chongqing and Sichuan, standing at around 40% (Gasgoo, 2024). Shaanxi, on the other hand, has a more mature supply chain for commercial vehicle components, with a coordination ratio of approximately 60% (Gasgoo, 2024). The province leads in the development of pure electric heavy-duty trucks and hydrogen fuel cell trucks (Shaanxi Supply Chain Collaboration Information Service Platform, 2023). By leveraging their complementary strengths, these three regions are working together to advance the high-quality development of the NEV industry in western China, strengthening regional industrial integration.

In addition to these features, each cluster demonstrates unique strengths in promoting innovation and competitiveness within the NEV industry. Together, they form a robust network that aligns with China's strategic objectives of reducing carbon emissions, advancing technological leadership, and strengthening global market influence in the NEV sector.

Policy serves as a guiding force for the development of the NEV industry, while annual government work reports offer more concrete directions for implementation. In the 2025 central government work report, the call to vigorously develop intelligent and connected NEVs (ICNEVs) marks a clear policy shift toward integrating the automotive sector with cutting-edge technologies such as artificial intelligence and big data (State Council, 2025b). ICNEVs represent the future direction of high-quality development in the automotive industry and are seen as key drivers of digital transformation in manufacturing and the cultivation of future-oriented industries.

Provinces have formulated stage-specific NEV development priorities based on their resource endowments and development trajectories, aiming to strengthen their roles in the NEV value chain. Of the 31 provincial government work reports, 29 included NEV-related content, with 15 explicitly mentioning NEV industry development (Figure 12). For instance, Anhui and Chongqing are building world-class NEV clusters (Anhui Provincial People's Government, 2025; Chongqing Municipal People's Government, 2022); Beijing and Henan are strengthening the synergy between vehicle assembly and the "three-electric" components (battery, motor, and electronic control) (Beijing Municipal People's Government, 2024a; Henan Provincial Development and Reform Commission, 2024); Beijing-Tianjin-Hebei and the Chengdu-Chongqing region are promoting regional resource integration through initiatives

like the "electric and hydrogen corridor" and Eco-Port (Beijing Municipal People's Government, 2025; Sichuan Provincial Information Network, 2025); Shanxi leverages its abundant methane resources to develop methanol-fueled vehicles (Shanxi Provincial People's Government, 2025). Innovation efforts are concentrated on intelligent connected technologies (such as vehicle-road-cloud pilot integration[11]), breakthroughs in key technologies (e.g., power batteries and intelligent driving), and commercialization of hydrogen energy (e.g., fuel cell heavy trucks) (Guangdong Provincial Department of Finance, 2025; MIIT, 2024; Sichuan Provincial People's Government, 2024). Most provinces have introduced policies to stimulate rural NEV adoption and encourage scrappage replacement schemes. Provinces like Guangdong and Shanghai are reinforcing their global production capabilities, while Shandong and Shaanxi are leveraging logistics platforms like the China-Europe Railway Express and Central Asia corridors to expand into overseas markets (People's Daily, 2023b; Shandong Provincial People's Government, 2024). Overall, China's NEV industry is evolving from large-scale expansion toward building an intelligent and green industrial ecosystem.

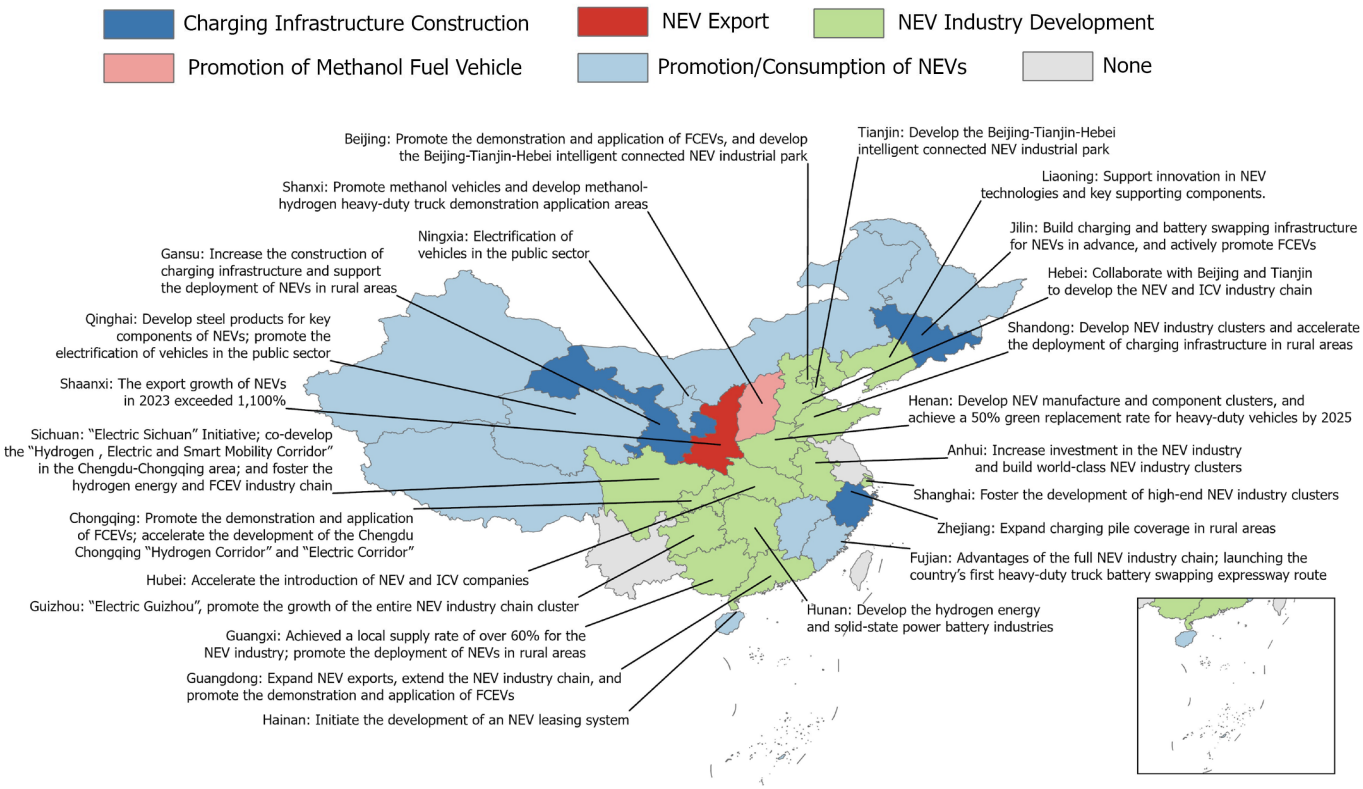

Figure 12. Provincial Strategies for NEV Development in China (2024-2025). The information and strategies are collected from the annual governmental report of provinces for 2024 and 2025. Source: official governmental reports, see Appendix for detailed information.

11. Refers to the integration of people, vehicles, roads, and cloud computing using advanced information and communication technologies, enabling coordinated sensing, decision-making, and control for safer, more efficient, and intelligent transportation systems.

4. Provincial and City-Level NEV Landscape 2025: A Unified Analysis of Charging Infrastructure

China has made significant breakthroughs in the development and application of NEVs over the past decade, with charging infrastructure playing a vital supporting role. Numerous studies have confirmed the positive relationship between charging infrastructure development and the diffusion of NEVs (G. Li et al., 2022; Ou et al., 2020; Sierzchula et al., 2014). Subsidy strategies for infrastructure development can positively impact EV promotion by stimulating the construction of charging infrastructure, whereas inadequate infrastructure development can severely hinder the growth of the EV industry (Qiu et al., 2019; X. Zhang et al., 2017). Currently, range anxiety, caused by battery capacity and charging time, remains one of the key obstacles to NEV adoption (Chakraborty et al., 2022). In 2023, the State Council issued the "Guiding Opinions on Further Building a High-Quality Charging Infrastructure System," proposing that by 2030, a high-quality charging infrastructure system will be largely established, providing strong support for the development of the NEV industry and effectively meeting the public's charging needs (State Council, 2023b).

The charging industry in China is undergoing sustained development and expansion, with the continuous growth of the scale of charging infrastructure. In recent years, China has built the world's largest, most wide-ranging, and most comprehensive charging infrastructure system (State Council, 2023b). From 2015 to 2024 (Figure 13), the number of nationwide charging piles, stations and battery swapping stations all exhibited an upward trend, with a big jump in growth since 2021. Specifically, the quantity of charging piles has experienced a rapid increase. By 2024, the total number of charging infrastructure units in China reached 12.8 million, including 3.6 million public charging piles and 9.2 million private charging piles (EVCIPA, 2025). Compared to 2021, the number of charging infrastructure units has increased by approximately four times. At the beginning, the number of public and private charging piles was nearly equal. However, since 2021, the number of private charging piles has grown at an annual rate of 45%, far outpacing the growth of public charging piles. According to statistics, in recent years, the vehicle-to-pile ratio for private NEVs in China has been approximately 40% (EV 100 Plus, 2004). The number of charging stations has increased in parallel with the growth of charging piles, reaching 230 thousand by 2024. In contrast, while the number of battery swapping stations remains small, it is growing rapidly. To address charging anxiety and promote NEVs, China has introduced a series of policies encouraging the adoption of battery swapping models: the pilot program for battery swapping applications officially launched in 2021 (Xinhua Net, 2021); in 2023, the "Notice on Measures to Restore and Expand Consumption" emphasized accelerating the promotion of the battery swapping model (State Council, 2023c). Currently,

battery swapping stations can be classified into three types: heavy-duty electric commercial vehicle swapping stations, centralized battery swapping stations for electric taxis, and battery swapping stations for private electric passenger vehicles (McKinsey Greater China, 2022). By 2024, the number of battery swapping stations in China had reached 4,400 (EVCIPA, 2025).

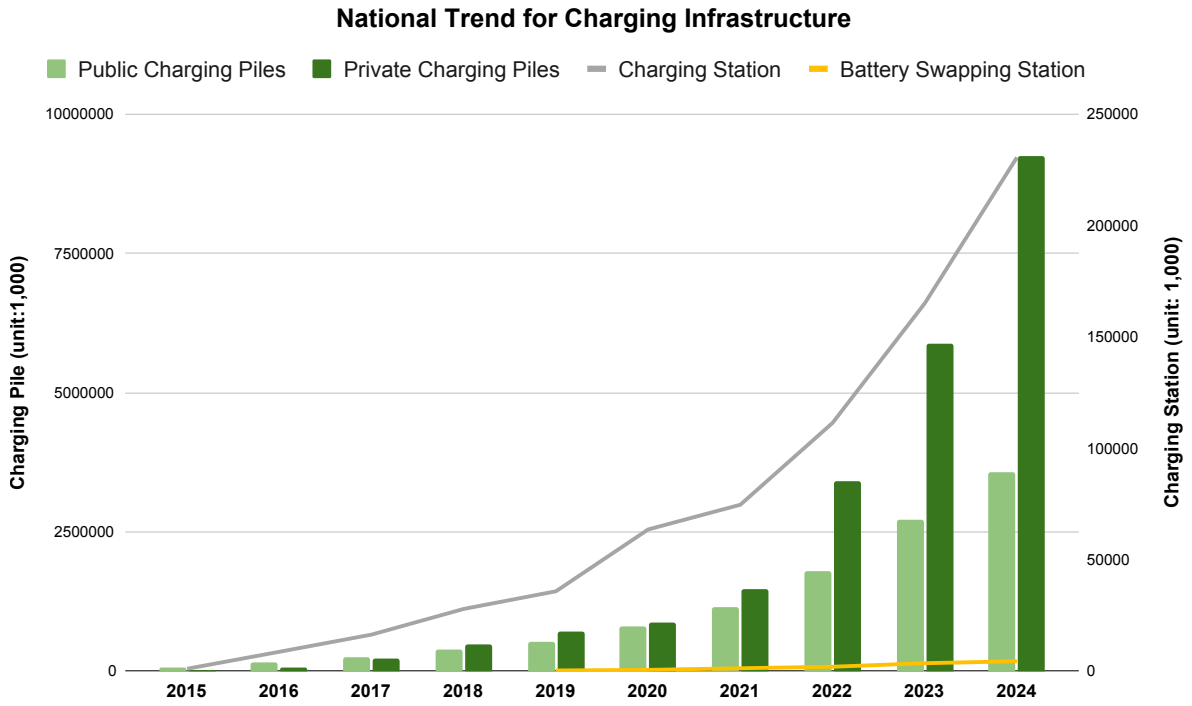

Figure 13. National Trend of Charging Infrastructure. Source: China Electric Vehicle Charging Infrastructure Promotion Alliance.

