THE OXFORD INSTITUTE FOR ENERGY STUDIES

OIES CHINA PROGRAMME:

An update on China's EV Revolution

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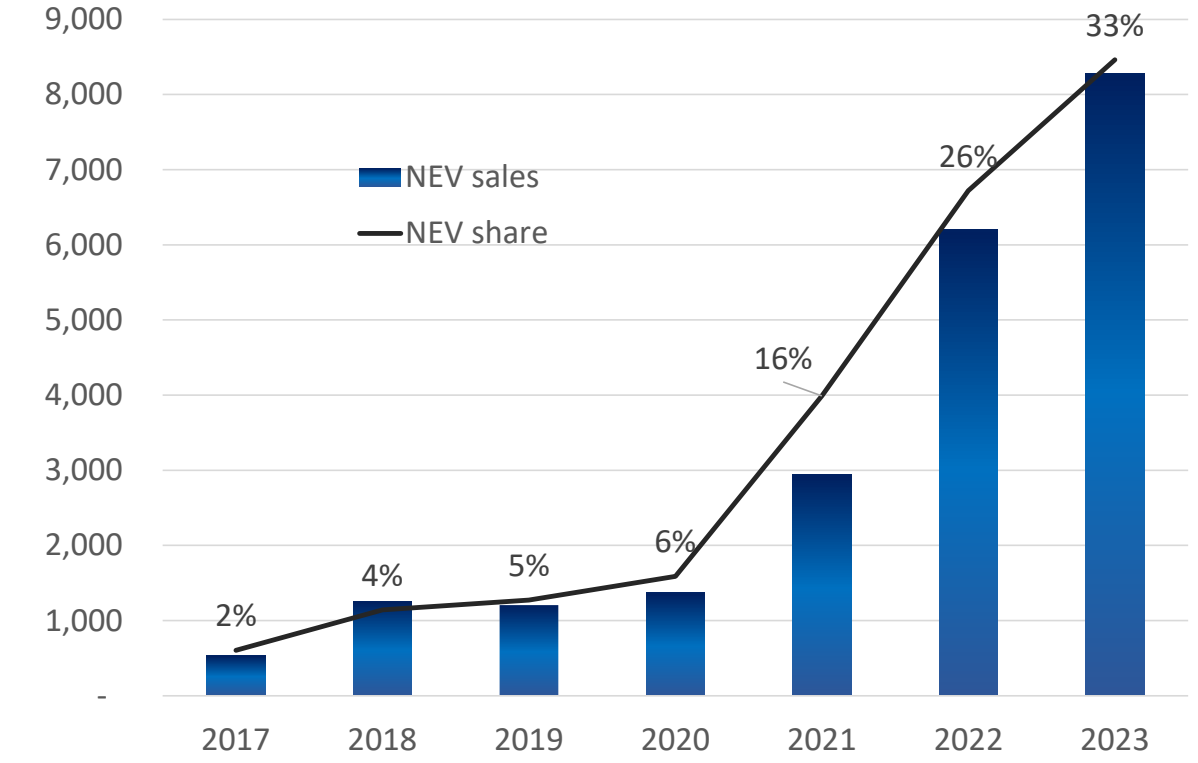
Background and contents

- Updates on the latest EV statistics from various Chinese organizations:
  - EV sales and market share: China and the world
  - EV sales by vehicle price, type, size
  - EV batteries and the growth of LFP share
  - EV emissions
  - EV charging: number of chargers, electricity consumption
  - Charging experience
- Additional analysis from the author's prior research,
- Summary of 2024 research questions

China EV sales continue to grow

China domestic New Energy Vehicle (NEV) sales, 2017-2023, and market share

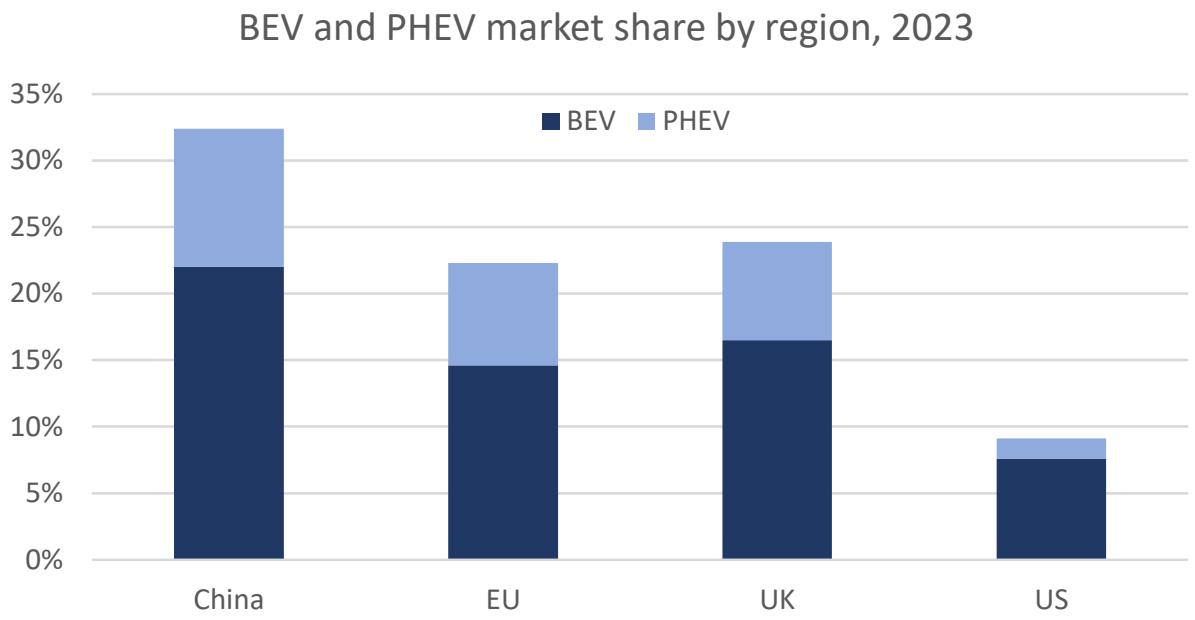


CAAM, based on domestic sales share of all vehicles, author calculations

- Industry projects 40% market share in 2024; CPCA 11 million sales in 2024
- Linear growth in NEV sales would yield sales of 10.5 million, a 40% share
- Compound growth of 33% would yield sales of 12 million, a 42% share

