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**Global and China Range Extended
Electric Vehicle (REEV) and Plug-in
Hybrid Electric Vehicle (PHEV)
Research Report, 2024-2025**

Dec. 2024

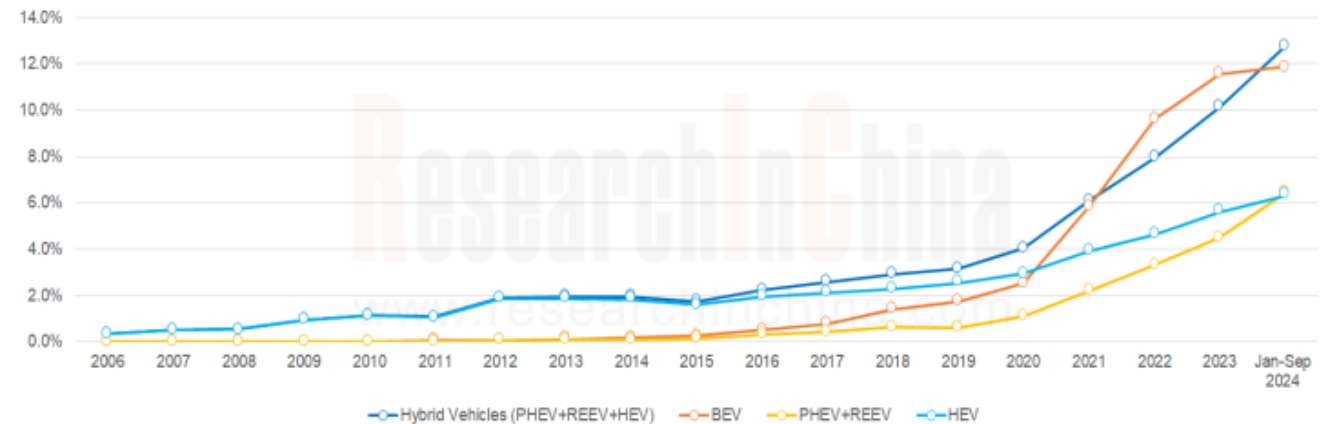
Research on REEV and PHEV: Head in the direction of high thermal efficiency and large batteries, and there is huge potential for REEVs to go overseas

In 2023, 9 million hybrid vehicles (PHEVs+REEVs+HEVs) were sold worldwide, accounting for 10.1% of the total vehicle sales. It is expected that over 12 million hybrid vehicles will be sold in 2024, making up of more than 13.5% of the total sales.

- In 2023, 4 million PHEVs & REEVs were sold worldwide, a year-on-year spike of 49.8%. It is estimated that the sales will reach 6 million units in 2024. From 2020 to 2024, the global sales of PHEVs & REEVs sustained a high annual growth rate, up to 65%, thanks to the boom in the Chinese market.
- In 2023, 5 million HEVs were sold worldwide, jumping by 34.4% year on year. The sales are expected to hit 5.2 million units in 2024. From 2021 to 2024, the global HEV market maintained an average annual growth rate of over 30%.

From January to September 2024, the global sales of plug-in hybrid vehicles including extended range vehicles (PHEVs & REEVs) exceeded general hybrid vehicles (HEVs) for the first time. Compared with HEVs, PHEVs & REEVs save more energy and are greener, and their prices have been much lower than before. It is expected that PHEVs & REEVs will become mainstream among hybrid vehicles to be sold in 2025.

Global New Energy Vehicle Sales Structure by Fuel Type, 2006-2024



Source: ResearchInChina

Global Hybrid Vehicle Sales Structure (PHEVs & REEVs & HEVs) by Region, 2019-2024

As per the sales of global hybrid vehicles (PHEVs & REEVs & HEVs) by region, China has become the main hybrid vehicle market since 2022 mainly thanks to the surging sales of PHEVs & REEVs.