Due to availability and accessibility, public charging infrastructure is key to promoting the adoption of NEVs (Pardo-Bosch et al., 2021; Schulz & Rode, 2022). In China, public charging stations, especially DC fast chargers, have become a substitute for the missing private charging piles (Funke et al., 2019). Currently, public charging stations in China are geographically concentrated (Figure 14), with the highest number of charging stations in the eastern coastal regions, such as Guangdong, Zhejiang, Jiangsu, Shanghai and Shandong. In 2024, Guangdong, Zhejiang, Jiangsu, and Shanghai accounted for 40% of the national total of public charging stations, with Guangdong leading at 18% (6.67 million) of the total, ranking first nationwide. These regions represent the most mature areas for EV adoption in China, with higher charging station density. Provinces such as Shandong, Anhui, Henan, Hubei, Sichuan, and Beijing also

have significant numbers of public charging stations, with the top 10 provinces contributing to 69% of the total public charging stations. In contrast, the western regions have relatively fewer charging stations, with provinces like Qinghai, Ningxia, Xizang, Gansu, Inner Mongolia, and Xinjiang having a total of 100,000 public charging piles by 2024.

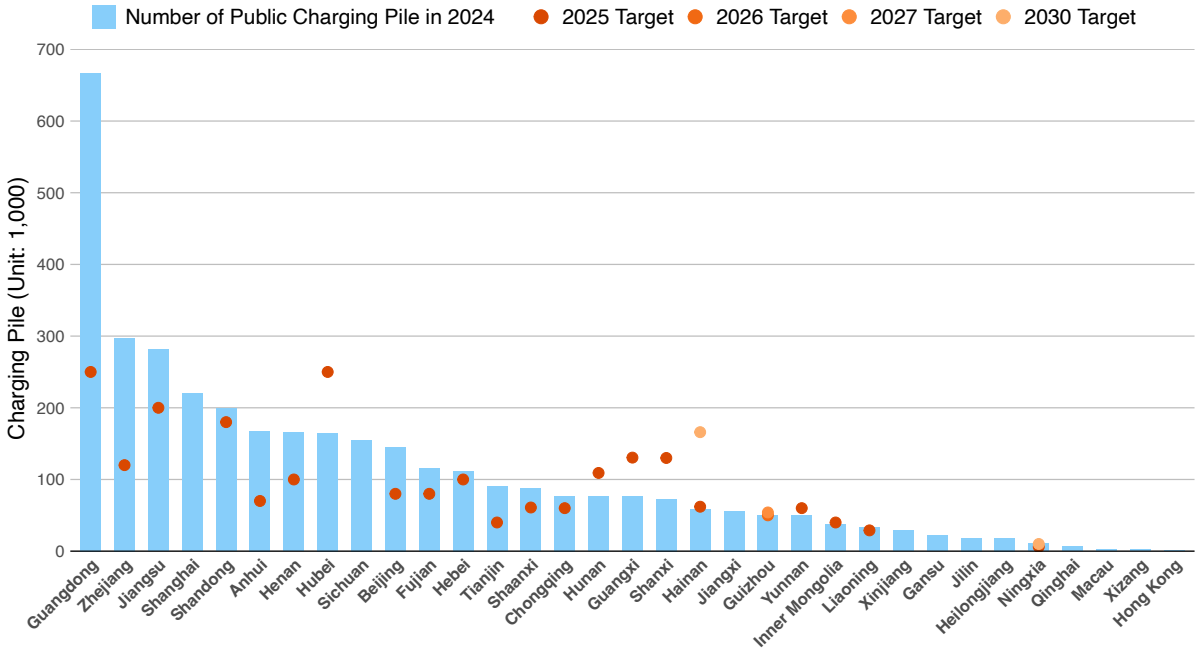

Figure 14. 2024 Provincial Public Charging Piles and Near-Term Targets. Source: China Electric Vehicle Charging Infrastructure Promotion Alliance; official policy documents, see Appendix for detailed information.

During the 14th FYP period, approximately 21 provinces have set targets for public charging infrastructure by 2025. Guangdong and Hubei have set the most ambitious targets, aiming to reach 250,000 public charging points by 2025. Zhejiang, Jiangsu, Shandong, Guangxi, Hunan, and Shanxi have set targets ranging from 100,000 to 200,000, while 9 other provinces have set targets between 50,000 and 100,000. Only 4 provinces have set targets lower than 50,000. Currently, provinces such as Guangdong, Zhejiang, Jiangsu, Shandong, Anhui, Henan, and Beijing have already met their 2025 public charging point targets. Hubei, Hunan, Guangxi, and Yunnan, however, are still some distance away from their 2025 goals. Guizhou, Hainan, and Ningxia have set medium- and long-term targets for 2026-2030, with Guizhou and Ningxia being relatively close to their targets.

From the perspective of the coordinated development of NEVs and charging infrastructure, there is still a significant gap in the number of public charging piles in China (Green Peace, 2024). In 2024, China's NEV-to-public-pile ratio was 8.8:1, meaning there were roughly 9 vehicles for every public charging pile. When we look at the provincial level, there are significant differences in the NEV-to-public-pile ratio across provinces (Figure 15), mainly influenced by factors such as economic development, policy support, geographic and climatic conditions, and industrial structure. Regions with lower NEV-to-public-pile ratios are mainly concentrated in the southeastern coastal and central areas, including Hubei, Guangdong, Anhui, Fujian, and Hainan where the ratio is below 7:1. These areas benefit from strong economic development, robust policy support, mild climates, and well-established NEV industry chains, leading to relatively lower ratios. The province with the lowest ratio is Xizang, with a ratio of 6:1. This may be attributed to Xizang's vast and sparsely populated territory, which results in a relatively low NEV stock, while the local government has actively promoted the construction of charging infrastructure (The People's Government of Xizang Autonomous Region, 2024). Guangdong, which ranks first in NEV stock and charging pile numbers, has a NEV-to-public-pile ratio of 6.3:1. In contrast, the northern regions exhibit a more polarized distribution, with the northwest having a relatively low ratio and the northeast having a relatively high ratio. Jilin and Liaoning, for example, have ratios of 17.4:1 and 15.7:1, respectively, ranking among the highest. The relatively low adoption of NEVs, cold winters, and weak foundations for the NEV industry in the north contribute to fewer NEVs compared to the south. However, the high ratio in the northeast reflects insufficient policy support and implementation of public charging infrastructure. In 2024, the three northeastern provinces of Jilin, Liaoning, and Heilongjiang accounted for less than 5% of China's total NEV sales, significantly constraining the development of public charging infrastructure. In the southwest, only Guangxi has a relatively high ratio, reaching 12:1. In recent years, Guangxi's NEV sales have been increasing at a rate of 100% per year, making it an important hub for the national NEV industry (China News, 2025). However, the construction of public charging infrastructure in Guangxi has not kept pace with the rapid growth in NEV sales, resulting in a lag in charging point development despite the growing number of NEVs.

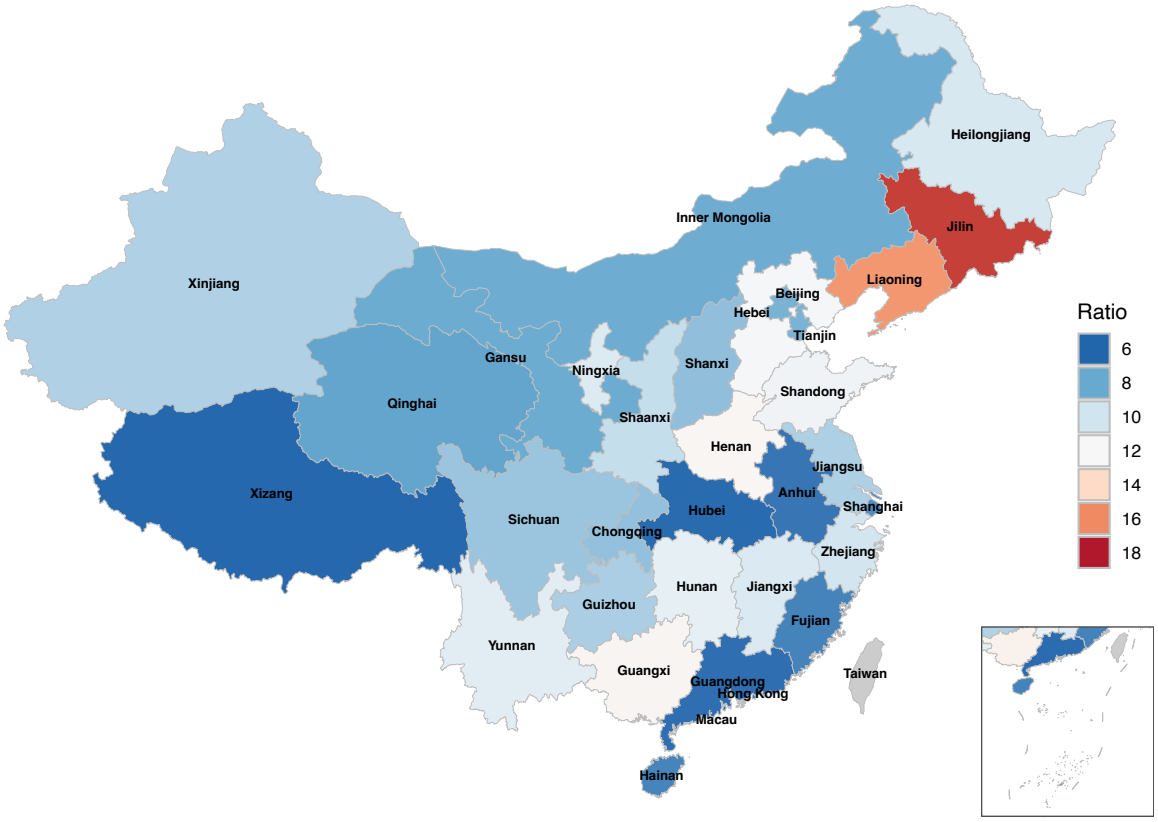

Figure 15. Provincial Ratio of NEV-to-Public-Pile in 2024. The figure is calculated based on each province's NEV stock and the number of public charging piles in 2024. Source: China Electric Vehicle Charging Infrastructure Promotion Alliance; Ministry of Public Security.

The regional distribution of public charging infrastructure at the city level remains highly uneven, with a heavy concentration in a few economically developed cities. In 2023, the top 20 cities accounted for 54% of the country's total public charging infrastructure, with the four first-tier cities—Beijing, Shanghai, Guangzhou, and Shenzhen—contributing 22%. These cities each had over 100,000 public charging piles (Figure 16), leading the country in scale. They also maintain relatively low NEV-to-pile ratios, ranging from 5.3 to 7.5, achieving dense coverage in major business districts, transportation hubs, and residential areas. For example, Shanghai has alleviated some of the pressure from older neighborhoods with insufficient infrastructure by expanding the "five-minute charging circle" and promoting community-shared charging piles (Huangpu District People's Government, 2022; Shanghai Municipal People's Government, 2024). Similarly, Shenzhen is advancing a "1-kilometer ultra-fast charging zone" to enhance charging efficiency (Shenzhen Municipal People's Government, 2024a). By 2024, the number of ultra-fast charging stations in the city has surpassed that of traditional gas stations (Shenzhen Municipal People's Government, 2024a).