China NEV market ahead of other major regions

2023 NEV market shares



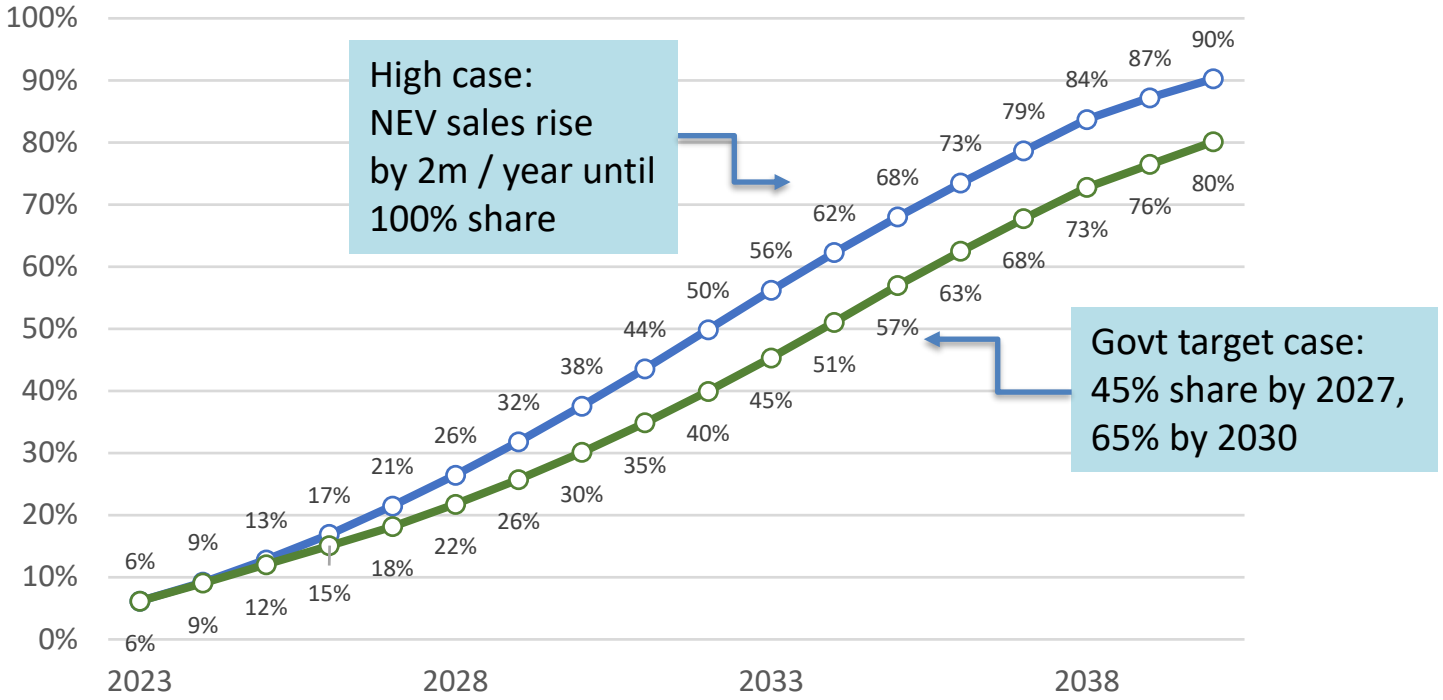
Source: ACEA 2024, HeyCar 2024, Cox Auto Inc 2024, InsideEVs 2024, and author calculations

Note: China share represents all vehicles, other countries light-duty passenger vehicles only

- China remains well ahead of other major auto markets in EV penetration

Penetration of overall vehicle fleet rising slowly

NEVs as share of total China vehicle stock under S-curve adoption

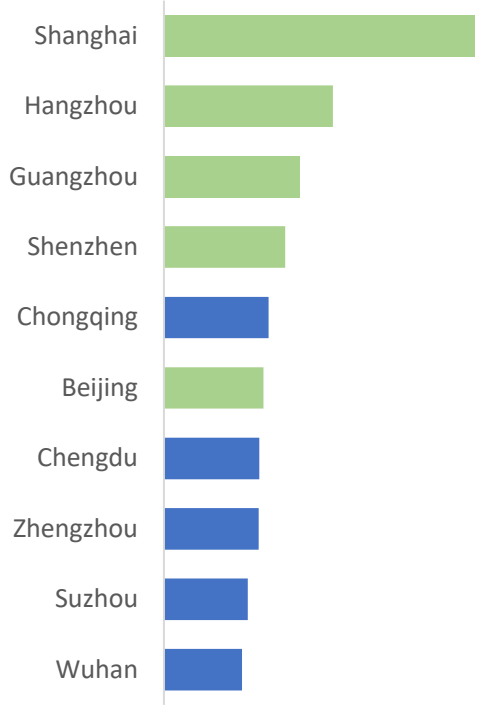


Source: Anders Hove, OIES, 2024

- Though EV sales growth has slowed, the market is still rising at around 2m vehicles / year
- Carrying this rate forward, China would reach 100% NEV market share around 2027
- Assuming vehicles last 15 years, this yields a 50% NEV share in the vehicle fleet by 2032
- Using government target of 45% sales in 2027 and 65% in 2030, EV stock lower by about 10 pp

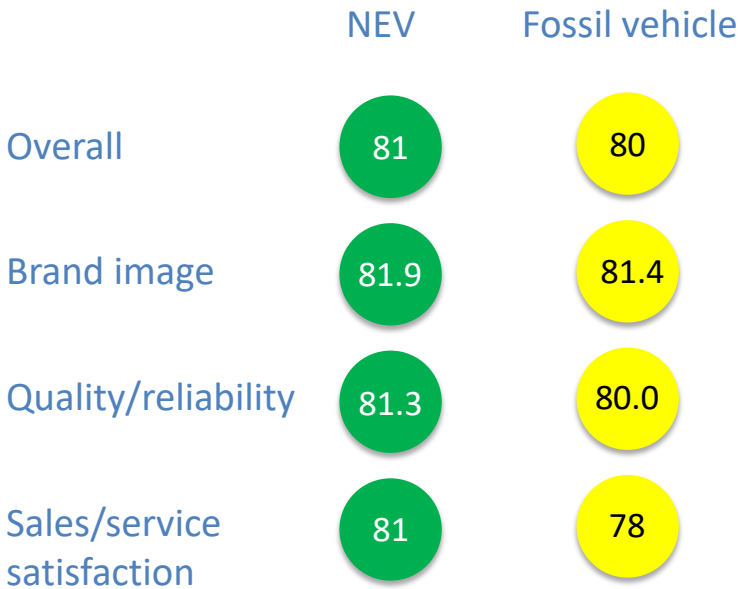
Several factors other than subsidies at work

Top NEV cities in Dec 2022
(green indicates license plate limit)



Source: CPCA/WAYS 2023

Customer satisfaction results

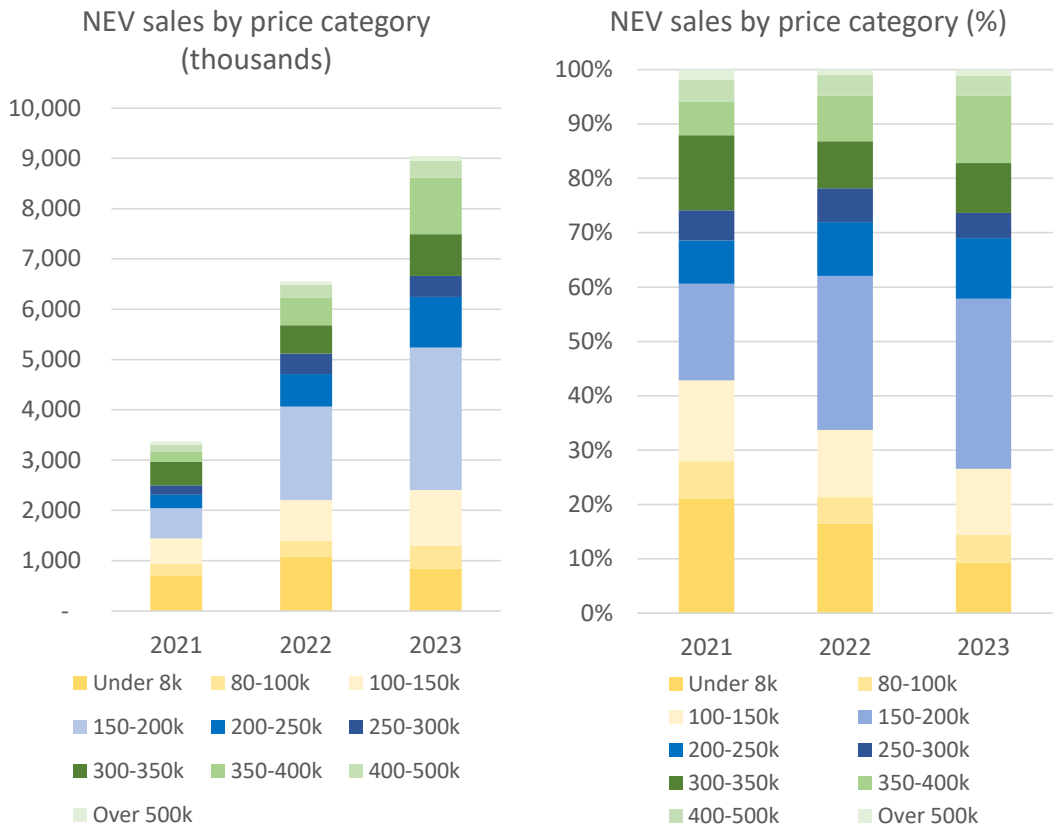


Source: China Association of Quality, 2023

- While license plate restrictions and local subsidies still matter, CPCA predicts most growth outside leading cities in 2024
- NEVs perform better on customer satisfaction metrics; NIO, BMW, Mercedes, BYD, and Tesla scoring well, smaller and lower-end vehicles scoring below fossil vehicles