Sales volume of PHEV&REEV&HEV (10,000)		2019	2020	2021	2022	2023	2024.1-9	
China		17.6%	18.7%	24.0%	36.3%	40.3%	46.9%	
Asia (excluding China)	Japan	36.4%	27.0%	18.0%	15.1%	15.0%	12.5%	
	South Korea	3.4%	4.3%	3.5%	3.4%	3.6%	3.3%	
	Others (except Japan and South Korea)	1.9%	1.6%	1.7%	1.9%	2.8%	2.6%	
Asia (excluding China)		41.6%	32.9%	23.1%	20.4%	21.4%	18.4%	
Europe	France	3.5%	4.9%	6.0%	5.4%	5.2%	4.2%	
	United Kingdom	4.1%	5.3%	5.4%	4.6%	4.2%	4.0%	
	Italy	2.4%	2.2%	3.6%	3.2%	2.7%	2.3%	
	Germany	3.5%	8.8%	8.1%	7.3%	3.4%	3.1%	
	Sweden	1.9%	2.6%	2.0%	1.5%	0.9%	0.7%	
	Norway	1.3%	1.3%	0.9%	0.4%	0.2%	0.1%	
Others (except Japan and South Korea)		6.2%	6.6%	7.5%	6.7%	6.2%	5.1%	
Europe		22.9%	31.9%	33.4%	29.1%	23.0%	19.5%	
North America	United States	16.5%	15.6%	18.8%	13.8%	14.8%	14.5%	
	Others (except Japan and South Korea)	1.2%	0.8%	0.6%	0.2%	0.2%	0.2%	
North America		17.8%	16.4%	19.4%	14.1%	15.1%	14.7%	
Southern Hemisphere		0.1%	0.1%	0.1%	0.1%	0.2%	0.4%	
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Source: ResearchInChina

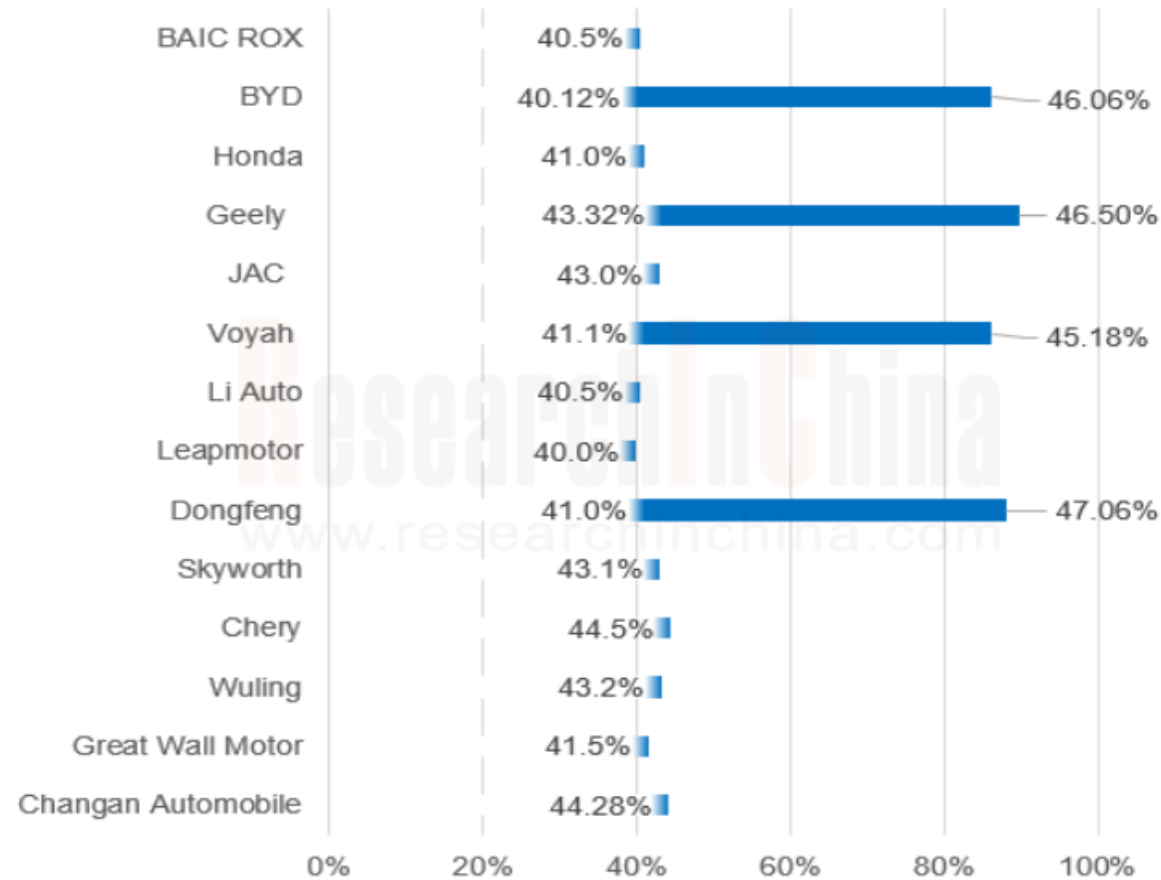
1. The thermal efficiency of engines for PHEVs & REEVs has reached 46% in China.