Several second-tier cities, including Wuhan, Tianjin, Hangzhou, and Chengdu, have also made strong progress, each surpassing 70,000 public charging piles. Wuhan has the lowest NEV-to-public-pile ratio among the top 20 cities (4.5:1). However, the high proportion of slow chargers limits overall efficiency, prompting the city to accelerate the deployment of ultra-fast charging stations (Wuhan Municipal People's Government, 2024). Hangzhou, with a relatively high ratio of 9.6:1, is expanding rural charging infrastructure as a key strategy to reduce range anxiety and boost NEV adoption (Hangzhou Municipal People's Government, 2024). The remaining cities each have between 20,000 and 50,000 public charging piles, but generally face higher NEV-to-public-pile ratios. Around 75% of the cities have set short-term targets for public charging infrastructure, such as Guangzhou, Beijing, Chengdu and Nanjing. While most are on track to meet or exceed their goals, cities such as Guangzhou, Nanjing, and Changsha have adopted more ambitious targets that will require continued policy and investment support.

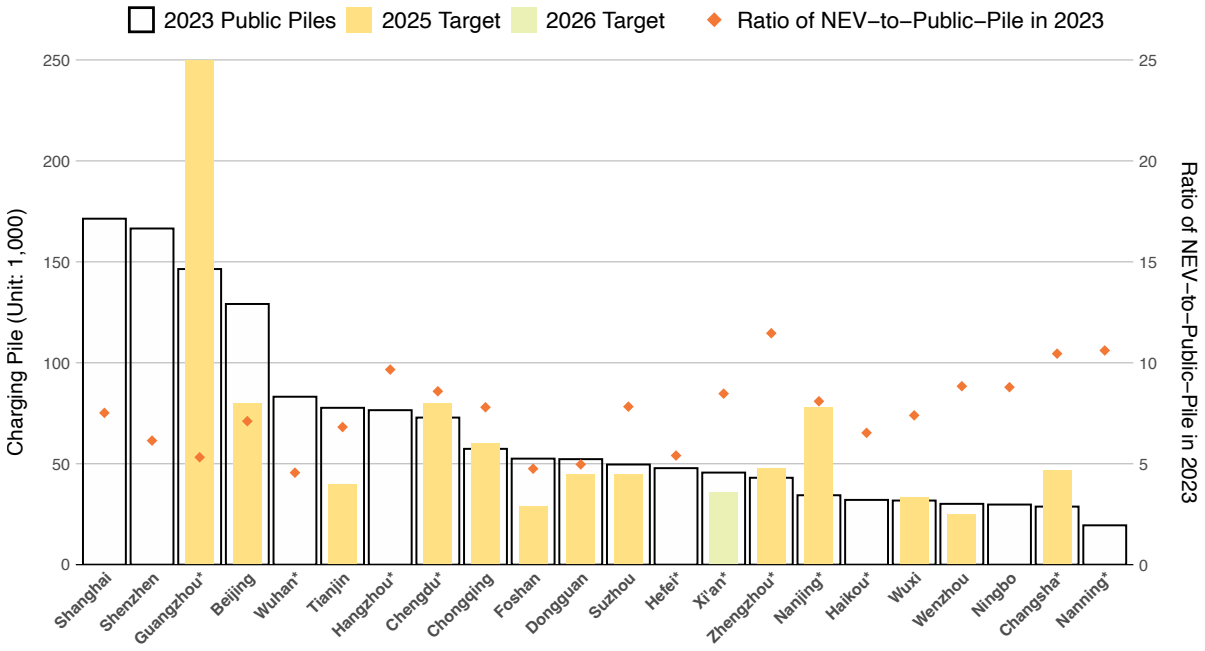

Figure 16. Top 20 Cities Public Charging Piles in 2023 and Near-Term Targets. Source: China Electric Vehicle Charging Infrastructure Promotion Alliance.

Figure 17 shows that cities within the same province tend to have similar NEV-to-public-pile ratios, underscoring that the development of public charging infrastructure is driven by province-level strategic planning. The layout and construction of public charging piles are often constrained by provincial energy plans, fiscal subsidies, and the development of supporting power grid infrastructure. Within the same province, municipal governments typically follow a unified set of provincial subsidy standards, charging-station layout plans, and power grid construction schedules. This high degree of policy coordination results in only

limited variation in NEV-to-public-pile ratios across cities. As one of the provinces with the most balanced development of the NEV-to-public-pile ratios, Guangdong provides annual subsidies for charging infrastructure during the 14th FYP period based on each city's number of public charging piles and total rated power. In 2023, the province allocated ¥278 million ($40 million) in subsidies to 20 cities (excluding Shenzhen), with both Guangzhou and Foshan each receiving more than ¥40 million ($5.8 million) (Energy Bureau of Guangdong Province, 2024). Although public charging piles are concentrated in the top 20 cities—particularly provincial capitals—these cities do not necessarily have lower NEV-to-public-pile ratios than other cities in the same province, such as Zhengzhou, Hangzhou, Changsha, and Nanning.

Although the maps reveal differences in public charging infrastructure across regions and provinces, the more pronounced disparities and imbalances are actually between urban and rural areas (Auto Review, 2024; China Energy News, 2024b; Economic Information Daily, 2025). Charging infrastructure is mainly concentrated in urban centers of economically developed provinces along the eastern coast and along major highways, where the NEV-to-public-pile ratios are generally lower. In contrast, cities with the highest NEV-to-public-pile ratios are mostly located in less developed regions such as Jilin, Liaoning, Henan, Guangxi, and Xinjiang, with many located in rural areas. As of March 2025, public charging facilities in counties and below accounted for only 15% of the national total (China National Radio, 2025).

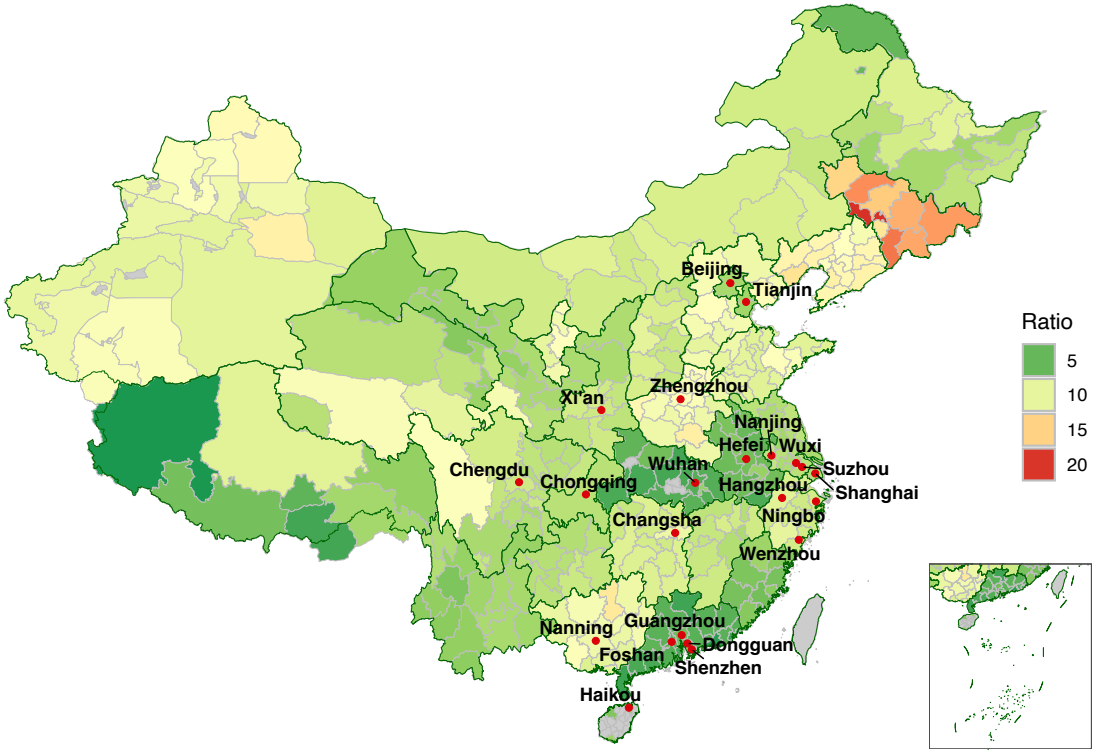

Figure 17. City-level Ratio of NEV-to-Public-Pile in 2023. The figure is calculated based on each city's NEV stock and the number of public charging piles in 2024. Note: Due to data limitations, the map only includes city-level data, and data of provincial municipalities/counties are missing. Source: China Electric Vehicle Charging Infrastructure Promotion Alliance; Ministry of Public Security.

Despite policy efforts at both the central and local levels to promote rural charging infrastructure, challenges remain in land use, electricity access, and operations. Rural land is often collectively owned, requiring policy support to allow its use for charging infrastructure (China Power, 2023). Additionally, rural grids are often weak and cannot support the high-capacity requirements of fast chargers (China Business Journal, 2024). NEVs are also relatively scarce and dispersed in rural areas, resulting in average utilization rates below 5%, which discourages private investment (China Business Journal, 2024). Currently, the development and operation of charging infrastructure in rural areas is primarily led by major state-owned enterprises (SOEs) such as State Grid, city-level investment platforms, and local private companies (China Business Journal, 2024). In 2024, NEV ownership among the rural household population represented just 37.8% of the national total (China National Radio, 2025), and inadequate charging accessibility has become the primary factor deterring rural consumers from purchasing NEVs.

In urban areas, infrastructure imbalance is mainly between central and suburban districts. For instance, in Chongqing, 64.4% of charging stations and 87% of battery swap stations are located in central districts (Chongqing Municipal Development and Reform Commission, 2022). Similarly, 69% of Zhengzhou's public charging facilities are concentrated in the urban core (Zhengzhou Municipal People's Government, 2024b). This uneven distribution increases charging wait times and limits the effective travel range of NEVs.

5. Next Phase in the Development of NEVs: The Emergence and Potential of Hydrogen Fuel Cell Vehicles

The decarbonization of the transportation sector plays a crucial role in China's progress toward its dual carbon goals, and achieving a zero-carbon transition for heavy-duty trucks is essential for carbon neutrality. In China, heavy-duty trucks refer to freight vehicles with a gross weight exceeding 15 tons, most of which are currently powered by diesel engines (Sinolink Securities, 2023). These vehicles are major contributors to greenhouse gas emissions and air pollution. As of now, China has nearly 9 million heavy-duty trucks (T. Li et al., 2024), and in 2020, their carbon emissions accounted for 21% of the total emissions from the national transportation sector (Rong, 2024), making them a key target for emission reduction. By 2050, carbon emissions from heavy-duty trucks are projected to increase by 80% compared to 2023, reaching a staggering 660 million tons (T. Li et al., 2024).

Battery-electric heavy-duty trucks (BETs) and hydrogen fuel cell heavy-duty trucks represent the two main technological pathways for decarbonizing freight transportation. While BETs have reached initial technological maturity, challenges such as high battery degradation due to heavy loads, limited range, and high charging infrastructure costs constrain their application. As a result, they are more suitable for short-distance, fixed-route operations such as closed-site transport and short island routes (Hao et al., 2019; T. Li et al., 2024; F. Liu et al., 2018). FCEVs, which convert hydrogen into electricity through fuel cells, offer advantages such as zero emissions, longer range, and fast refueling (Yan et al., 2024). With higher energy density than lithium-ion batteries, fuel cells can help overcome range limitations in electric trucks while improving transport efficiency. However, the limited scale of hydrogen fuel cell production, along with high vehicle and infrastructure costs, poses challenges to FCEV adoption (Zheng et al., 2020). As of 2020, China had only 7,355 FCEVs (International Energy, 2021). To accelerate FCEV adoption and drive technological advancements, China launched demonstration city clusters in 2020, with a focus on medium- to long-distance and heavy-duty commercial vehicles (Ministry of Finance, 2020). This was followed in 2022 by the *Medium- and Long-Term Plan for Hydrogen Industry Development (2021-2035)*, which set a target of 50,000 FCEVs by 2025 (NDRC, 2022b). By 2024, 16 provinces and municipalities had announced short-term FCEV deployment targets.