Mid-range NEVs showed strongest growth

NEV sales by price category, 2021 to 2023



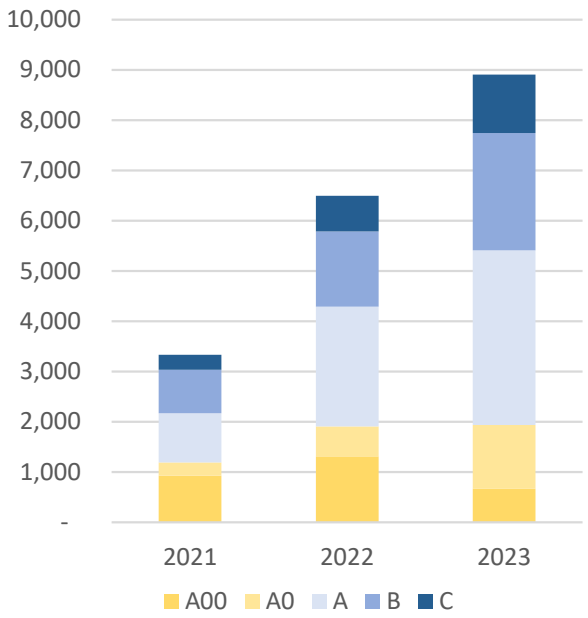
Source: OIES 2024; data from CAAM 2024

- 32% of sales are priced at RMB 150,000 – 200,000 (roughly US$ 24,000 – 30,000)
- All categories showed strong growth, led by mid-range categories

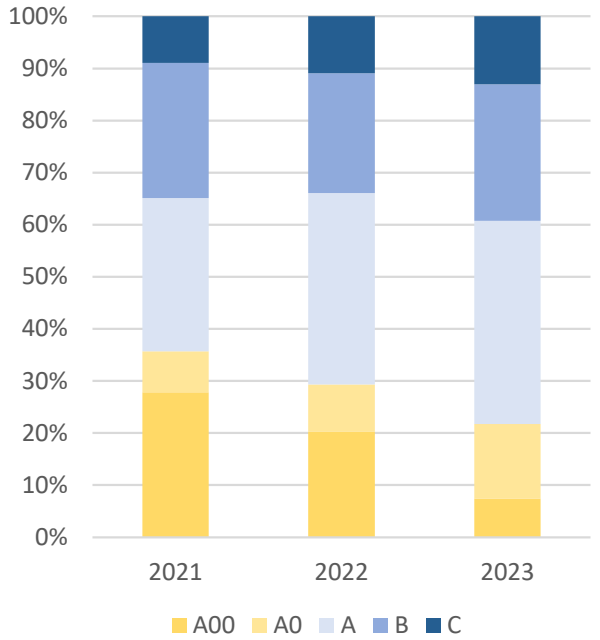
Larger-size NEVs showed strongest growth

China NEV sales by size category, 2021 to 2023

EV sales by size category (thousands)



EV sales by size category (%)

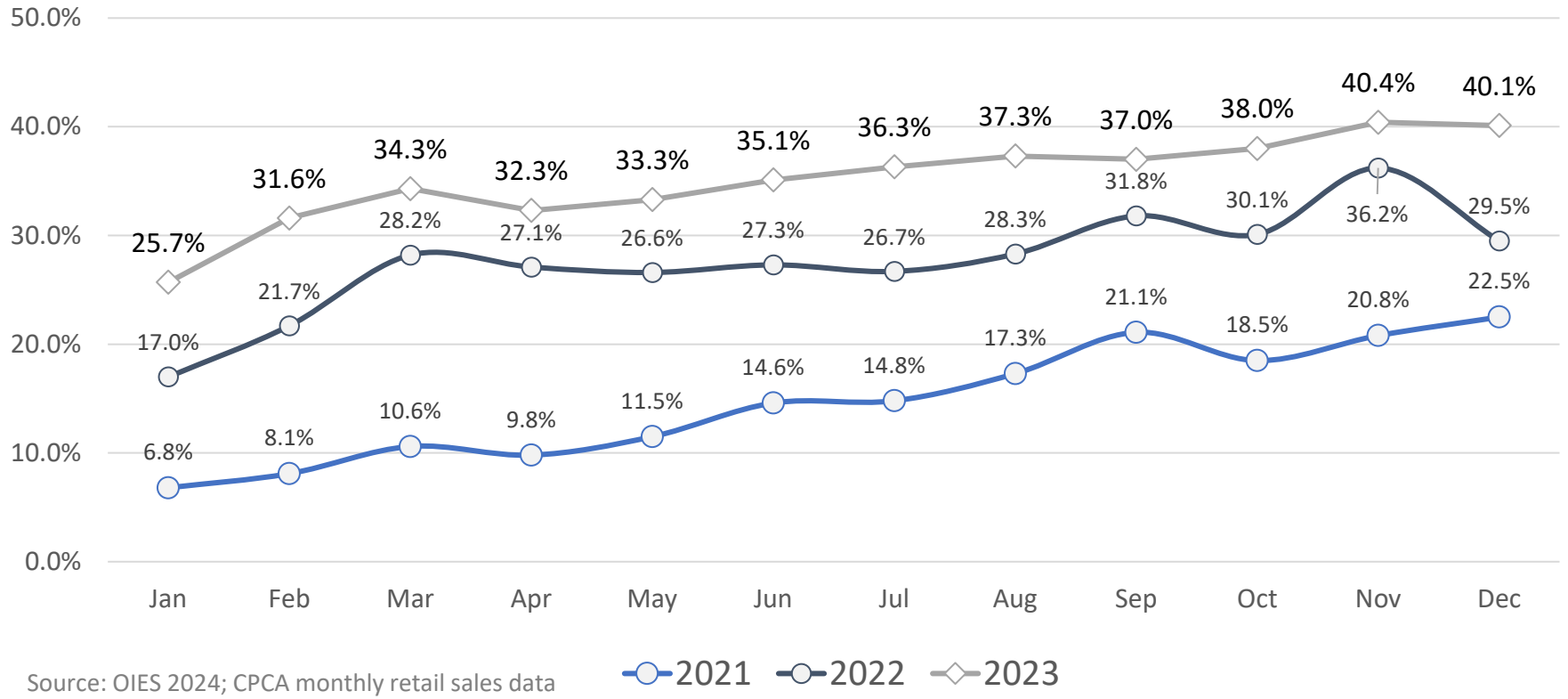


Source: OIES 2024; data from CAAM 2024

- Micro-EVs (class A00) continued to lose market share, while other categories grew
- Strongest growth of A-class vehicles (includes sedans, crossovers, small SUVs)