Most traditional fuel vehicles use the Otto cycle, that is, a cycle in which the compression ratio is equal to the expansion ratio. The most obvious way to further improve the thermal efficiency is to make the compression ratio lower than the expansion ratio, that is, the working stroke is higher than the compression stroke. Hybrid-specific engines that leverage the Miller/Atkinson cycle which can achieve higher thermal efficiency with much less low-end torque thus come into being. Electronic structures replace conventional mechanical accessories: for other power output sources are added to a plug-in hybrid system, the plug-in hybrid engine is relieved of a lot of burden. The control logic of most hybrid systems will allow engines to run directly in a relatively efficient range, avoiding such operating conditions as idling and low speed.

OEMs like BYD, Geely, Dongfeng, GAC, Great Wall Motor and Chery are vigorously investing in research and development. It is expected that a large number of hybrid engines with 45% thermal efficiency will be ready for industrial application from 2025. In 2024, BYD DM5.0 used a more efficient 1.5L/1.5T hybrid engine, with a maximum thermal efficiency of 46.05%/45.3%.

Engine Thermal Efficiency of Domestic Models on Sale

Engine Thermal Efficiency of Domestic Models on Sale (%)



Source: ResearchInChina

The power battery capacity of China's hot-selling PHEVs & REEVs has exceeded 43kWh.

From 2023 to 2024, the battery capacity of China's PHEVs & REEVs increased a lot, from about 15kWh to 30kWh. In the future, large batteries will become an inevitable trend in the development of PHEVs & REEVs. The battery capacity of REEVs is higher than that of PHEVs, but they are all involved with power batteries.

