Comment

Supplementary information to:

Affordable mobility for all: why we need smaller, cheaper electric vehicles

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This Supplementary information comprises:

1. Sales data collection for the graphic ‘Small vehicles, big opportunity’
2. Assumptions and data used to estimate carbon emissions savings by low-speed EVs
3. Methodology for estimating the cost of low-speed EVs
4. References
5. CRediT information

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1. Sales Data Collection for the figure 'Four-wheeled low-speed EV sales and implied annual emission savings from new sales'

A continuous, unified official time series for four-wheeled low-speed EV sales in China is not available. Official statistics cover only the early years of the market (2011–2016), with no subsequent data released by authoritative sources. To provide the most complete historical picture possible and to support the analysis of long-term market trends and their environmental implications, we undertook a systematic effort to identify and compile data from multiple available sources. The sales data visualized in this figure are therefore drawn from three categories of sources—official institutes, business consulting agencies, and industry media reports—each offering partial coverage of the market's trajectory.

We acknowledge the inherent heterogeneity of these sources and have taken several steps to ensure transparency and to address potential concerns about data reliability and comparability. First, we clearly distinguish between data types throughout the figure and its accompanying notes. Second, where multiple estimates exist for the same period (2017–2022), we report the range and use averaged values to mitigate single-source bias. Third, for the most recent period (2023–2024), we adopt a conservative estimation approach informed by available intelligence and field observations, with full disclosure of our methodology. Detailed data sources, assumptions, and limitations are provided below.

1.1. Sales Data from official institute (2011–2016)

Table 1 (2011–2016) is sourced from the Annual Report on New Energy Vehicle Industry in China, compiled by the China Automotive Technology & Research Center (CATARC)[1]. The CATARC is a research institute established in 1985, aiming to meet China's need of managing the automotive industry, and now belongs to the Assets Supervision and Administration Commission of the State Council, P. R. China. These official statistics, reported in the unit of 10,000-vehicle, document the early growth phase of four-wheeled low-speed EV sales during this period.

Table 1. Four-wheeled low-speed EV sales (2011–2016)

Year	2011	2012	2013	2014	2015	2016
Vehicles (10,000 units) [1]	6.80	9.60	34.40	40.40	58.80	103.20

1.2. Sales Data from business consulting agencies (2017–2022)

For the period 2017–2022, no official sales data have been published. Table 2 therefore draws on datasets from established business consulting agencies including Zhiyan Consulting[2] and

GuanYan Report[3]. These platforms provide annual sales estimates for four-wheeled low-speed EVs, also in units of 10,000 vehicles. While figures vary somewhat across sources—reflecting differences in estimation methodologies and market definitions—both sources consistently capture the same overarching market trajectory: a peak in 2017–2018 followed by a sustained decline. To reconcile inter-source differences and present a balanced estimate, we report the values from each source and calculate the annual average. The close alignment between the two series and the smooth transition from the 2016 official figure to the 2017 average support the coherence of the combined dataset.

Table 2. Four-wheeled low-speed EV sales (2017–2022)

Year	2017	2018	2019	2020	2021	2022
Vehicles (10,000 units)[3]	134.40	132.20	84.00	70.90	31.70	29.90
Vehicles (10,000 units)[4]	135.80	125.10	86.70	73.20	34.80	33.40
Average (10,000 units)	135.10	128.65	85.35	72.05	33.25	31.65

1.3. Sales Data for 2023–2024: Authors' Estimates

As of the time of writing, neither official statistics nor published reports from business consulting agencies are available for 2023–2024. To extend the time series to the most recent period, we consulted industry media and market intelligence sources. Several outlets reported estimated annual sales in the range of 300,000–350,000 units[4,5], suggesting that the market may be stabilizing after several years of decline. To assess the credibility of these reports, we conducted field observations in Shandong and Henan provinces—two major markets for low-speed EVs—during December 2024 and January 2025. Observations of showroom activity, dealer interviews, and local market conditions were broadly consistent with the reported range.

Accordingly, we adopt a conservative assumption of 300,000 units for both 2023 and 2024. This figure represents the lower bound of the reported range and is intended to avoid overstatement of recent market size while capturing the apparent stabilization trend. We emphasize that these are informed estimates rather than precise measurements, and we have taken a deliberately cautious approach in their derivation.

2. Assumptions and data used in estimating the carbon emissions savings by low-speed EVs

To estimate the carbon emissions reductions achieved by low-speed EVs, we make several key assumptions based on available data and technical specifications. First, the average monthly travel distance for these vehicles is taken as 488 km (approximately 16.3 km per day)[6]. Next, to account for emissions from electricity consumption, we refer to 2022 grid emission factors published by the Ministry of Ecology and Environment, P. R. China[7]. In 2022, the national average is 0.5366 kg CO_2/kWh, but regional factors differ depending on local electricity production sources: for example, 0.7252 kg CO_2/kWh in coal-reliant Hebei province and 0.1073 kg CO_2/kWh in Yunnan province, which utilizes abundant hydropower.

Regarding vehicle configuration, a typical low-speed EV is assumed to have a 60 V, 60 Ah battery paired with a 3 kW motor, allowing an average speed of 25 km/h and a range of roughly 60 km per full charge. Based on its operational characteristics, we derive an ideal energy consumption rate of 0.06 kWh per km, which translates to approximately 0.525 kg CO_2 per day and 191.56 kg CO_2 per year (365 days) under the national average grid emission factor (258.87 kg per year in Hebei, 38.3 kg per year in Yunnan). We compare these electricity-based CO_2 emissions with those of an equivalent fossil-fueled vehicle traveling the same distance.