Monthly market share already 40%

Monthly passenger NEV market share, 2021 to 2023

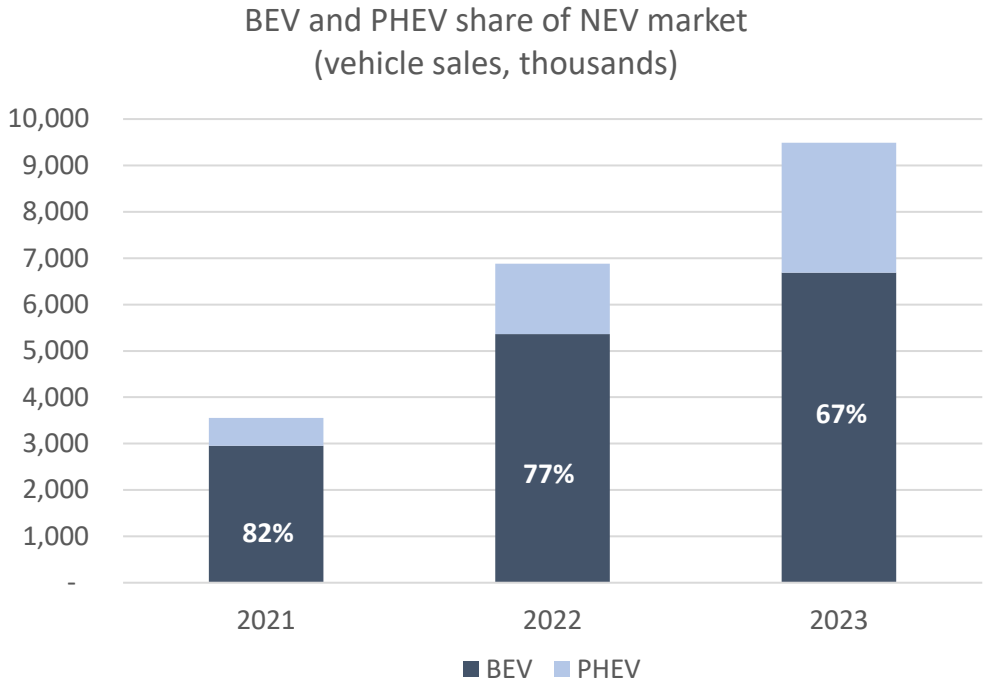


Source: OIES 2024; CPCA monthly retail sales data

- NEV market share increased by 10 percentage points for the full year
- Monthly share rose a similar amount, ending above 40% in Nov-Dec

PHEV share growing as NEVs get larger

China NEV sales by battery category, 2021–2023, thousands

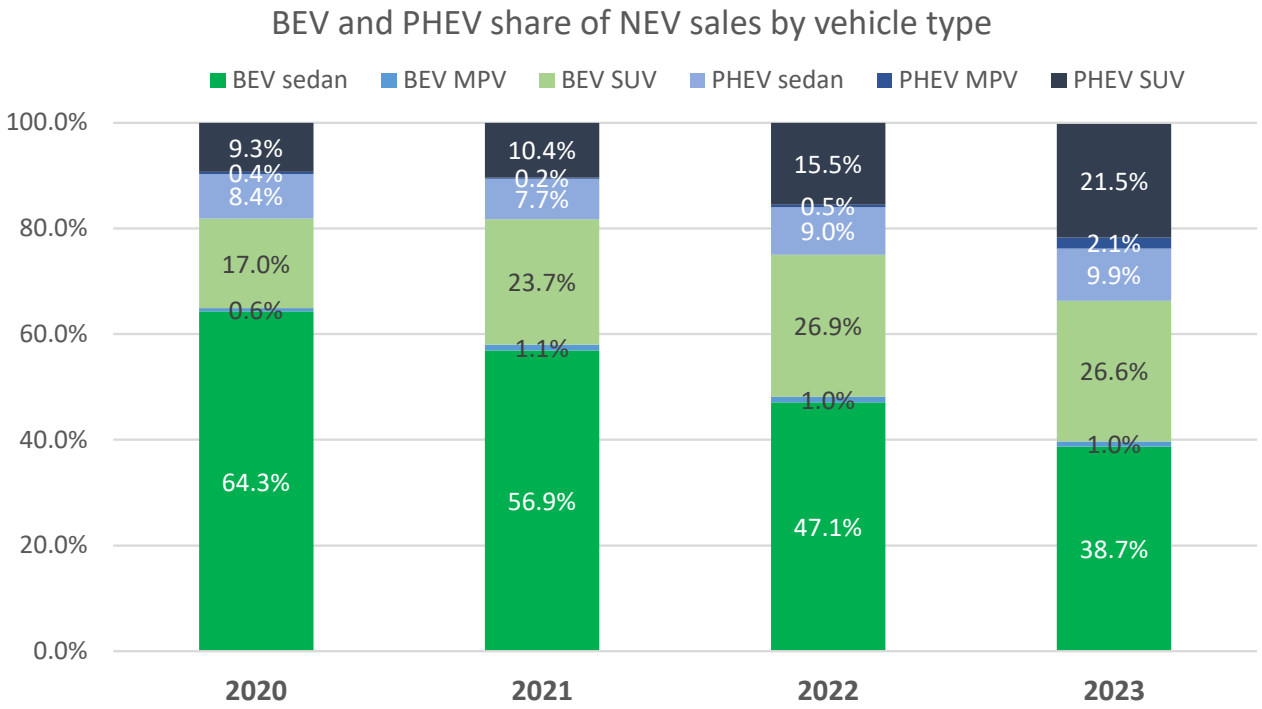


Source: OIES 2024, based on CAAM 2024 data

- PHEV sales grew by around 80%, compared to 20% for pure EVs
- PHEV's grew 150% in 2022, and have grown 5x since 2021 (compared to 2x for BEVs)

PHEV share growing as NEVs get larger

China NEV sales by size category, 2020 to 2023, percent

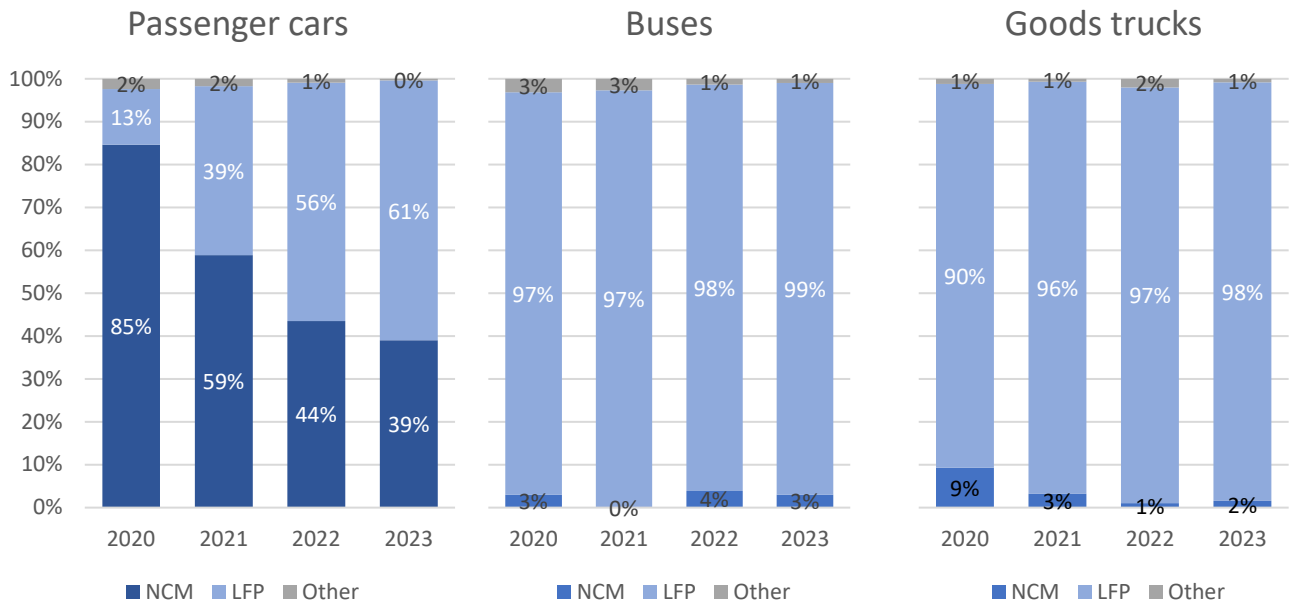


Source: OIES 2024; data CPCA 2024

- PHEV sales are capturing a larger market share mainly due to MPV and SUV categories
- However, SUV sales are also rising for BEV models, and BEV SUVs outnumber PHEV SUVs
- BEV sedans have seen the largest share decline, though absolute sales still rose 12% in 2023