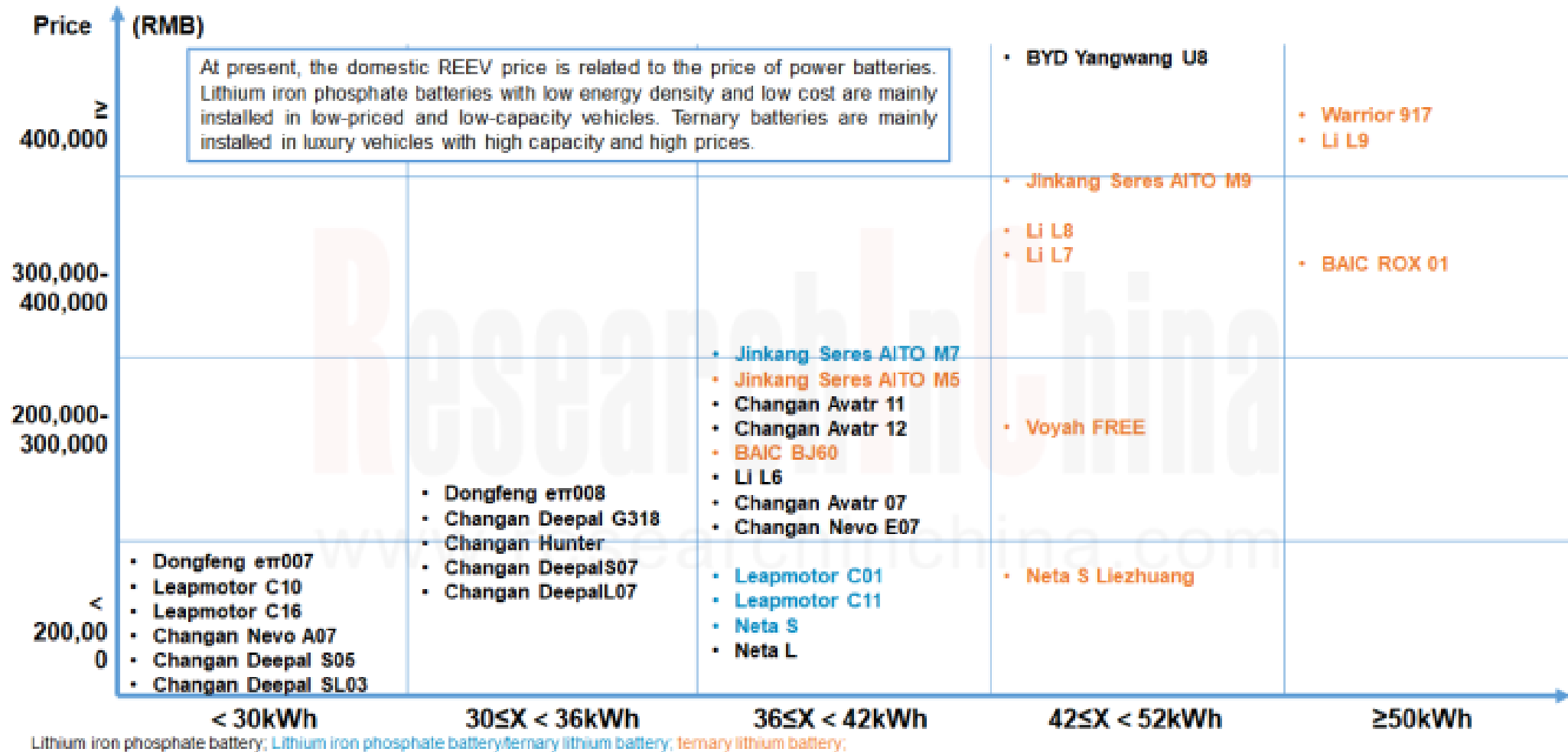
- The battery capacity of the long-range editions of REEVs like BAIC ROX 01, BYD U8, AITO M9, Voyah FREE, Li L7/L8/L9, Leapmotor C01/C11, Neta S, and M-Hero 917 has exceeded 43kWh. The EV mode range of REEVs is generally longer than PHEVs;
- The battery capacity of the long-range editions of PHEVs like BYD Denza N8/N9, JAC Refine RF8, Voyah Dreamer/Passion, Chery Jetour Shanhai T2, Great Wall WEY Gaoshan/Blue Mountain has hit more than 43kWh;

Compared with small batteries, large batteries offer greater benefits in application in vehicles:

- A large battery is healthier than a small battery in service life: Battery lifespan mainly refers to cycle life, namely the number of charge and discharge cycles the battery can complete before its capacity drops (0%~100%~0%). Because of its low capacity, a small battery will definitely charge and discharge more frequently, while a large battery can dilute the charge and discharge frequency to a certain extent, and its cycle life will be relatively longer.
- Higher battery performance: Compared with small batteries, under the same power requirements, the discharge rate of large batteries is lower, which can avoid damage to the materials and structural stability of the batteries during high current discharge.

