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# Analysis of Battery Range Problems and Countermeasures for Improvement in New Energy Electric Vehicles

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**ABSTRACT**
Insufficient range, as a core pain point in the development of new energy electric vehicles (EVs), profoundly affects user acceptance and market penetration process. This paper focuses on the battery range issue, systematically analyses the causes of range degradation from the dimensions of technical bottlenecks, environmental constraints, usage habits and supporting systems, and puts forward a comprehensive countermeasure system covering battery technological innovation, thermal management system upgrading, charging infrastructure improvement, user habit guidance, and policy synergy, with the aim of providing theoretical support and practical paths for the enhancement of EV range capability and user experience.

**KEYWORDS**
New energy electric vehicles; Battery life; Range degradation; Enhancement countermeasures; Battery technology

## 1 Introduction

With the acceleration of the global energy transition and the promotion of the "dual-carbon" goal, new energy electric vehicles (NEVs) have seen explosive growth. However, as a core performance indicator, range is always the focus of consumers' attention and the difficulty of industrial breakthrough. The significant gap between the real range and the nominal value, the "cut" of the range in winter, and the anxiety of long-distance travel seriously constrain the user experience and market confidence. Therefore, in-depth analysis of the factors affecting battery range and exploration of scientific and effective improvement paths are of key significance in promoting the high-quality development of the NEV industry.

## 2 The key constraints of new energy electric vehicle battery life

### 2.1 Battery technology bottleneck: energy density and material stability difficulties

Energy density ceiling: the current mainstream lithium-ion battery (ternary, lithium iron phosphate) energy density improvement tends to slow down, the physical and chemical limit constraints are obvious. Enhancement of battery capacity is often to increase the weight and volume at the expense of the vehicle design challenges.

Material stability challenges: high-energy density materials (such as high-nickel ternary) are prone to thermal runaway risk under extreme operating conditions; lithium dendrite growth may lead to internal short circuit, threatening safety and reducing the effective capacity; long-term charging and discharging cycles to accelerate the structural degradation of electrode materials (such as positive electrode material dissolution, negative electrode SEI film thickening), resulting in a continuous capacity degradation (usually about 2-3% per year decline).

### 2.2 Ambient temperature effect: the "range killer" of low temperature

Low-temperature performance plummet: under low-temperature environment (especially below 0℃), the electrolyte viscosity increases, ionic conductivity decreases, the internal chemical reaction rate of the battery decreases significantly, and the usable capacity decreases drastically (the range of some models shrinks up to 40% -50% at -20℃).

Dramatic increase in temperature control energy consumption: in order to ensure that the battery works in the appropriate temperature range (usually 15℃ -35℃) and to meet the heating needs of the passenger compartment, PTC heating or heat pump air conditioning systems need to consume a large amount of battery energy, which further squeezes out the driving range.

### 2.3 Driving behaviour and vehicle use: the neglected "mileage losses"

Impact of driving style: Energy-intensive driving behaviours such as rapid acceleration and hard braking significantly increase power consumption; wind resistance energy consumption increases by a factor of one when driving at sustained high speeds (>100km/h).

Load and Accessory Consumption: In-vehicle electrical appliances such as air-conditioning (especially cooling/heating), high-power stereo, seat heating/ventilation, etc. continuously consume electric energy; increased vehicle load directly increases driving resistance.

Energy Recovery Efficiency: Brake energy recovery system setup strategy and driver's operating habits affect the recovery efficiency, and efficient recovery can significantly extend the range (especially in congested road conditions).

### 2.4 Charging infrastructure and management strategies: a test of efficiency and convenience

Charging anxiety and conservative strategies: Insufficient coverage of public fast charging stations, time-consuming queues, and slow charging speeds (especially in low temperatures) cause user anxiety and lead to "power panic", forcing drivers to reserve more redundant power, which shortens the usable range in disguise.

Battery Management System (BMS) Limitations: In order to protect battery life and safety, BMS usually limits charging and discharging power ("power clamping") at extreme temperatures or low battery levels, which affects vehicle performance and energy utilisation efficiency.