LFP greatly increased its market share

China NEV battery consumption, LFP versus NMC, 2020-2023



2022:

LFP
125-135
Wh/kg

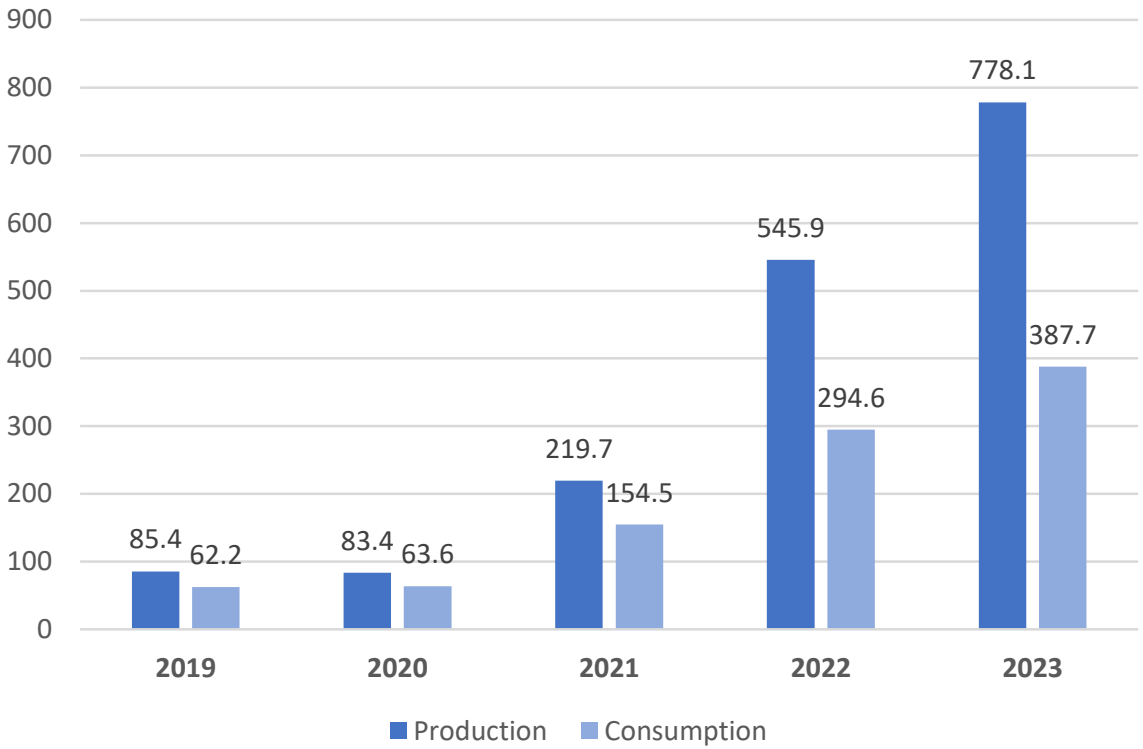
NMC
145-160
Wh/kg

Source: CPCA and Kerui Consulting, Jan 2024

- Passenger BEVs account for 75% of vehicle battery capacity consumption, buses 7%, PHEVs 17%
- LFP continues to expand market share in passenger car segment, reaching 2/3 share
- LFP sales in vehicles grew 42% by GWh capacity, compared to 14% for NMC

Battery production surging, overcapacity looms

China NEV battery production versus domestic consumption (GWh)



Source: OIES 2024; ESCN, Jan 2024 (2023 data); EV100, 2023 (historical)

- China exported 152 GWh, of which car batteries accounted for 87%; growth 85%+
- CBEA expects production of 1100 GWh in 2024, an increase of roughly 25%
- In 2023, sodium-ion and solid-state battery output started, still under 1 MWh/year

Falling battery materials costs to sustain growth

Comparison of key EV inputs: year-end 2022 versus 2023

	2022	2023	change
Lithium carbonate	RMB 600k/tonne	RMB 100k/tonne	-83%
Nickel	USD 30k/tonne	USD 16k/tonne	-45%
Synthetic graphite	RMB 51k/tonne	RMB 42k/tonne	-18%
Natural graphite	RMB 48k/tonne	RMB 33k/tonne	-31%
LFP electrolyte	RMB 5.3	RMB 1.9	-63%
NMC cell	RMB 0.92/Wh	RMB 0.515/Wh	-44%
LFP cell	RMB 0.825/Wh	RMB 0.42/Wh	-48%

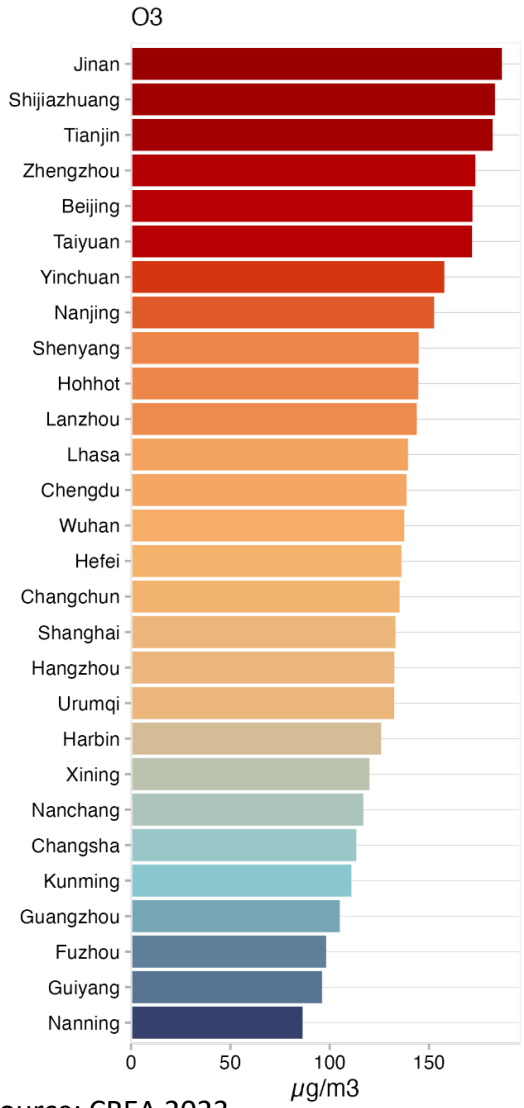
Source: OIES 2024, CBEA 2024

- CBEA expects battery cells to reach RMB 0.3/Wh in 2024
- Lower capacity utilization expected, even with retirement of outdated production lines
- Industry optimistic on growth, willing to cut prices to retain market share

China only gradually increasing national NEV goals

- Official target for 2025 remains 20% market share for NEVs, set in 2020
- December 2023 Beautiful China policy included target of 45% for 2027
- November 2023 MIIT document suggested 65% for 2030
- Recent policy targeting overcapacity in NEVs