It is not the better for hybrid vehicle batteries to have larger capacity. Because the weight and cost are also rising, so OEMs have been researching what capacity batteries should be used and what size of engine and motor they should match.

The power battery capacity of China's hot-selling PHEVs & REEVs has exceeded 43kWh.



Source: ResearchInChina

The comprehensive range of Chinese PHEVs & REEVs is planned to be 2,000km.

Domestic hybrid models, including BYD, Geely, Chery, Dongfeng, Roewe and many other plug-in hybrids with large fuel tanks, have a range of 2,000 kilometers. BYD DM 5.0 has achieved a comprehensive cruising range of 2,100km+, but it is only priced at RMB100,000, with lower price but longer range. The 2,000-kilometer range has become a new arena for OEMs to compete fiercely.

- 1. Large fuel tanks: The increase in range is related to larger fuel tanks. For example, Chery EXEED STERRA ET, a medium-to-large SUV, can run 2,141.4 kilometers with a full tank and a full charge. It has a 67L fuel tank and is equipped with a 32kWh battery pack. Chery Fulwin T10, a medium-sized plug-in hybrid SUV, has a 70L fuel tank and a comprehensive range of 1,400km.
- 2. Higher engine thermal efficiency: The engine thermal efficiency of BYD, GAC, Geely, Dongfeng, Chery and other Chinese OEMs has reached 46% in the past two years. With such hybrid engines and fuel tanks, everyone has secured a range of up to 2,000 kilometers. Compared with the 46% thermal efficiency of domestic OEMs, the thermal efficiency of A25B-FXS 2.5, Toyota's gasoline engine for passenger cars, is about 41%, and the highest thermal efficiency of Volkswagen is 39%.
- 3. Large batteries: The extended-range edition of 2024 Leapmotor C11 packs a 43.74kWh battery with NEDC range of 300km.

The overseas REEV market is in its infancy, leaving huge scope for Chinese OEMs to go overseas

The extended-range type is a series type, and the technology route is much simpler than the hybrid type. It is quick to get started, and does not require too much technical accumulation, with a relatively low threshold. In 2024, there were 36 REEV models on sale in China, more than doubling in 2023 with 17 models. In 2025, seven REEV models will be launched on market, including Deepal's 6-seat REEV, IM's first REEV, Changan Nevo C798, Xpeng's first REEV, STERRA's second SUV/MPV REEV, Voyah's 6-seat SUV REEV, and Leapmotor A12.

•Chinese REEV OEMs' hybrid system - architecture - model

There are currently a total of 25 passenger car REEV models on sale. Brands such as Li Auto, AITO and Leapmotor prevail in the number of models and sales volume. Li Auto sells each REEV at a price of higher than RMB300,000; Changan performs well in REEV models, and its brand Deepal features cost-effective models in a price range of RMB110,000-190,000.

From the perspective of parameters, passenger car REEVs are mainly medium-sized and medium-to-large sized passenger cars, with battery capacity of around 40kWh and EV mode range longer than 200km.

•Foreign OEMs are competing to launch their own extended-range vehicles to seize the hybrid market.

Compared with PHEVs, REEVs have a simple structure and high plasticity, and are more popular in the high-end market. In the international market, foreign OEMs have planned to launch their own extended-range vehicles. Foreign brands have planned REEVs and intended to develop and improve extended-range systems and launch them on market.

For example, Hyundai, Mazda, Stellantis, Nissan, BMW, Volkswagen Scout, etc. have all planned or launched extended-range vehicles. It is reported that over 80% of consumers chose the extended-range edition of Volkswagen Scout which was just launched in North America in October 2024. From 2025 to 2030, REEVs will not only gain popularity in the domestic market, but will be very hot in foreign markets.