With strong policy support, China's FCEV industry experienced significant growth between 2019 and 2024 in both production and sales, forming a preliminary industrial ecosystem (Figure 18). In 2024 alone, annual FCEV sales reached 5,405 units, with hydrogen fuel cell heavy-duty trucks accounting for 82% of total sales and 5.4% of the new energy heavy-duty truck market (Sina Finance, 2025). Over the period from 2015 and 2024, cumulative FCEV production and sales reached 24,042 and 23,501 units, respectively (Century New Energy Network, 2025).

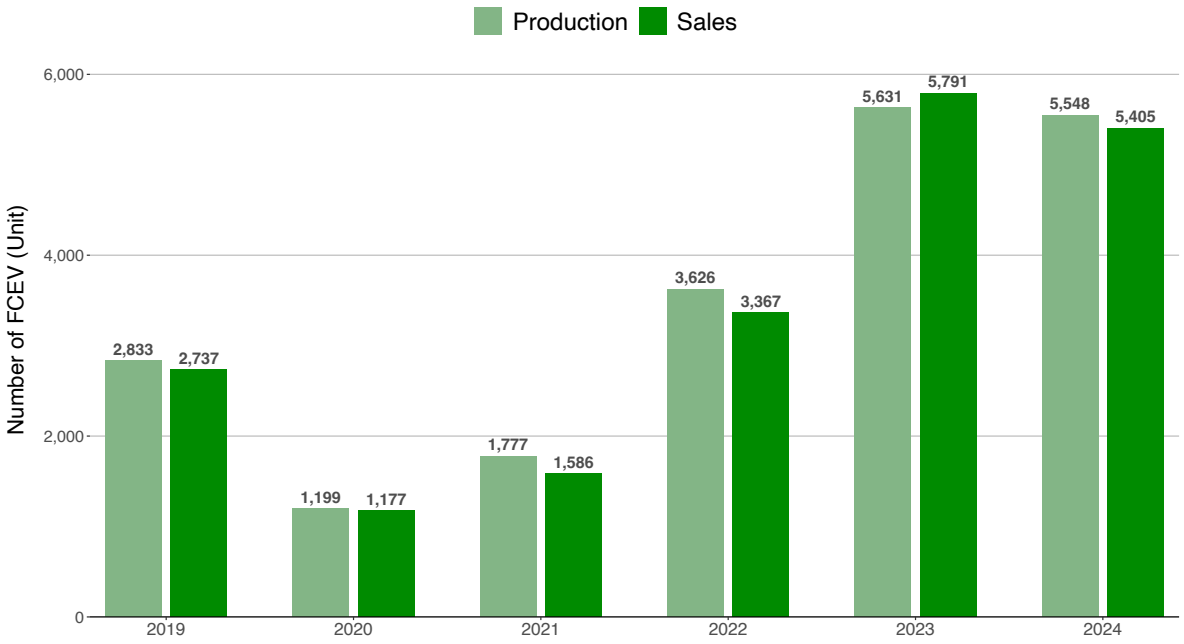

Figure 18. Annual Production and Sales for FCEV in 2019-2024 in China. Source: China Association of Automobile Manufacturers.

In 2021, the central government approved five city clusters—Beijing-Tianjin-Hebei, Shanghai, Guangdong, Hebei, and Henan— to launch FCEV demonstration programs involving a total of 41 cities (Zhou et al., 2022). The four-year demonstration period includes specific FCEV adoption targets (Figure 19). During this period, funding allocation from the central government is determined based on a points-based evaluation system, with each city cluster eligible to receive up to ¥1.87 billion ($271 million), designated for supporting FCEV industry development (Zhou et al., 2022).

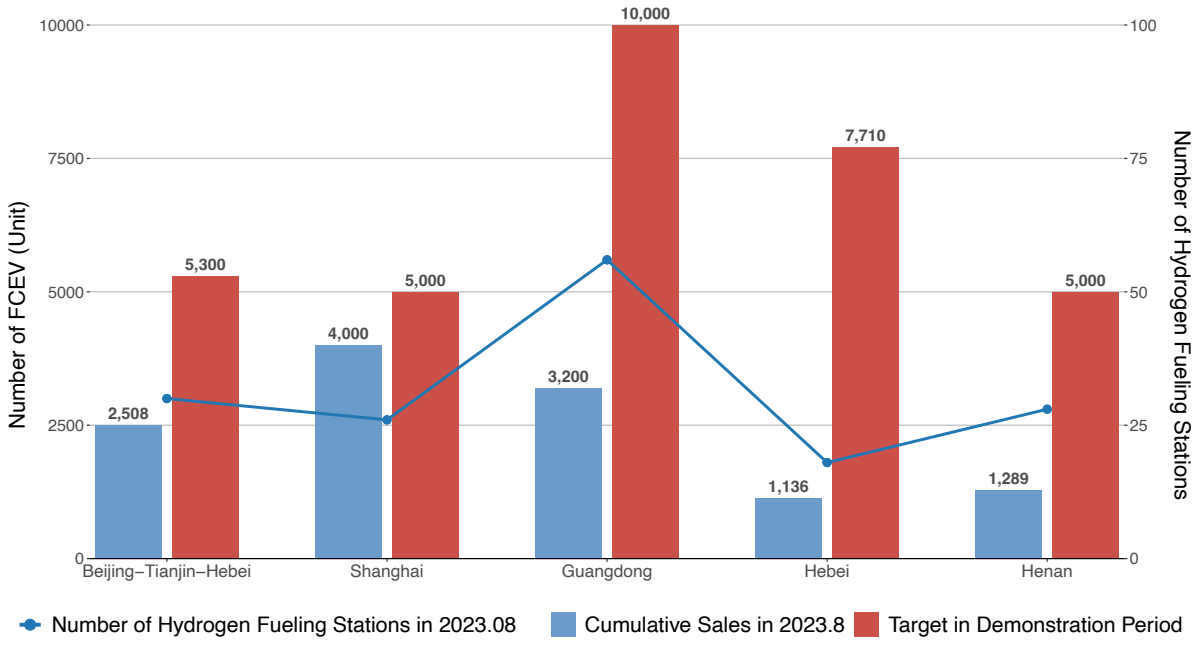

Figure 19. Target and Sales for FCEV and Number of Hydrogen Fueling Station (HFS) in Demonstration Period. Source: China Auto M.S., 2023; Hydrogen Discovery, 2023.

Production and sales of FCEVs have become increasingly concentrated in these demonstration clusters. By August 2023, the five clusters had achieved 47%, 80%, 32%, 15%, and 26% of their respective FCEV deployment targets (Figure 19). The Shanghai cluster led with the promotion of 4,000 vehicles, while Guangdong built the highest number of hydrogen refueling stations. However, hydrogen prices in Guangdong remain the highest among the five regions (Table 3), largely due to a mismatch between hydrogen production and consumption sites that drives up storage and transportation costs (T. Li et al., 2024). Additionally, the province also relies heavily on externally sourced hydrogen, further contributing to higher prices (Souhu Auto, 2024).

Each city cluster has introduced various policies to accelerate FCEV deployment and expand refueling infrastructure (Table 3), while also exploring application scenarios suited to local conditions. For example, the Beijing-Tianjin-Hebei cluster focuses on commercial vehicle applications across 9 distinct use cases; the Shanghai cluster is developing a model centered on medium- to long-distance and medium- to heavy-duty FCEVs; and the Henan cluster leverages abundant local hydrogen resources to promote integrated development of hydrogen production, vehicle deployment, and aftermarket services (21st Century Business Herald, 2023).

Table 3. Current Status and Incentive Policies of FCEV in the 5 Major Demonstration City Clusters.

Region	Number of Hydrogen Fueling Station	Hydrogen Price (¥/kg)	FCEV Operation Scenes	Incentive Policies (Partial)
Beijing-Tianjin-Hebei	30	30-40	Winter Olympics demonstration; cross-regional hydrogen corridors; exploring 9 scenarios such as chartered transport and construction waste logistics, promoting the adoption of 20 vehicle models	Beijing: Matches national incentives (1:1) for FCEV adoption and key component innovation; provides subsidies for FCEV operation and HFS construction/operation
				Tianjin: Matches national subsidies (1:1) for FCEV purchases; offers up to ¥5 million ($0.73 million) in one-time subsidies for HFS construction
Shanghai	26	40-60	Expanding ride-hailing operations; exploring applications in heavy-duty transport, logistics, public transit, municipal sanitation, construction waste removal, and rental services	Provides incentives based on national subsidies for FCEV demonstration and operation, key component industrialization, and HFS construction/operation
Guangdong	56	50-60	Demonstrating applications for construction waste trucks, fuel cell taxis, cross-regional logistics transport, and port operations	Increases R&D support, offering incentives for key component development and industrialization based on national subsidies; provides direct subsidies for HFS construction
Hebei	18	<35	Exploring fuel cell bus operations in cold northern regions; demonstration in the Zhangjiakou Winter Olympics zone	Tangshan: Provides incentives and subsidies for FCEV adoption, HFS construction, and new energy technology introduction
				Zhangjiakou: Subsidizes HFS construction and operation; matches national subsidies (1:1) for FCEV demonstration and key components; allocates ¥10 million ($1.45 million) for an FCEV regulatory platform
Henan	28	35	Intercity heavy-duty logistics transportation	Jiaozuo: Offers subsidies for FCEV adoption and operation, incentives for HFS construction, and compensation for replacing traditional fuel (gas) dump trucks with FCEV dump trucks
				Kaifeng: Provides financial support for FCEV development

Source: Hydrogen Discovery, 2023; official policies from the city government, see Appendix for details.

Supported by these demonstration programs, China's FCEV industry has made rapid progress. Key technological indicators, such as rated power, system power density, stack power density, and driving range, have all seen significant improvements (China Automotive News, 2024a). By 2023, the cost of fuel cell systems had dropped to ¥3,000 ($435) per kW, an 80% reduction from 2020 (21st Century Business Herald, 2023). Meanwhile, the volumetric power density of stacks reached 4,000 W/L, a 35% increase over 2020 levels (21st Century Business Herald, 2023). By then, China had become the world's largest FCEV market in 2023 (China Automotive News, 2024a).

Despite this progress, the commercialization of FCEVs still faces significant challenges. These include:

High production costs. The purchase price of hydrogen fuel cell heavy-duty trucks remains far higher than that of comparable diesel trucks, with the fuel cell system accounting for about 48% of the total vehicle cost (T. Li et al., 2024).

High hydrogen fuel costs. The hydrogen industry is still in its early stage. Building hydrogen refueling stations requires heavy investment while technical bottlenecks hinder the rollout of sufficient stations for large-scale commercial operation (China Automotive News, 2024a).

Insufficient infrastructure. High raw material prices, together with storage and transportation constraints, keep hydrogen supply cost elevated, which in turn drives up the price at the point of use (T. Li et al., 2024).

In addition, the carbon reduction potential of hydrogen fuel cell vehicles is also a key factor influencing the adoption of hydrogen fuel cell heavy-duty trucks. Since hydrogen fuel cells generate no carbon emissions during operation, the overall carbon emissions of these trucks primarily depend on the emissions produced during hydrogen production (T. Li et al., 2024; Phogat et al., 2025). Only when the hydrogen used in such trucks is primarily by-product hydrogen or green hydrogen can hydrogen fuel cell vehicles deliver meaningful carbon reduction benefits (T. Li et al., 2024).

Currently, national-level subsidies remain focused on vehicle procurement. Over two years, the Ministry of Finance has allocated approximately ¥2.77 billion ($400 million) in FCEV demonstration incentives (Ministry of Finance, 2023b). At the local level, supportive policies include building hydrogen corridors and waiving highway tolls for FCEVs, helping reduce hydrogen usage costs (China Daily, 2024). However, as 2025 marks the conclusion of both the 14th FYP period and the four-year city cluster demonstration program, China still faces a substantial gap in meeting its national FCEV deployment targets.