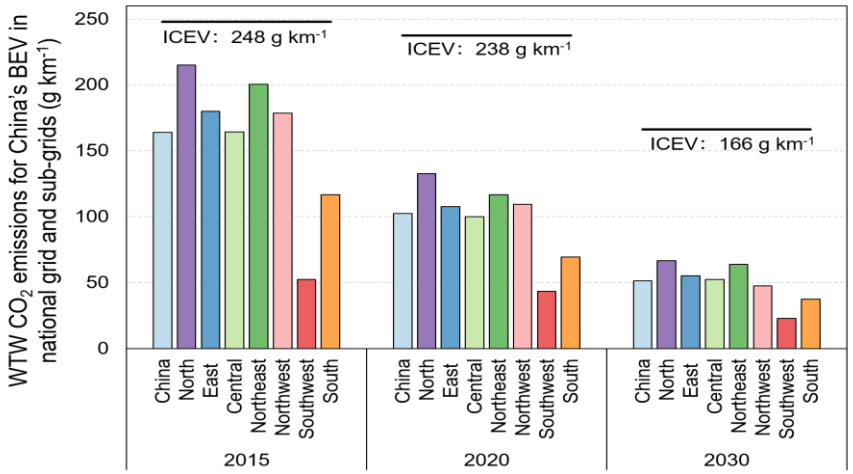
- Air quality targets may encourage cities to boost NEV policies, license plate lotteries
- Summer ozone an increasing air quality concern; NOx and VOC emissions from vehicles are a more important driver compared to PM2.5 (mainly caused by coal consumption in industry and heating sectors)



Source: CREA 2023

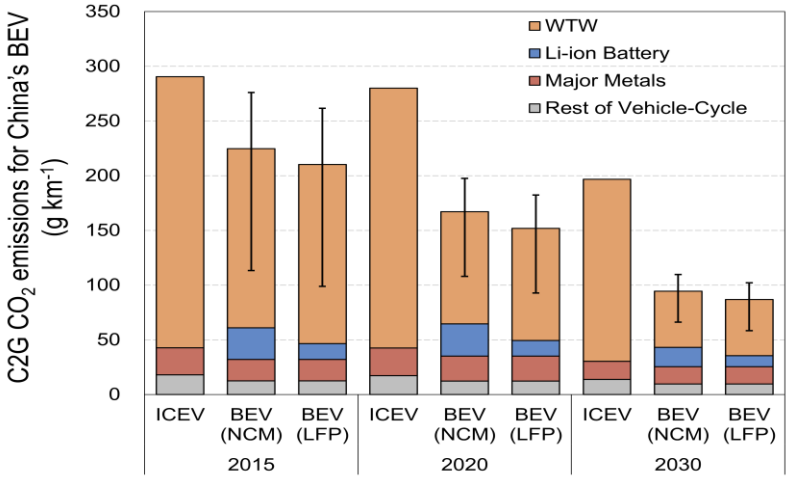
EV adoption contributes to carbon neutrality goals

EV, ICEV life-cycle well-to-wheels CO_2, 2015-2030



Source: Tsinghua School of the Environment, 2022

CO_2 of different battery types, 2015-2030

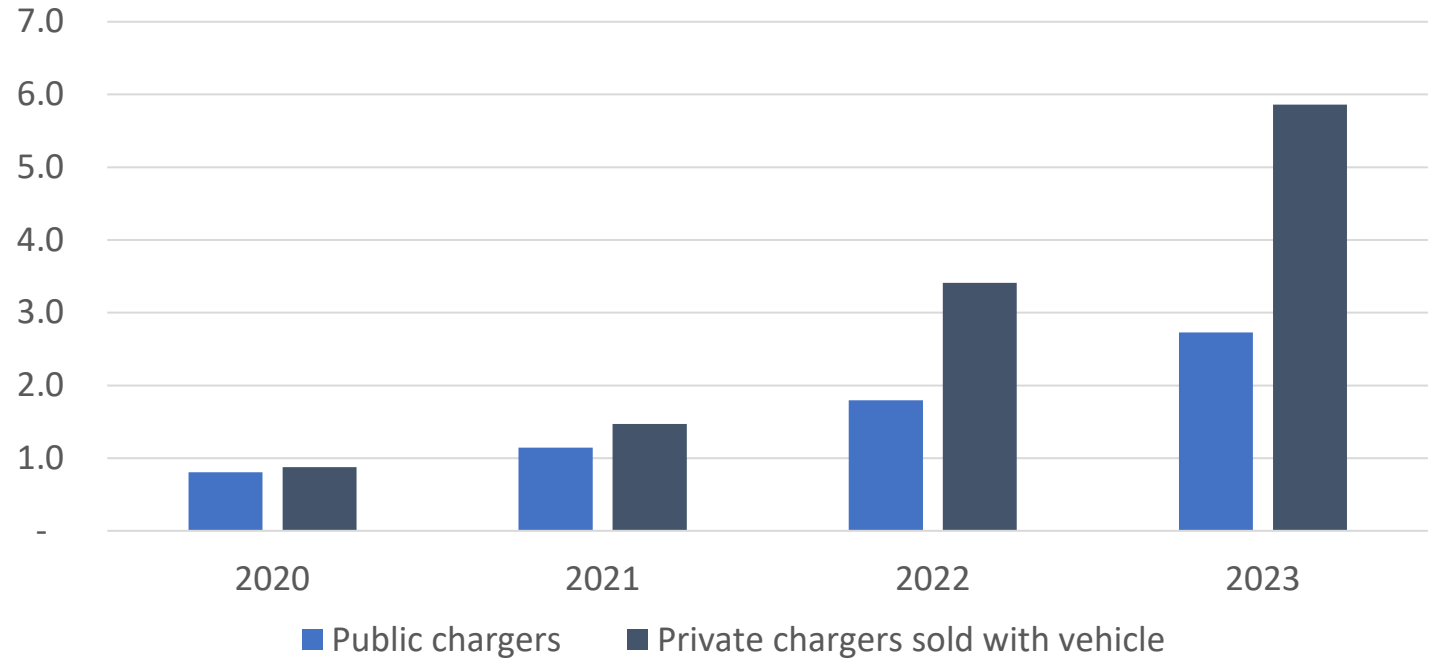


Source: Tsinghua School of the Environment, 2022

- NEV push initially began as an industrial strategy, but increasingly can contribute to carbon targets
- EV life-cycle emissions falling dramatically due to improved energy density, lower grid carbon
- EV emissions are at least 40% lower than ICEV emissions in all regions of China
- This assumes EV charging uses the average kWh produced by the grid in these regions, and does not account for time-of-use charging characteristics