## 3 Comprehensive countermeasures to enhance the battery range of new energy electric vehicles

### 3.1 Breakthrough battery core technology, improve energy density and cycle life

Accelerate the industrialisation of solid-state batteries: invest heavily in the research and development of solid-state electrolyte technology, solve interface impedance, cost and other problems, and strive to achieve early mass production applications. Solid-state batteries have subversive advantages such as higher theoretical energy density (>400Wh/kg), intrinsic safety (no liquid electrolyte leakage, no risk of combustion), and wider operating temperature range.

Development of new battery systems: Layout basic research on next-generation high-energy systems such as lithium-sulfur batteries and lithium-air batteries, so as to reserve long-term technological competitiveness.

Optimise the existing lithium battery system: Continuously improve anode and cathode materials (e. g. ultra-high nickel anode, silicon and carbon composite anode), develop new electrolyte additives, and optimise the battery structure design (e. g. CTP/CTC technology), so as to enhance the energy density and fast-charging performance, improve low-temperature characteristics, and extend the cycle life.

### 3.2 Strengthen the effectiveness of thermal management to achieve full-range temperature adaptation

Promote high-efficiency heat pump air-conditioning: accelerate the popularisation of heat pump systems in EVs, whose heating efficiency ratio (COP) is much higher than that of traditional PTC (up to 2-3 times), and significantly reduce energy consumption for heating in winter.

Develop an intelligent thermal management system: Integrate the thermal management needs of the battery, motor, electronic control and passenger compartment, and realise waste heat recovery and multi-heat source synergy. Apply intelligent algorithms to accurately predict and dynamically regulate the battery temperature (e. g., preheating before driving and keeping warm during charging) to ensure that the battery is always in the efficient working area.

Explore new temperature control materials and structures: Research the application of phase change materials (PCM) in the control of battery pack temperature uniformity; optimise the design of battery pack thermal barrier and insulation to reduce the temperature control energy consumption in extreme environments.

### 3.3 Optimise user driving and charging strategies to explore energy-saving potentials

Promote intelligent driving assistance and energy-saving guidance: Provide real-time feedback of energy consumption data through the in-vehicle system, and provide economic route planning, driving behaviour scoring and optimisation suggestions; popularise the single-pedal mode, and cultivate users' habits of efficient energy recovery.

Enhance user education and habit cultivation: Popularise scientific knowledge of car use (e.g. reasonable tyre pressure, reduction of non-essential loads, anticipatory driving), guide users to form energy-saving driving habits, and understand the effect of temperature on range.

Improve charging network and enhance user experience: Accelerate the construction of super charging piles (800V high-voltage platform) on highways, in urban core areas and in public places; improve the reliability, compatibility and payment convenience of charging piles; promote "plug and charge", intelligent reservation and staggered-peak charging guidance; and explore the integrated power station of "light storage, charging and discharging". Explore "light storage, charging and discharging" integrated power station, and enhance the power grid synergy .

### 3.4 Deepen the synergy between battery management algorithms and policies.

Develop intelligent BMS and range prediction: apply big data and AI algorithms to build an accurate range prediction model (dynamic range display) based on the state of health (SOH) of the battery, real-time working conditions (temperature, load, driving style), and road condition information, so as to eliminate users' "mileage anxiety".

Improve testing standards and information disclosure: Promote testing standards such as WLTC and CLTC to be closer to actual use scenarios; require car companies to clearly label typical range under different operating conditions (especially low temperature) to enhance information transparency.

Strengthen policy support and standard guidance: Increase financial subsidies and tax incentives for the research and development of high-energy-density, long-life and low-temperature-resistant battery technologies; formulate mandatory standards and incentive policies for battery recycling and step-down utilisation, and promote the recycling of resources and the reduction of whole-life-cycle costs.

## 4 Lead-acid batteries

Status: The most traditional, most mature and lowest cost battery technology. Widely used in low-speed electric vehicles (e. g., elderly mobility scooters, electric tricycles), electric bicycles, and starting batteries for fuel vehicles. They have been replaced by lithium-ion batteries in mainstream electric vehicles.

Advantages: low cost; mature manufacturing process, perfect industrial chain; mature recycling system (recycling rate >95%); relatively high safety (not easy to thermal runaway).

Disadvantages: very low energy density (30-50 Wh/kg), resulting in short range and bulky battery packs; short cycle life (300-500 deep cycles); low charging and discharging efficiency; heavy metal lead, environmental pollution risks (need to be strictly recycled).