6. Conclusion and Policy Recommendation

6.1 Conclusion

This report analyzes data on the adoption of NEVs and the development of charging infrastructure in China during the 14th Five-Year Plan period. By integrating national and local government policies along with their 2025 targets, it assesses NEV development at both the provincial and city levels. Based on a comparative analysis of regional NEV stock, sales, and production, as well as the public charging infrastructure, vehicle-to-public-pile ratios, and the development of FCEVs, the report draws the following conclusions:

China's NEV industry has developed at an extraordinary pace, transitioning from policy-driven growth to a more market-oriented model. Even after the complete phase-out of central government subsidies in 2022, NEV sales have continued to rise, with the penetration rate increasing from 25.6% in 2022 to 46% in 2024. While some incentives—such as purchase tax exemptions and trade-in subsidies—are still in place, consumer demand has become the primary driving force behind NEV adoption.

China's NEV development shows significant regional disparities. In 2024, the top 8 provinces in terms of NEV stock accounted for 60% of the national total.

- The overall market trend can be characterized as "mature leadership in the east, rapid growth in the central region, and emerging potential in the west and northeast." The eastern region—particularly the Pearl River Delta and Yangtze River Delta—plays a critical role in driving NEV market development, supported by well-established industrial chains, extensive charging infrastructure, and strong consumer purchasing power. In contrast, the central and western regions are experiencing rapid development, marked by exceptionally high growth rates.
- First-tier cities are experiencing steady, slower growth due to market saturation, while second-tier cities are growing rapidly and extending penetration into rural areas. In 2023, the NEV penetration rate in rural China remained relatively low at just 17%, suggesting vast market potential. With ample room for expansion, rural areas are poised to become a major source of NEV market growth in the future.

Most provinces and municipalities have already met or are on track to meet their 2025 NEV targets ahead of schedule. These targets include NEV stock, annual sales, sales penetration rate, production volume, and the number of public charging facilities. Notably, 16 provinces had already surpassed the central government's 2027 target of a 45% NEV sales penetration rate by 2024.

China's NEV production demonstrates both path dependence and path-breaking characteristics. Traditional automotive manufacturing hubs, such as Guangdong and Shanghai, have leveraged their mature industrial chains to advance rapidly. Meanwhile, provinces with a weaker conventional automotive base, such as Anhui, have achieved breakthroughs in the NEV sector through policy support and industrial upgrading. The combined forces of policy incentives and market demand have driven the development of the NEV industry and contributed to the emergence of world-class NEV industrial clusters.

China has established an extensive public charging network for NEVs, but the distribution of charging infrastructure remains uneven, with significant regional and spatial disparities. Overall, public charging facilities are heavily concentrated in eastern and southern provinces, particularly in a few developed cities. In 2023, the top 20 cities accounted for 54% of the total public charging piles nationwide. While urban central districts are generally well-served, suburban districts and vast rural areas face insufficient infrastructure coverage. In particular, the development of charging infrastructure in rural regions presents major challenges.

Hydrogen fuel cell heavy-duty trucks have demonstrated sufficient technical maturity for short-range industrial logistics, but their market development remains below expectations. High purchase and refuel costs, and inadequate infrastructure have resulted in overall costs that remain considerably higher than those of comparable diesel trucks. At present, adoption is still largely concentrated within designated demonstration city clusters and remains heavily reliant on subsidies from national and local governments.

6.2 Policy Recommendation

Based on the above analysis, this report puts forward the following recommendations for areas where China should strengthen policies and investment efforts in the coming years to support the development of NEVs:

Establish a scientifically grounded and quantitative assessment system at the provincial and municipal levels to forecast and evaluate local demand for NEVs and charging infrastructure based on actual local conditions. The planning and implementation of NEV adoption and charging infrastructure development should proceed in a coordinated manner. The currently imbalanced vehicle-to-public-pile ratio in many areas is partly due to insufficient understanding of infrastructure demand. Localized factors—such as population density, travel patterns, and grid capacity—should be fully considered in demand assessments. Accurate and scientific evaluations will not only support government agencies in setting realistic development targets but also help relevant departments allocate resources more effectively.

Strengthen collaboration between governments and automobile manufacturers to develop NEV models that meet the specific needs of local consumers. Given China's vast territory, regional variations in economic, cultural, and geographic conditions significantly influence consumer preferences. In urban areas, there is typically higher demand for features such as extended driving range, fast charging, and battery swapping. In rural areas, affordable and practical mini-sized vehicles are generally more favored. In mountainous regions, key considerations may include climbing capability, range, and ride comfort. Close cooperation between local governments and manufacturers can help accurately identify local consumer demands, promote the development of suitable NEV models, and accelerate adoption.

Actively promote the adoption of new energy commercial vehicles, with a particular focus on hydrogen FCEVs. China should prioritize their deployment in long-haul transport, where FCEVs hold advantages over battery electric trucks due to longer range. Despite their significant emission reduction potential, FCEVs still face high costs and technological bottlenecks. Thus, policy support should go beyond purchase subsidies to include R&D and operational incentives. Expanding green hydrogen production is key to reducing hydrogen costs and maximizing emission reduction benefits. Establishing a standardized carbon accounting system for hydrogen is also critical for evaluating FCEV climate impacts and improving production technologies.

Implement targeted policies to support the development of charging infrastructure networks in emerging cities, suburban and rural areas. Emerging cities are experiencing rapid growth in NEV stock, requiring financial support to meet the surging demand for public charging infrastructure. In suburban and rural areas, flexible solutions such as shared private charging piles can help address charging needs. Additionally, rural regions require supportive policies related to grid upgrades, land use for charging facilities, and construction and operation subsidies. Tailoring policy and financial support to the specific characteristics of each region will help unlock further consumer demand for NEVs.

Reform China's vehicle taxation system, which is currently based on traditional fuel vehicles. Vehicle taxes contribute to around 10% of China's total tax revenue (State Council, 2024a), serving as a key source of funding for infrastructure such as road construction and maintenance. However, the current tax system excludes BEVs and FCEVs, leading to accelerated tax revenue losses as NEV adoption rises. This trend risks creating funding gaps for public infrastructure. Moreover, China has yet to integrate CO_2 emissions into its vehicle taxation framework, limiting its role in promoting energy conservation and emissions reduction. The rapid uptake of NEVs underscores the urgent need to redesign the vehicle tax system to align with sustainability goals and technological advancement in the auto industry.

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Appendix

A1. Growth Rate Figures Before and Between the 14th Five-Year-Plan Period

The growth rate figures include the Compound Annual Growth Rate (CAGR) of New Energy Vehicle (NEV) stock at both the provincial and city levels for the periods 2017–2020 and 2021–2024, as well as the provincial-level CAGR of NEV new sales for the periods 2016–2020 and 2021–2024. These figures are calculated based on NEV stock data from 2017 to 2024 and annual NEV new sales data from 2016 to 2024.

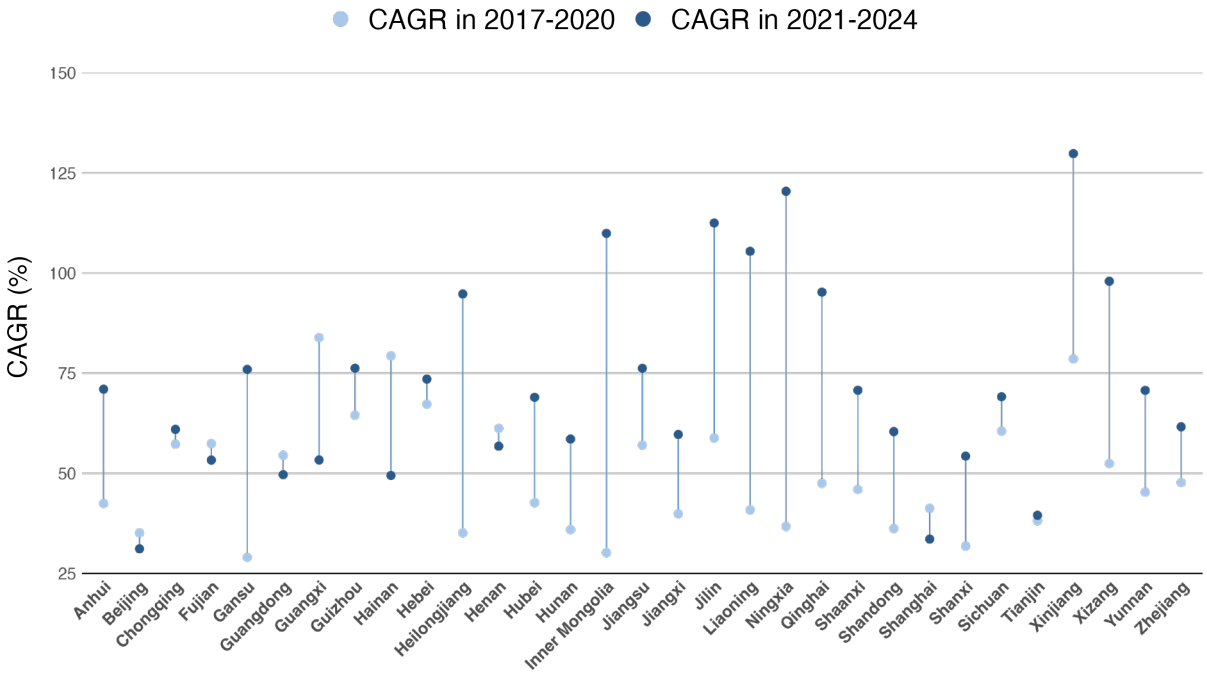

Figure S1. Provincial CAGR of NEV Stock in 2017-2020 and 2021-2024. For detailed descriptions about how NEV stock changed during these 2 periods, see chapter 3.1.

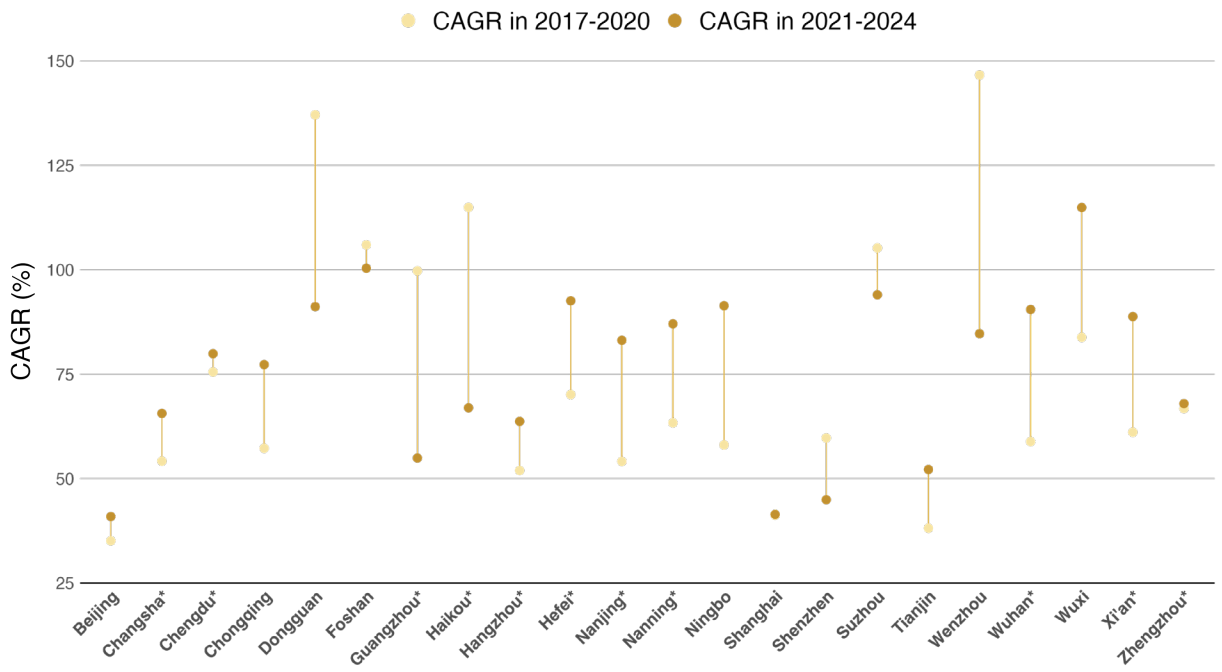

Figure S2. City-Level CAGR of NEV Stock in 2017-2020 and 2021-2024. For detailed descriptions about how NEV stock changed during these 2 periods, see chapter 3.1.