Charging infrastructure grew at pace

China cumulative charging installations

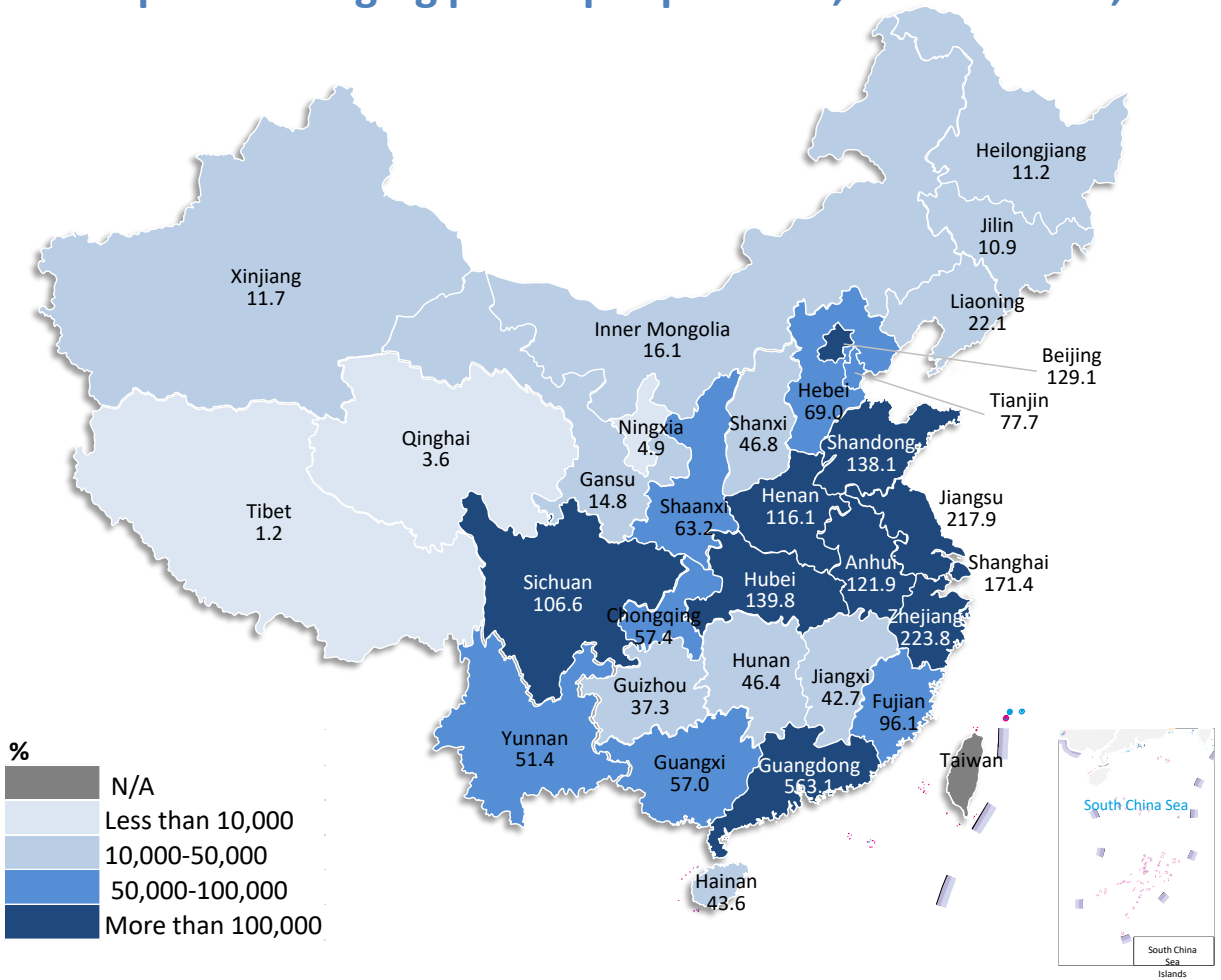


Source: OIES 2024, based on EVCIPA 2024

- EVCIPA estimates China has 2.7 million public chargers, of which 1.2 million are DC chargers
- In 2023, 3.45 million chargers were sold together with the vehicle, suggesting around 40% of new EV and PHEV buyers have private charging
- Numbers likely omit some private chargers installed separately

Coastal provinces lead on charging infrastructure

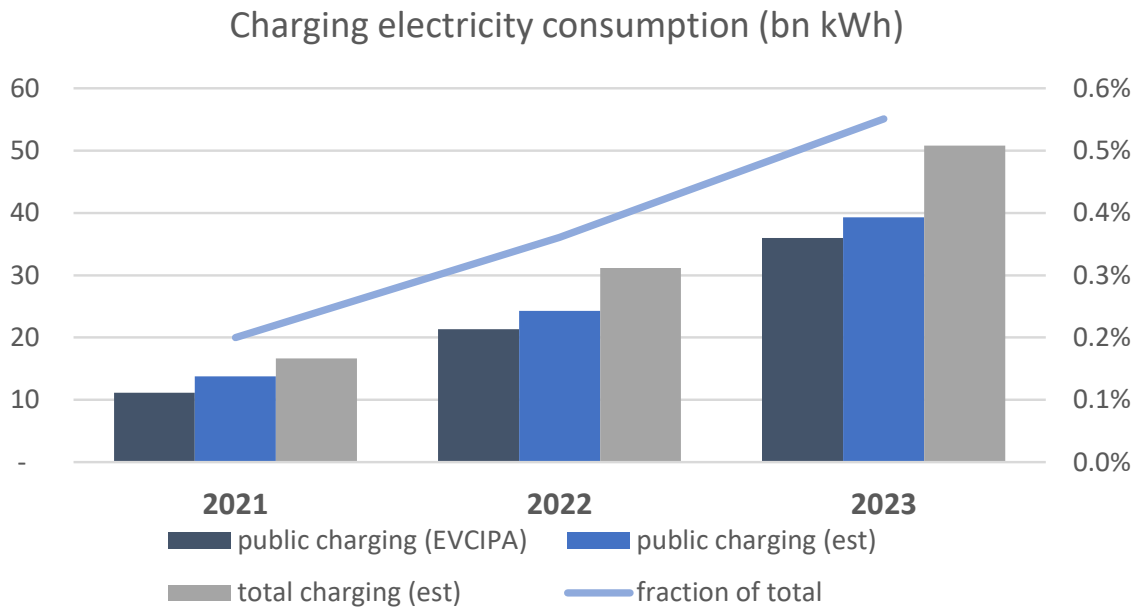
Number of public charging points per province, in thousands, 2023



Source: OIES 2024, based on EVCIPA data; the depiction and use of boundaries shown on the map are not warranted to be error free nor do they imply endorsement of OIES

Public charging electricity use fairly modest

China NEV public charging electricity consumption rising quickly

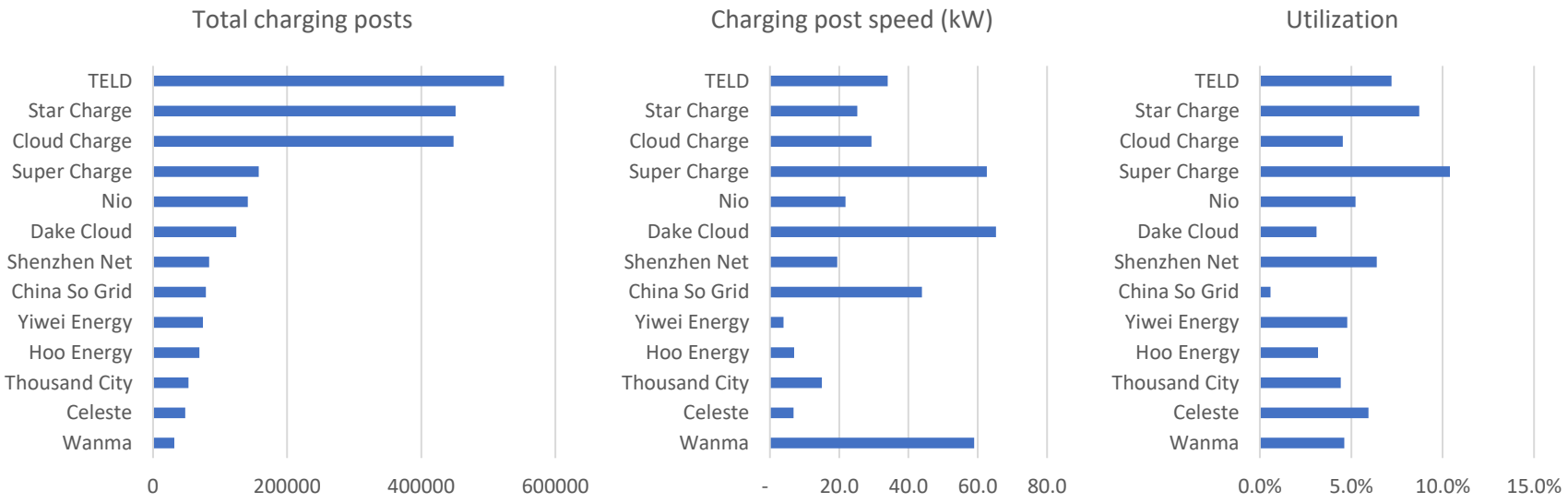


Source: OIES 2024; EVCIPA data

- Public chargers delivered 35 billion kWh in 2023, up 69% year-on-year, using EVCIPA data
- Including estimates for State Grid and private charging, this could be around 50 billion kWh
- This higher estimate is around 0.5% of China's full-year electricity consumption (=250,000 bbl/day)
- Assuming 20 million NEVs at year-end, December consumption represents 190 kWh per vehicle, sufficient for 1000 km – suggesting large fraction of drivers use public charging regularly