Burning 1 L of gasoline produces around 2.3 kg CO_2[8]. Assuming a comparable gasoline vehicle consumes 8.5 L per 100 km, it travels 16.3 km per day would emit approximately 3.19 kg of CO_2 per day, or 1,164.35 kg of CO_2 annually (365 days). Consequently, switching to a low-speed EV reduces annual emissions by about 972.79 kg of CO_2 under the national average grid emission factor (905.48 kg in Hebei, and up to 1,126.05 kg in Yunnan), indicating that the emissions savings in Yunnan are approximately 16% greater than those under the national average grid factor. These results underscore the significant decarbonization potential of low-speed EVs, particularly in regions with cleaner energy grids.

To provide a comprehensive 14-year view (2011–2024) as shown in the figure 'Four-wheeled low-speed EV sales and implied annual emission savings from new sales', we used Ember's historical series of China's electricity carbon intensity and rescaled it to match the official national average grid emission factors published by the Ministry of Ecology and Environment, then treated the adjusted series as a proxy for grid emission factor[7,9]. In 2022, Ember reports 586.75 gCO_2/kWh, while the Ministry of Ecology and Environment reports 536.6 gCO_2/kWh. To reconcile this difference, we calculated a single scaling factor based on the 2022 gap (approximately 0.914) and applied it to Ember's full 2011–2024 series, thereby deriving a calibrated time series of China's national-average grid emission factor.

With the calibrated grid emission factors seriers established, we then followed the same methodology used for the per-vehicle emissions-savings calculation described above, applying each year's adjusted grid factor to the low-speed EV's electricity consumption and comparing the resulting annual EV emissions against the fixed gasoline-vehicle baseline. This produces a year-specific per-vehicle savings series. Finally, to generate the total emission-savings bars in the figure, we multiplied each year's per-vehicle savings by the corresponding annual vehicle sales, and implied annual emission savings from new sales.

Table 3. Four-wheeled low-speed EV sales and estimated carbon dioxide and implied annual emission savings from new sales (2011–2024)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Vehicles (10,000 units)	6.8	9.6	34.4	40.4	58.8	103.2	135.1	128.65	85.35	72.05	33.25	31.65	30	30
Grid carbon intensity (Ember, gCO_2/kWh)	752.36	720.28	717.51	693.85	667.85	651.76	644.21	636.89	619.63	606.29	599.05	586.75	583.04	555.4
Calibrated grid emission factor (gCO_2/kWh)	688.06	658.72	656.18	634.55	610.77	596.05	589.15	582.45	566.67	554.47	547.85	536.6	533.21	507.93
Low-speed EV annual emissions (kg CO_2/vehicle·year)	245.62	235.14	234.24	226.51	218.03	212.77	210.31	207.92	202.28	197.93	195.57	191.55	190.34	181.32
Per-vehicle annual savings (kg CO_2/vehicle·year)	918.73	929.21	930.11	937.84	946.32	951.58	954.04	956.43	962.07	966.42	968.78	972.8	974.01	983.03
Implied annual emission savings from new sales (Mt CO_2/year)	0.06247	0.0892	0.31996	0.37889	0.55644	0.98203	1.2889	1.2304	0.82112	0.69631	0.32212	0.30789	0.2922	0.29491

3. Methodology for estimating the cost of low-speed EVs

The cost estimation of low-speed EVs begins with a component-based analysis, reflecting their simplified design and reliance on mature technologies evolved from China's e-bike industry. Core structural elements, such as the steel or aluminum chassis, form the foundation of the vehicle, with steel frames costing approximately 2,000–3,000 CNY due to material affordability, while aluminum variants increase expenses by 20–30%. The powertrain, comprising a 3–5 kW electric motor and controller, accounts for 1,500–2,500 CNY, balancing performance needs with budget constraints. Energy storage remains a critical cost driver: lead-acid batteries (60V/60Ah) at 600–1,000 CNY align with the target budget, whereas lithium-ion alternatives (1,000–2,000 CNY) exceed it. Ancillary systems, including braking, lighting, wiring, and basic interiors (seats, dashboards), add 2,500–3,500 CNY, emphasizing functional minimalism over luxury.

Assembly and labor costs further shape the total expenditure. Final integration of subsystems into the rolling chassis benefits from China's established manufacturing infrastructure, with labor expenses estimated at 500–1,000 CNY per unit, leveraging streamlined processes inherited from e-bike production. Economies of scale play a pivotal role, as bulk procurement of standardized components (e.g., motors, batteries) and localized supply chains reduce per-unit costs by 10–15% at production volumes exceeding 10,000 units annually. This scalability mirrors the evolution of low-speed EVs from their e-bike predecessors, where high-volume output enabled affordability while addressing practical demands like cargo capacity and weather protection.

Prioritizing steel frames and lead-acid batteries minimizes upfront material expenses, while omitting advanced electronics or premium interiors preserves functional simplicity. Regulatory advantages further reduce costs, as low-speed EVs often bypass stringent safety certifications required for highway vehicles. Key assumptions underpinning this model include stable raw material prices (e.g., steel at ~4 CNY/kg), consistent labor rates (~30–50 CNY/hour in regional manufacturing hubs), and uninterrupted supply chains. While this budget-oriented approach limits technological sophistication, it aligns with the historical ethos of low-speed EVs as accessible mobility solutions, balancing utility and affordability for urban and rural users.

4. References

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CRediT information

Linni Jian and Yunwang Chen contributed equally to this work. Linni Jian led the conceptualization, provided supervision, developed the methodology, administered the project, and contributed to review and editing of the manuscript. Yunwang Chen conducted the investigation, performed the formal analysis, wrote the original draft and contributed to review and editing of the manuscript. Ching-chuen Chan provided guidance and feedback for the study and administered the project. All authors discussed the results and contributed to the final version of the manuscript.