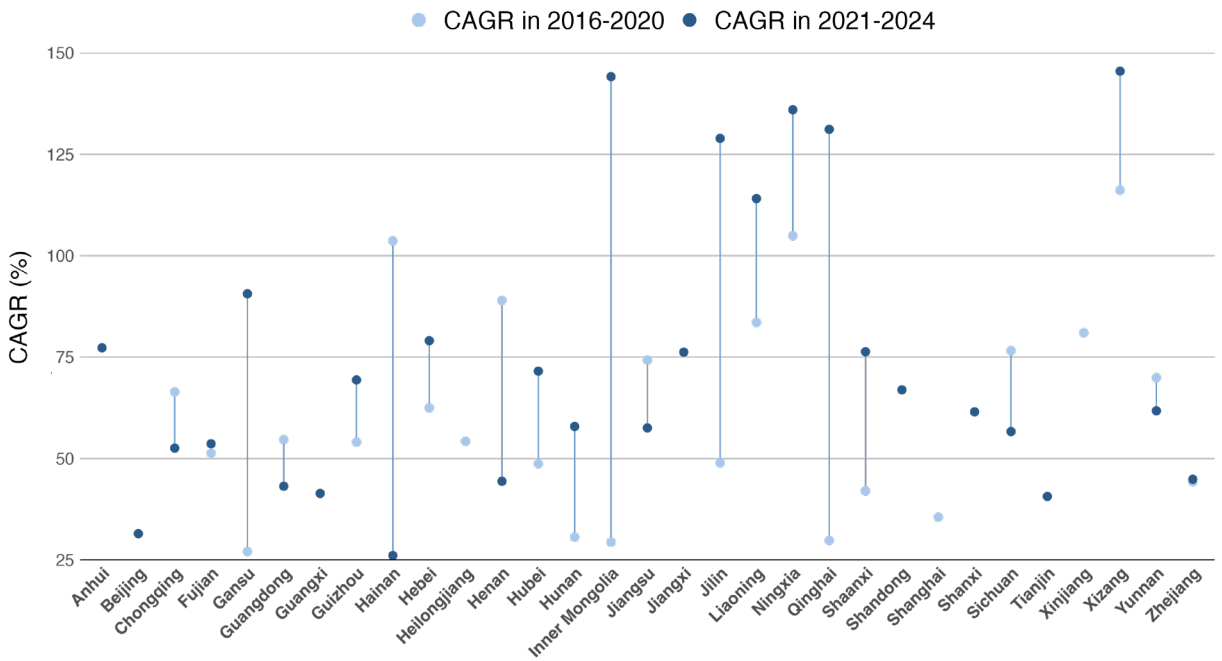

Figure S3. Provincial CAGR of NEV New Sales in 2016-2020 and 2021-2024. For detailed descriptions about how NEV new sales changed during these 2 periods, see chapter 3.2.

A2. Policy Analysis

By December 2024, this analysis collected nearly 300 provincial-level policy documents and around 50 city-level policies from the official websites and policy databases of 31 provinces (excluding Hong Kong, Macao, and Taiwan). These documents included keywords such as "new energy vehicles (NEVs)", "charging infrastructure", "hydrogen fuel cell vehicles", and other relevant synonyms. They were categorized by policy instrument type and key policy focus areas. The types of policy instruments considered in this analysis include strategies (e.g., action plans or industrial development plans), laws and regulations, economic instruments (e.g., tax exemptions or subsidies), and voluntary programs (e.g., pilot projects and government-funded initiatives). By March 2025, this analysis also gathered the 2024 and 2025 annual government work reports from all 31 provinces, and content related to NEVs was systematically categorized. Please see the tables below for examples of collected policies and government reports.

Table S1. National Policies for China's NEVs during the 14th Five-Year-Plan Period.

Year	National Policy	Key Content
2020	新能源汽车产业发展规划（2021—2035年） New Energy Vehicle Industry Development Plan (2021–2035) (State Council, 2020)	By 2025, NEVs are expected to account for about 20% of total new vehicle sales in China. The NEV industry will make significant progress in core technologies, market share, and infrastructure, aiming to achieve full electrification and intelligent mobility by 2035, thereby establishing a globally competitive industrial system.
	三部门关于开展新能源汽车下乡活动的通知 Notice from Three Departments on Launching the "NEVs Going to the Countryside" Campaign (CAAM, 2020)	Promote the adoption of NEVs in rural areas and guide the upgrading of rural residents' travel modes.
2021	绿色交通"十四五"发展规划 The 14th Five-Year Plan for the Development of Green Transportation (Ministry of Transport, 2021)	By 2025, new energy vehicles will account for 72% of urban buses, 35% of taxis (including ride-hailing vehicles), and 20% of urban logistics vehicles nationwide.
2022	关于进一步提升电动汽车充电基础设施服务保障能力的实施意见 Implementation Opinions on Further Enhancing the Service and Support Capacity of Electric Vehicle Charging Infrastructure (NDRC, 2022a)	By 2025, China will establish an intelligent charging network capable of supporting 20 million electric vehicles.
	氢能产业发展中长期规划（2021-2035 年） Medium- and Long-Term Plan for the Development of the Hydrogen Energy Industry (2021–2035) (NDRC, 2022b)	By 2025, China will have initially established a fuel cell vehicle industry system, with around 50,000 FCEVs in operation. By 2030, a well-developed hydrogen technology innovation and clean hydrogen production system will be in place. By 2035, a mature hydrogen energy industry system will be established to support the nation's green energy transition.

2023	关于全面推进美丽中国建设的意见 Opinions on Comprehensively Promoting the Construction of a Beautiful China (State Council, 2023b)	By 2027, NEVs are expected to account for about 45% of all newly added automobiles.
	加快推进充电基础设施建设 更好支持新能源汽车下乡和乡村振兴的实施意见 Implementation Opinions on Accelerating Charging Infrastructure Development to Better Support NEV Deployment in Rural Areas and Rural Revitalization (NDRC, 2023)	Promote appropriately advanced construction of charging infrastructure in rural areas and optimize the environment for purchasing and using NEVs.
	关于进一步构建高质量充电基础设施体系的指导意见 Guiding Opinions on Further Building a High-Quality Charging Infrastructure System (State Council, 2023a)	By 2030, China aims to establish a comprehensive, well-structured, and efficiently functioning charging infrastructure network that adequately supports the growth of the NEV industry and reliably meets the public's charging and transportation needs.
2024	推动大规模设备更新和消费品以旧换新行动方案 Action Plan for Large-Scale Equipment Renewal and Consumer Goods Trade-In (State Council, 2024a)	Continue promoting the electrification of urban public buses and support the renewal and replacement of aging new energy buses and their power batteries.
	汽车以旧换新补贴实施细则 Implementation Rules for Vehicle Trade-In Subsidies (State Council, 2024b)	For scrapping selected types of old vehicles and purchasing new energy passenger cars, a subsidy of ¥10,000 ($1,450) is provided; for scrapping selected types of fuel-powered passenger cars and purchasing fuel-powered passenger cars with an engine displacement of 2.0 liters or below, a subsidy of ¥7,000 ($1,015) is provided.
	关于进一步做好汽车以旧换新有关工作的通知 Notice on Further Improving the Work Related to Vehicle Trade-In Programs (State Council, 2024c)	For scrapping selected types of old vehicles and purchasing new energy passenger cars, a subsidy of ¥20,000 ($2,900) is provided; for scrapping selected types of fuel-powered passenger cars and purchasing fuel-powered passenger cars with an engine displacement of 2.0 liters or below, a subsidy of ¥15,000 ($2,170) is provided.

Table S2. Provincial Key Policies for NEV and Charging Infrastructure Development

Province	Policy
Anhui	Action Plan for the Development of the NEV Industry in Anhui Province (2021–2023) (Anhui Provincial People's Government, 2021)
	Several Policies to Enhance the Quality, Quantity, and Efficiency of the NEV and Intelligent Connected Vehicle Industry (Anhui Provincial Development and Reform Commission, 2022)
	High-Quality Charging and Battery Swap Service System Construction Plan (2023–2027) (Anhui Provincial Development and Reform Commission, 2023)
	Three-Year Action Plan for the High-Quality Development of the Hydrogen Energy Industry in Anhui Province (Anhui Provincial Development and Reform Commission, 2024)

Beijing	Beijing Hydrogen Fuel Cell Vehicle Industry Development Plan (2020–2025) (Beijing Municipal Bureau of Economy and Information Technology, 2020)
	14th Five-Year Plan for the Development of NEV Charging and Battery Swap Infrastructure in Beijing (Beijing Municipal Commission of City Management, 2022)
	Beijing "14th Five-Year Plan" for Energy Development (Beijing Municipal People's Government, 2022)
Chongqing	Action Plan for Promoting High-Quality and Green Development of the Manufacturing Industry (2022–2025) Guided by Carbon Peaking and Carbon Neutrality Goals (Chongqing Municipal People's Government, 2022a)
	Chongqing "14th Five-Year Plan" for Energy Development (2021–2025) (Chongqing Municipal People's Government, 2022b)
	Chongqing "14th Five-Year Plan" for the Development of Charging Infrastructure (Chongqing Development and Reform Commission, 2022)
Fujian	Fujian Province New Energy Vehicle Industry Development Plan (2022–2025) (Fujian Provincial People's Government, 2022)
	Implementation Opinions on Comprehensively Promoting the "Electric Fujian" Initiative (2023–2025) (Fujian Provincial Department of Industry and Information Technology, 2023)
	Implementation Plan for Accelerating the Development of a High-Quality Charging Infrastructure System in Fujian Province (Fujian Provincial Development and Reform Commission, 2024)
Gansu	Gansu Province Carbon Peak Implementation Plan (Gansu Provincial People's Government, 2022)
Guangdong	Guangdong Province 14th Five-Year Plan for the Development of Electric Vehicle Charging Infrastructure (Guangdong Provincial Energy Bureau, 2021)
	Guangdong Province Carbon Peaking Implementation Plan (Guangdong Provincial People's Government, 2022)
	Guangdong Province 14th Five-Year Special Plan for Addressing Climate Change (Guangdong Provincial Department of Ecology and Environment, 2022)
	Guangdong Province Action Plan for Accelerating the Development of Fuel Cell Vehicle Demonstration City Clusters (2022–2025) (Guangdong Provincial Development and Reform Commission, 2022)
	Guangdong Province Action Plan for Developing the Automotive Strategic Pillar Industry Cluster (2023–2025) (Guangdong Provincial Department of Industry and Information Technology, 2023)