Lithium-ion battery: (Currently absolute mainstream)

Status quo: Dominates the electric vehicle market (>90%). According to the anode material is mainly divided into:

Lithium iron phosphate: high safety, long cycle life (>3000 times), low cost (cobalt-nickel free), relatively stable raw material supply. In recent years, through structural innovation (such as blade battery) to improve the volume utilisation rate, energy density has increased significantly, in the low-end and economic models accounted for a significant increase.

Lithium ternary: high energy density (>200 Wh/kg, high-end models >250 Wh/kg), good low temperature performance. Mainly divided into NCM (nickel-cobalt manganese) and NCA (nickel-cobalt aluminium), high nickel (such as NCM811) is the main direction to improve energy density. Higher cost (containing cobalt-nickel), slightly worse thermal stability than lithium iron phosphate, high requirements for thermal management system. Mainly used in high-end, the pursuit of long range models.

Advantages: high energy density (significantly improve range); long cycle life (far better than lead acid); no memory effect; low self-discharge rate; high power density (support fast charging and discharging).

Disadvantages: Costs are still significantly higher than lead-acid (although continuing to decline); risk of thermal runaway, requiring a complex and expensive thermal management system (BMS); significant low-temperature performance degradation (especially lithium iron phosphate); bottlenecks and price fluctuations in the supply of raw materials (lithium, cobalt, and nickel); and recycling technologies are still in the process of being developed and scaled up.

Solid-state battery: (important future direction)

Status: In the early stage of R&D and industrialisation, many car companies and battery giants have invested heavily in research and development. Some companies have demonstrated prototypes or small-scale pilot production lines, but large-scale mass production and vehicle loading is still expected to take several years (optimistically estimated to gradually land in 2025-2030).

Advantages: very high theoretical safety (solid-state electrolyte is non-flammable and inhibits lithium dendrites); huge potential for energy density (>400 Wh/kg, hopefully exceeding 500 Wh/kg); support for ultra-fast charging; wider range of operating temperatures; possible to simplify the structure of battery packs (e.g., elimination of cooling systems).

Disadvantages: Extremely high manufacturing costs at present; key technical challenges such as ionic conductivity, interfacial stability (electrode/electrolyte contact), and long-term cycle life of solid-state electrolyte materials (e. g., sulphides, oxides) to be solved; complex production process, and difficulty in large-scale mass production.

Summary: Lead-acid batteries still have a market in specific areas by virtue of their cost and safety advantages, but they cannot meet the needs of mainstream electric vehicles. Lithium-ion batteries are currently the undisputed hegemony, lithium iron phosphate and lithium ternary each have their own strengths, jointly supporting the electrification process. Solid-state batteries represent the future direction, with huge potential, but technology maturity and cost control is the key threshold for industrialisation. In the next few years, lithium technology (especially material system optimisation and structural innovation) will continue to iterate, while breakthroughs in solid-state batteries will gradually reshape the industry landscape. The comprehensive improvement of cost, energy density, safety, life and fast charging performance is the eternal pursuit.

## 5 Conclusion

The improvement of new energy electric vehicle range is a complex system engineering involving material science, electrochemistry, thermal management, power electronics, artificial intelligence and infrastructure construction. The current range dilemma stems from the superposition of multiple factors, such as the intrinsic limitations of battery materials, harsh environmental challenges, differences in user habits and insufficient supporting systems. To solve the problem, it is necessary to adhere to the comprehensive strategy of "technology-based, system optimisation and synergy, user habit guidance, policy environment protection":

In the short term, by optimising the performance of the existing lithium-ion battery system, applying high-efficiency heat pumps on a large scale, vigorously improving the fast charging network, and guiding users to energy-saving driving, we can effectively alleviate "mileage anxiety" and enhance user experience. In the long run, the only way to achieve breakthroughs in the field of disruptive technologies such as solid-state batteries and industrialisation, combined with intelligent thermal management of the entire region and a high degree of synergy in the energy supply ecology, can fundamentally solve the range bottleneck, and to promote the electric vehicle to truly achieve a comprehensive beyond the fuel car, laying a solid foundation for the depth of decarbonisation in the field of transport. Although the road of range enhancement is full of challenges, through the collaborative innovation and unremitting efforts of the industry, academia, research and government, the future of electric vehicles will surely be heading for a farther and freer green journey.

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