Utilization numbers are low

Average Chinese charging post:
30 kW, charges 39 kWh per day, used 77 minutes per day



Source: OIES 2024, based on EVCIPA 2024

- Previously utilization reported at around 10%
- Calculation from EVCIPA data suggests utilization around 5% for public chargers
- Average Chinese charging post has a charge rate of 30 kW, charges 39 kWh per day, for around 77 minutes per day – implies around 2-3 customer sessions per day

Charging payment seamless, but given low utilization, operations and maintenance not always good

At left, CAMS charger with WeChat QR code for unlocking space, payment

Below, non-operating X-Charge station shown as available in car navigation, apps

Source: Anders Hove photos, Beijing, 2022

- Interoperability: Most EV charging uses WeChat or AliPay, does not require app download or RFID card
- Apps and chargers still don't communicate, broken chargers still shown as visible on apps
- Charging providers have inadequate incentive to maintain chargers or communicate with apps
- Battery swap has issues with queues and is limited to certain brands

Chinese automakers are jumping into V2G

V2G / V2L prior to 2022:
- Nissan
- Renault
- Kia
- Mitsubishi

V2G / V2L in 2023:
- Nissan
- Renault
- Kia
- Mitsubishi
- Ford
- VW / Porsche
- Rivian

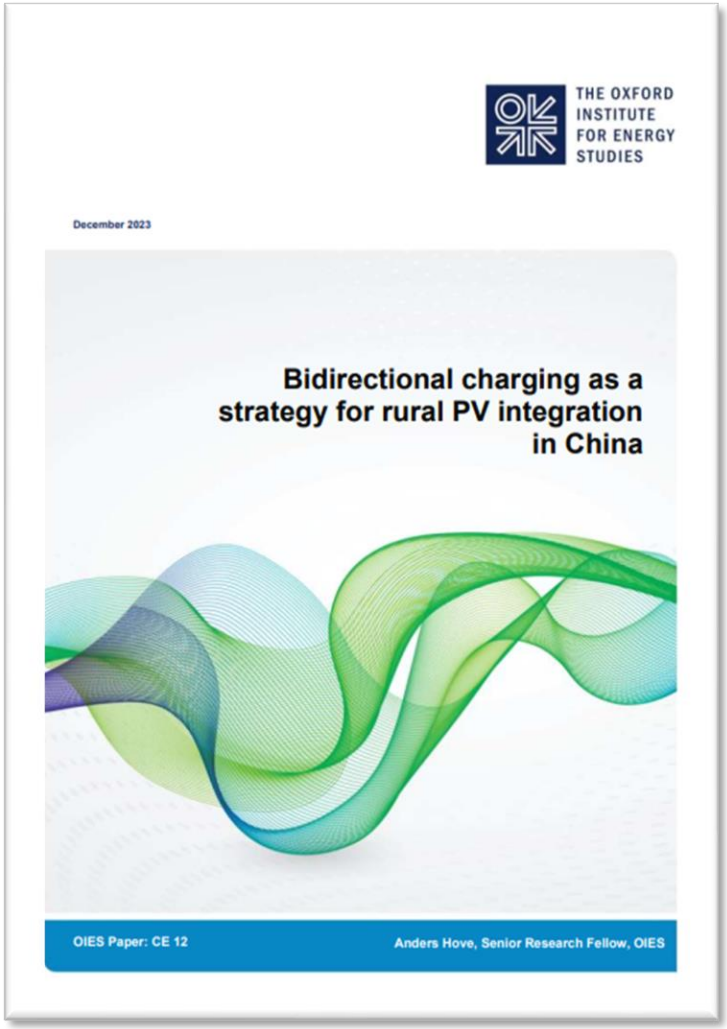
V2G / V2L in 2025:
- Nissan
- Renault
- Kia
- Mitsubishi
- Ford
- GM
- Hyundai
- VW / Porsche
- Rivian
- Great Wall Motors
- BYD
- Geely
- FAW
- Xiaopeng
- NIO
- Seres Automobile
- GAC Aon

- Note: the cost of making a vehicle V2G-capable is minimal compared to the cost of the charger
- Prior to 2022, there were no consumer V2G chargers in the market except for Nissan Leafs under the Chademo standard

V2G frequently mentioned in policy documents

- 电力需求侧管理办法: 征求意见稿 [Electricity Demand-side Management Rules: Draft for Comment], National Development and Reform Commission, 5 March 2023
- 关于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 [Opinions on Accelerating Charging Infrastructure Construction and Increasing Support for New Energy Vehicles in the Countryside and Implementing the Rural Revitalization Programme, National Development and Reform Commission and National Energy Administration, 14 May 2023
- 关于进一步构建高质量充电基础设施体系的指导意见 [Opinions on Further Building Out Charging Infrastructure System], China State Council, 8 June 2023
- 关于实施农村电网巩固提升工程的指导意见 [Opinions on Raising the Quality of Rural Electricity Grid Stability], National Development and Reform Commission, National Energy Administration, and National Rural Revitalization Department, 4 July 2023
- 加强新能源汽车与电网融合互动的实施意见 [Strengthening NEV Grid Interaction], NDRC, NEA, MIIT, December 2023: policy mentions target of 5 demo cities and 50 local pilots for bidirectional charging

2023 OIES study of V2G paired with rural PV



- V2G has potential to help absorb over-production of solar in rural areas
- Rural vehicles well-suited for V2G given more sporadic driving patterns
- Under present time-of-use prices and solar tariffs, V2G revenues insufficient to incentivize adoption
- Current policy does not permit individuals to engage in V2G or V2H; only aggregators and pilots active

https://www.oxfordenergy.org/publications/bidirectional-charging-as-a-strategy-for-rural-pv-integration-in-china/

Conclusions

- Despite slower growth, China's NEV market continues to expand, and is on track to surpass 50% market share for new vehicles in the next 18 months
- NEV sales are expanding for almost all market segments, but the most rapid growth is among PHEVs for larger vehicles, though PHEVs are still a minority of NEV sales volume
- Under either a rapid or slower growth scenario, NEVs are set to surpass 50% of the total vehicle stock by the early 2030s
- Battery output is expanding faster than the NEV market, and the slowdown in NEV sales growth has resulted in lower materials prices, which could sustain lower prices for larger batteries needed for the mass market, as well as exports
- Charging has expanded enormously, but utilization is low; electricity statistics suggest EV owners rely heavily on public charging, using electricity sufficient to travel 1000 km per month
- Chinese EV brands and policy makers are focused on smart charging as well as bidirectional charging, though efforts are limited to pilots

2024 EV research questions

- **China's role in EV critical minerals** supply chains, policies, markets, and institutions. How has China achieved dominance, what is the outlook and what does it mean for foreign companies and governments?

- **China's EV innovation under Western pressure for shifting supply chains:** This research examines how China became dominant in EV technology, and how current global trade and industrial policy trends might affect this innovation dominance.

- **Continuous updates on progress towards deploying V2G:** In 2023, published 2 papers on V2G for integrating rural distributed solar. In 2024, follow progress of local pilots.

About the OIES China Programme

- Launched in 2019, the OIES China Energy Research Programme, is a centre of analytical excellence offering **insights into the factors that inform China's energy policies and choices** and their pivotal role in global energy markets.
- Providing **academic expertise and rigor to inform business players and governments** on China's energy policies, on clean energy advances and challenges and on their implications for markets.
- **Independent experts** with decades of **experience working in and with China**, with extensive contacts in the private sector, government and NGO community in Europe, the US and China.
- **Research Fellows** include: Michal Meidan, Anders Hove, Philip Andrews-Speed, Yan Qin, David Sandalow, Kevin Tu and Brad Simmons.
- The China programme also draws on the wider OIES network, offering a **unique combination of deep technical energy expertise with extensive China knowledge.**

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