Guangxi	Guangxi Province New Energy Vehicle Industry Development Plan for the 14th Five-Year Plan Period (Guangxi Zhuang Autonomous Region People's Government, 2021)
	Guangxi Province Comprehensive Energy Conservation and Emission Reduction Implementation Plan for the 14th Five-Year Plan Period (Guangxi Zhuang Autonomous Region People's Government, 2022)
	Guangxi Province Medium- and Long-Term Plan for Hydrogen Energy Industry Development (2023–2035) (Guangxi Zhuang Autonomous Region Development and Reform Commission, 2023)
	Guangxi Province Plan for Further Building a High-Quality Charging Infrastructure System (Guangxi Zhuang Autonomous Region People's Government, 2023)
Guizhou	Guizhou Province New Energy Vehicle Industry 14th Five-Year Development Plan (Guizhou Provincial Department of Industry and Information Technology, 2022)
	Guiding Opinions on Accelerating High-Quality Development of the New Energy Vehicle Industry and Promoting the "Electric Guizhou" Initiative (Guizhou Provincial People's Government, 2023)
	Guizhou Province Electric Vehicle Charging and Battery-Swap Infrastructure Development Plan (2024–2027) (Guizhou Provincial Energy Bureau, 2024)
Hainan	Hainan Province Carbon Peaking Implementation Plan (Hainan Provincial People's Government, 2022)
	Hainan Province Medium- and Long-Term Action Plan for NEV Promotion (2023–2030) (Hainan New Energy Vehicle Promotion Center, 2023)
	Hainan Province Medium- and Long-Term Hydrogen Energy Industry Development Plan (2023–2035) (Hainan Provincial Development and Reform Commission, 2023)
Hebei	14th Five-Year Plan for Hydrogen Energy Industry Development in Hebei Province (Hebei Provincial Development and Reform Commission, 2021)
	Opinions of the Hebei Development and Reform Commission on Accelerating the Construction of a High-Quality Charging Infrastructure System Province-wide (Hebei Provincial Development and Reform Commission, 2023)
	Implementation Opinions on Accelerating the Construction of a Blue Sky, Green Land, and Clear Water Hebei and Fully Advancing the Beautiful China Initiative through Concrete Actions (Hebei Provincial People's Government, 2024)
Heilongjiang	Heilongjiang Province Implementation Plan for Promoting Large-Scale Equipment Renewal and Trade-In of Consumer Goods (Heilongjiang Provincial People's Government, 2024)
Henan	Guiding Opinions on Further Accelerating the Development of the New Energy Vehicle Industry (Henan Provincial People's Government, 2022)
	Henan Province Three-Year Action Plan for Implementing the Strategy of Expanding Domestic Demand (2023–2025) (Henan Provincial People's Government, 2023b)
	Henan Province Three-Year Action Plan for Electric Vehicle Charging Infrastructure Development (2023–2025) (Henan Provincial People's Government, 2023a)

Hubei	14th Five-Year Development Plan for Hubei Province's Automobile Industry (Hubei Provincial Department of Economy and Information Technology, 2021)
	Hubei Province Implementation Plan for Synergistic Pollution and Carbon Reduction (Hubei Provincial Department of Ecology and Environment, 2022)
	Implementation Opinions on Accelerating the Development of a High-Quality Charging Infrastructure System in Hubei Province (Hubei Provincial People's Government, 2023a)
	Implementation Plan for the Transformation and Development of Hubei Province's Automobile Industry (2023–2025) (Hubei Provincial People's Government, 2023b)
Hunan	Implementation Opinions of the General Office of the People's Government of Hunan Province on Accelerating the Construction of Electric Vehicle Charging and Battery-Swapping Infrastructure (Hunan Provincial People's Government, 2021)
	Hunan Province Carbon Peaking Implementation Plan (Hunan Provincial People's Government, 2022)
	Hunan Province Industrial Sector Carbon Peaking Implementation Plan (Hunan Provincial Department of Industry and Information Technology, 2022)
Inner Mongolia	Opinions on Promoting High-Quality Development of the Hydrogen Energy Industry in Inner Mongolia (People's Government of Inner Mongolia Autonomous Region, 2022)
	Implementation Plan for Carbon Peaking in the Industrial Sector of Inner Mongolia (Department of Industry and Information Technology of Inner Mongolia Autonomous Region, 2023)
Jiangsu	Jiangsu Province "14th Five-Year Plan" for New Energy Vehicle Industry Development (People's Government of Jiangsu Province, 2021)
	Jiangsu Province Implementation Plan for Coordinated Pollution Reduction and Carbon Mitigation (Department of Ecology and Environment of Jiangsu Province, 2023)
	Jiangsu Province Medium- and Long-Term Hydrogen Industry Development Plan (2024–2035) (Development and Reform Commission of Jiangsu Province, 2024)
Jiangxi	Jiangxi Province Three-Year Action Plan for Accelerating the Construction of Electric Vehicle Charging Infrastructure (2021–2023) (Development and Reform Commission of Jiangxi Province, 2020)
	Jiangxi Province Medium- and Long-Term Plan for Hydrogen Energy Industry Development (2023–2035) (Development and Reform Commission of Jiangxi Province, 2023)
Jilin	Medium- and Long-Term Development Plan for "Hydrogen-Powered Jilin" (2021–2035) (Jilin Provincial People's Government, 2022a)
	Strategic Plan for the High-Quality Development of the New Energy Industry in Jilin Province (2022–2030) (Jilin Provincial People's Government, 2022b)
	High-Quality Development Action Plan for New Energy and Intelligent Connected Vehicle Industry in Jilin Province (Jilin Provincial People's Government, 2024b)
	Implementation Plan for Further Building a High-Quality Charging and Battery Swap Infrastructure System in Jilin Province (Jilin Provincial People's Government, 2024c)

Liaoning	Hydrogen Energy Industry Development Plan of Liaoning Province (2021–2025) (Liaoning Provincial Development and Reform Commission, 2021)
	14th Five-Year Special Plan for Electric Vehicle Charging Infrastructure in Liaoning Province (Liaoning Provincial Development and Reform Commission, 2022)
	Liaoning Province Carbon Peak Action Plan (Liaoning Provincial People's Government, 2022)
Ningxia	Ningxia Hui Autonomous Region Carbon Peak Implementation Plan (People's Government of Ningxia Hui Autonomous Region, 2022)
	Ningxia Hui Autonomous Region Hydrogen Industry Development Plan (Development and Reform Commission of Ningxia Hui Autonomous Region, 2022)
Qinghai	Qinghai Province Medium- and Long-Term Hydrogen Industry Development Plan (2022–2035) (Development and Reform Commission of Qinghai Province, 2022)
Shaanxi	Shaanxi Province "14th Five-Year" Development Plan for Electric Vehicle Charging Infrastructure (Development and Reform Commission of Shaanxi Province, 2021)
	Shaanxi Province "14th Five-Year" Hydrogen Energy Industry Development Plan (Development and Reform Commission of Shaanxi Province, 2022)
	Shaanxi Province Action Plan for Accelerating the Development of New Energy and Intelligent Connected Vehicle Industry (2024–2027) (State Council, 2024d)
Shandong	Shandong Province Medium- and Long-Term Development Plan for the Hydrogen Energy Industry (2020–2030) (Shandong Provincial People's Government, 2020)
	Shandong Province 14th Five-Year Plan for Green, Low-Carbon, and Circular Development (Shandong Provincial Development and Reform Commission, 2022)
	Shandong Province 14th Five-Year Development Plan for Electric Vehicle Charging Infrastructure (Shandong Provincial Energy Bureau, 2022)
	Shandong Province New Energy Vehicle Industry Development Plan (2021–2025) (Shandong Provincial Committee of the Chinese People's Political Consultative Conference, 2022)
	Shandong Province Action Plan for the High-Quality Development of the New Energy Vehicle Industry (Shandong Provincial People's Government, 2023a)
	Shandong Province Three-Year Action Plan for Promoting New Energy Vehicles in Rural Areas (2023–2025) (Shandong Provincial People's Government, 2023b)
Shanghai	Shanghai Implementation Plan for Accelerating the Development of the NEV Industry (2021–2025) (Shanghai Municipal People's Government, 2021)
	Implementation Opinions on Further Promoting the Construction of Charging and Battery-Swap Infrastructure in the City (Shanghai Municipal People's Government, 2022)
	Hydrogen Energy Application Plan in the Transportation Sector of Shanghai (2023–2025) (Shanghai Municipal Transportation Commission, 2023)
	Shanghai Clean Air Action Plan (2023–2025) (Shanghai Municipal People's Government, 2023)

Shanxi	Medium- and Long-Term Hydrogen Energy Industry Development Plan in Shanxi Province (2022–2035) (Shanxi Provincial People's Government, 2022)
	Implementation Plan for Carbon Peaking in the Industrial Sector of Shanxi Province (Shanxi Provincial Department of Industry and Information Technology, 2023)
	14th Five-Year Plan and Three-Year Action Plan (2023–2025) for EV Charging (Swap) Infrastructure in Shanxi Province (Shanxi Provincial People's Government, 2023)
Sichuan	Sichuan Province Implementation Plan for Promoting Electric Vehicle Charging Infrastructure Development (Sichuan Provincial Development and Reform Commission, 2020)
	Sichuan Province Hydrogen Industry Development Plan (2021–2025) (Sichuan Provincial Department of Economy and Information Technology, 2020)
	Sichuan Province Carbon Peaking Implementation Plan (Sichuan Provincial People's Government, 2022)
	Sichuan Province Carbon Peaking Implementation Plan for the Industrial Sector (Sichuan Provincial Department of Economy and Information Technology, 2023)
Tianjin	Implementation Plan for Accelerating the Development of New Energy and Intelligent Connected Vehicle Industry in Tianjin (2023–2027) (Tianjin Municipal People's Government, 2023)
	Implementation Plan for Further Building a High-Quality Charging Infrastructure System in Tianjin (Tianjin Municipal Development and Reform Commission, 2023)
Xinjiang	Guiding Opinions on Further Accelerating the Promotion, Application, and Development of the New Energy Vehicle Industry (Xinjiang Uygur Autonomous Region People's Government, 2022)
	Autonomous Region Three-Year Action Plan for Hydrogen Industry Development (2023–2025) (Development and Reform Commission of the Xinjiang Uygur Autonomous Region, 2023)
Xizang	Xizang Autonomous Region Implementation Plan for Strengthening Support for Large-Scale Equipment Renewal and Consumer Goods Replacement (Development and Reform Commission of the Xizang Autonomous Region, 2024)
Yunnan	Yunnan Province New Energy Vehicle Industry Development Plan (2021–2025) (Department of Industry and Information Technology of Yunnan Province, 2021)
	Implementation Opinions on Further Building a High-Quality Charging Infrastructure System (Development and Reform Commission of Yunnan Province, 2023)
Zhejiang	14th Five-Year Plan for the Development of the NEV Industry in Zhejiang Province (Development and Reform Commission of Zhejiang Province, 2021)
	Action Plan to Improve the High-Quality Charging Infrastructure Network and Promote NEV Sales in Rural Areas (2023–2025) (People's Government of Zhejiang Province, 2023)
	Action Plan to Accelerate NEV Industry Development in Zhejiang Province (Development and Reform Commission of Zhejiang Province, 2023)
	Implementation Opinions on Promoting High-Quality Development of the New Energy Manufacturing Industry (2023–2025) (Department of Economy and Information Technology of Zhejiang Province, 2023)

Table S3. City-Level Key Policies for NEV and Charging Infrastructure Development.

City	Policy
Chengdu	Chengdu Energy Vehicle Charging and Battery Swapping Infrastructure Plan (2023-2025) (Chengdu Municipal Bureau of Economy and Information Technology, 2023a)
	Chengdu New Energy and Intelligent Connected Vehicle Industry Development Plan (2023-2030) (Chengdu Municipal Bureau of Economy and Information Technology, 2023b)
	Chengdu's Action Plan (2024-2026) to Promote Hydrogen Fuel Cell Commercial Vehicles (Chengdu Municipal Bureau of Economy and Information Technology, 2024)
Changsha	Changsha 14th Five-Year Plan for New Energy Vehicle Charging Infrastructure (Changsha Municipal Development and Reform Commission, 2023a)
	Changsha Hydrogen Energy Industry Development Action Plan (2023-2025) (Changsha Municipal Development and Reform Commission, 2023b)
Dongguan	Dongguan 14th Five-Year Plan for Vehicle Charging Infrastructure (2021-2025) (Dongguan Municipal Development and Reform Bureau, 2022)
	Dongguan Hydrogen Industry Development Action Plan (2023-2025) (Dongguan Municipal Development and Reform Bureau, 2023)
Foshan	Foshan's 14th Five-Year Energy Development Plan (Foshan Municipal People's Government, 2022)
Guangzhou	Guangzhou 14th Five-Year Plan for Intelligent and New Energy Vehicle Innovation Development (Guangzhou Development and Reform Commission, 2021)
	Guangdong Province Energy Vehicle Charging Infrastructure Development 14th Five-Year Plan (Guangdong Energy Administration, 2021)
	Guangzhou Hydrogen Infrastructure Development Plan (2021-2030) (Guangzhou Development and Reform Commission, 2022)
Haikou	Haikou Carbon Peaking Implementation Plan (Haikou Municipal People's Government, 2023)
	Haikou Hydrogen Energy Industry Development Plan (2023-2035) (Haikou Municipal Development and Reform Commission, 2024)
Hangzhou	Hangzhou's 14th Five-Year Plan for Energy-Saving and New Energy Vehicle Industry Development (Hangzhou Municipal People's Government, 2021)
	Hangzhou's Action Plan to Promote Replacement of Old Consumer Goods (Hangzhou Municipal People's Government, 2024)

Hefei	Hefei 14th Five-Year High-Quality Energy Development Plan (Hefei Municipal People's Government, 2022a)
	Hefei 14th Five-Year New Energy Vehicle Industry Development Plan (Hefei Municipal People's Government, 2022b)
Nanjing	Nanjing's Landmark New Energy Vehicle Industry Action Plan (Nanjing Municipal People's Government, 2018)
	Nanjing "14th Five-Year Plan" Major Infrastructure Construction Plan (Nanjing Municipal People's Government, 2021)
	Nanjing Energy Storage and Hydrogen Industry Development Action Plan (2023-2025) (Nanjing Municipal Bureau of Industry and Information Technology, 2023)
Nanning	Nanning Energy Development 14th Five-Year Plan (Nanning Municipal People's Government, 2023)
Ningbo	Ningbo New Energy Vehicle Industry Development Plan (2023-2030) (Ningbo Municipal People's Government, 2023)
	Ningbo High-Quality Charging Infrastructure Network Action Plan (Draft) (Ningbo Municipal Energy Bureau, 2024)
Shenzhen	Shenzhen Hydrogen Energy Industry Development Plan (2021-2025) (Shenzhen Development and Reform Commission, 2021)
	Shenzhen's Three-Year Action Plan (2023-2025) to Build a New Generation of World-Class Auto City (Shenzhen Municipal People's Government, 2023)
	Shenzhen Hydrogen Energy Industry Innovation Development Action Plan (2024-2025) (Shenzhen Development and Reform Commission, 2024)
Suzhou	Suzhou's 14th Five-Year Plan for Energy Vehicle Charging and Battery Swap Infrastructure (Suzhou Municipal People's Government, 2022)
	Suzhou's Plan for Equipment Renewal and Consumer Goods Replacement (Suzhou Municipal People's Government, 2024)
Wenzhou	Wenzhou's Five-Year Action Plan (2022-2026) for Accelerating New Energy Industry Innovation (Wenzhou Municipal People's Government, 2022)
	Wenzhou Pilot Plan (2023-2025) for Rural New Energy Vehicle Charging Infrastructure (Wenzhou Municipal People's Government, 2023)
Wuhan	Wuhan's 14th Five-Year Climate Change Response Plan (Wuhan Municipal Ecology and Environment Bureau, 2022)
	Wuhan Economic Development Zone New Energy Vehicle and Intelligent and Connected Vehicle Industry Upgrade Action Plan (2023-2025) (Wuhan Economic & Technological Development Zone Administrative Committee, 2023)

Wuxi	Wuxi's Hydrogen and Energy Storage Industry Action Plan (2023-2025) (Wuxi Municipal Development and Reform Commission, 2023)
	Wuxi Auto and Parts Industry Cluster Action Plan (2023-2025) (Wuxi Municipal People's Government, 2023a)
	Wuxi's 14th Five-Year Plan for New Energy Vehicle Charging and Swapping Infrastructure (Wuxi Municipal People's Government, 2023b)
Xi'an	Xi'an Automobile Industry Development Plan (2018-2025) (Xi'an Municipal People's Government, 2018)
	Xi'an Municipal Government Opinions on Promoting High-Quality New Energy Vehicle Development (Xi'an Municipal People's Government, 2021)
Zhengzhou	Zhengzhou's Implementation Opinions on Accelerating New Energy Vehicle and Intelligent Connected Vehicle Development (Zhengzhou Municipal People's Government, 2022)
	Zhengzhou Action Plan (2024-2025) to Accelerate Energy Vehicle Charging Infrastructure (Zhengzhou Municipal People's Government, 2024a)
	Zhengzhou Energy Vehicle Charging Infrastructure Development Plan (2024-2035) (Zhengzhou Municipal People's Government, 2024b)
	Zhengzhou Medium- and Long-term Hydrogen Industry Development Plan (2024-2035) (Zhengzhou Municipal People's Government, 2024c)

Table S4. NEV Related Content in Provincial Government Reports in 2024 and 2025.

Province	Category	Content
Anhui	NEV Industry Development	Increase investment in the NEV industry; build world-class NEV industry clusters and create an internationally influential NEV industry innovation center; and launch pilot projects for carbon footprint accounting in the NEV sector. (Anhui Provincial People's Government, 2024, 2025)
Beijing	Promotion of FCEVs	Promote the demonstration and application of FCEVs; establish key component industry chains of NEV; stimulate NEV consumption; and develop the Beijing-Tianjin-Hebei intelligent connected NEV industrial park. (Beijing Municipal People's Government, 2024, 2025)
Chongqing	Promotion of FCEVs	Promote the demonstration and application of FCEVs; accelerate the development of the Chengdu-Chongqing "Hydrogen Corridor" and "Electric Corridor"; and promote integrated innovation across the entire industry chain of ICVs and NEVs. (Chongqing Municipal People's Government, 2024, 2025)
Fujian	Promotion of NEVS	Advantages of the full NEV industry chain; launching the country's first heavy-duty truck battery swapping expressway route. (Fujian Provincial People's Government, 2024)

Gansu	Charging Infrastructure Construction	Increase the construction of charging infrastructure and support the deployment of new energy vehicles in rural areas. (Gansu Provincial People's Government, 2024)
Guangdong	Promotion of FCEVs	Expand NEV exports; promote the demonstration and application of FCEVs; develop charging and battery swapping infrastructure in rural areas; stimulate NEV consumption; extend the NEV industry chain; and advance technological breakthroughs in power batteries and intelligent driving systems. (Guangdong Provincial Department of Finance, 2025; Guangdong Provincial People's Government, 2024)
Guangxi	NEV Industry Development	Achieved a local supply rate of over 60% for the NEV industry; promote the deployment of NEVs in rural areas. (Guangxi Zhuang Autonomous Region People's Government, 2024)
Guizhou	NEV Industry Development	"Electric Guizhou": Promote the growth of the entire NEV industry chain cluster; advance the construction of charging and battery swapping infrastructure; and expand NEV consumption. (Guizhou Provincial People's Government, 2024)
Hainan	Promotion of NEVs	Initiate the development of an NEV leasing system. (Hainan Provincial People's Government, 2024)
Hebei	NEV Industry Development	Collaborate with Beijing and Tianjin to develop the NEV and ICV industry chain. (People's Daily, 2024a)
Hubei	NEV Industry Development	Accelerate the formation of NEV and ICV companies; expand NEV exports; and initiated the trial production of the world's first hydrogen-powered heavy-duty truck with a 1,000-kilometer range in 2024. (Hubei Provincial People's Government, 2024, 2025)
Hunan	NEV Industry Development	Develop the hydrogen energy and solid-state power battery industries. (Hunan Provincial People's Government, 2024, 2025)
Henan	NEV Industry Development	Develop NEV manufacture and component clusters; apply ICV scenarios; and achieve a 50% green replacement rate for heavy-duty vehicles by 2025. (Henan Provincial Development and Reform Commission, 2024; Henan Provincial People's Government, 2025)
Jilin	Charging Infrastructure Construction	Build charging and battery swapping infrastructure for NEVs in advance, with a penetration rate of 30% to 50%; actively promote FCEVs; and accelerate the automotive industry's transformation towards NEV and ICV technologies. (Jilin Provincial People's Government, 2024a, 2025)
Liaoning	NEV Industry Development	Traditional industrial bases seek transformation into new energy: Support innovation in NEV technologies and key supporting components. (Liaoning Provincial Department of Commerce, 2024)
Ningxia	NEV Consumption	Electrification of vehicles in the public sector. (Ningxia Hui Autonomous Region People's Government, 2024)
Qinghai	NEV Consumption	Develop steel products for key components of new energy vehicles; promote the electrification of vehicles in the public sector. (Qinghai Provincial People's Government, 2024, 2025)
Shaanxi	NEV Export	The export growth of NEVs in 2023 exceeded 1,100%; in 2024, hydrogen fuel cell heavy-duty truck sales ranked first in the country. (Shaanxi Provincial People's Government, 2024, 2025)

Shandong	NEV Industry Development	Develop NEV industry clusters, expand new energy bus exports to the Central Asian market, and accelerate the deployment of charging infrastructure in rural areas. (Shandong Provincial People's Government, 2024)
Shanghai	NEV Industry Development	Foster the development of high-end NEV industry clusters. (Shanghai Municipal People's Government, 2024)
Shanxi	Promotion of Methanol Fuel Vehicle	Promote methanol vehicles; develop methanol-hydrogen heavy-duty truck demonstration application areas; and stimulate new energy vehicle consumption. (People's Daily, 2024b; Shanxi Provincial People's Government, 2025)
Sichuan	NEV Industry Development	"Electric Sichuan" Initiative: Accelerate the electrification process in key areas such as the construction of charging and battery swapping infrastructure, the promotion of NEVs, the development of the power battery industry, and the upgrading of the NEV industry. Co-develop the "Hydrogen Corridor," "Electric Corridor," and "Smart Mobility Corridor" in the Chengdu-Chongqing area; and foster the hydrogen energy and FCEV industry chain. (Sichuan Provincial Information Network, 2025; Sichuan Provincial People's Government, 2024)
Tianjin	NEV Industry Development	Develop the Beijing-Tianjin-Hebei intelligent connected NEV industrial park. (Tianjin Municipal People's Government, 2025)
Zhejiang	Charging Infrastructure Construction	Expand charging pile coverage in rural areas and support the development of the NEV industry. (Zhejiang Provincial Department of Economy and Information Technology, 2025)

Table S5. Incentive Policies of FCEV in the 5 Major Demonstration City Clusters.

Cluster	City	Policies
Beijing-Tianjin-Hebei	Beijing	Notice on the Application for Beijing Fuel Cell Vehicle Demonstration Projects (2023–2025) (Beijing Municipal Bureau of Economy and Information Technology, 2024)
	Tianjin	Notice on Issuing the Guiding Opinions on Local Fiscal Support Policies for Fuel Cell Vehicle Demonstration Cities (Tianjin Municipal Finance Bureau, 2023)
Shanghai	—	Implementation Rules for the Special Fund for Fuel Cell Vehicle Demonstration and Application in Shanghai (Shanghai Municipal Commission of Economy and Informatization, 2023)
Guangdong	—	Action Plan for Accelerating the Development of Fuel Cell Vehicle Demonstration City Clusters in Guangdong Province (2022–2025) (Guangdong Provincial Development and Reform Commission, 2022)
Hebei	Tangshan	Several Policies on Supporting the Construction of a New Energy System in Tangshan (2024 Revision) (Tangshan Municipal People's Government, 2024)
	Zhangjiakou	Several Measures to Support the Construction of a Fuel Cell Vehicle Demonstration City in Zhangjiakou (Zhangjiakou Municipal People's Government, 2022)

Henan	Jiaozuo	Several Policies Supporting the Demonstration and Application of Hydrogen Fuel Cell Vehicles in Jiaozuo (Jiaozuo Municipal People's Government, 2024)
	Kaifeng	Action Plan for Fuel Cell Vehicle Demonstration and Application in Kaifeng (2022–2025) (Kaifeng Municipal Bureau of Industry and Information Technology, 2022)

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