Table of Content (1)

1 Hybrid Vehicle Structure, Definition and Policies

1.1 Hybrid Vehicle Structure and Definition

1.1.1 Hybrid Vehicle - Definition and Structure

Hybrid Power System - by Motor Location

Hybrid Power System - by Power Structure

Hybrid Power System - by Drive Motor Power

Hybrid Power System - by Hybrid Level / Fuel Economy

Hybrid Vehicle Industry Chain

1.2 Structure and Definition of Extended-range Hybrid Power System

REEV Supply Chain - Official Definition

REEV Supply Chain - System Structure

REEV VS PHEV

REEV Supply Chain - System Composition

REEV Supply Chain - Electrical Architecture

“Extended Range + Large Battery” is the Development Direction of REEVs

REEV Supply Chain - Difficulties in System Development

1.3 China's Hybrid Vehicle Policies and Regulations - Carbon Emissions and CAFC & NEV Credits

Carbon Neutrality Progress in Major Countries Worldwide

Electrification Goals of Major Countries/Regions Worldwide

Electrification Policies of Major Countries/Regions Worldwide

China's Vehicle Emission Regulations

Calculation of China's Automobile Carbon Emissions

Chinese Passenger Cars - CAFC & NEV Credits Policy (1)

Chinese Passenger Cars - CAFC & NEV Credits Policy (2)

1.4 China's Hybrid Vehicle Policies and Regulations - Development Planning Development Trends of Hybrid Vehicles

Energy Saving and New Energy Vehicle Technology Roadmap 2.0 - Hybrid Passenger Car Development Planning

Development Plan of New Energy Vehicle Industry (2021-2035)

1.5 Impacts of Policies on the Development of Hybrid Vehicles

New Energy Vehicle Credits Drive the Development of Hybrid Vehicles

Hybrid Vehicles Help Traditional OEMs in Average Fuel Consumption Credits

Hybrid Vehicles Are Rapidly Replacing Fuel Vehicles

2 Status Quo and Trends of Global and Chinese Hybrid Vehicle Markets

2.1 Global Hybrid Vehicle Market

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for More Than 12% of Global Sales Volume

Global Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs)

Global Sales Proportion of Hybrid Vehicles Exceeded That of Battery-electric Vehicles in 2024

Global Sales Volume of PHEVs & REEVs - by Region

Global Sales Volume of PHEVs & REEVs - by Brand

Global Sales Volume of HEVs - by Region

Global Sales Volume of HEVs - by Brand

2.2 Chinese Hybrid Vehicle Market

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for 18.5% of China's Sales Volume

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in China

Sales Proportion of REEVs Exceeded That of HEVs in China in 2024

Table of Content (2)

2.3 European Hybrid Vehicle Market

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for 13% of Europe's Sales Volume

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in Europe

Sales Proportion of HEVs Exceeded That of PHEVs & REEVs in Europe in 2024

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in Europe - by Country

Proportion of New Energy Vehicles in Major European Countries by Type - Hybrid VS Battery-electric

2.4 Hybrid Vehicle Market in Japan, South Korea and Southeast Asia

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for 11% of Asia's Sales Volume (excluding China)

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in Asia (excluding China)

Sales Proportion of HEVs Exceeded That of PHEVs & REEVs in Asia (excluding China) in 2024

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in Asia (excluding China) - by Country

2.5 North American Hybrid Vehicle Market

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for 13% of North America's Sales Volume

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in North America

Sales Proportion of HEVs Exceeded That of EVs in North America in 2024

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in North America - by Country

Planning for Hybrid Models in North America, 2025E-2030E

2.6 Hybrid Vehicle Market in the Southern Hemisphere

Hybrid Vehicles (PHEVs & REEVs & HEVs) Account for Less Than 1% of Sales Volume in the Southern Hemisphere

Sales Volume of Hybrid Vehicles (PHEVs & REEVs & HEVs) in the Southern Hemisphere

Sales Proportion of PHEVs & REEVs Exceeded That of HEVs in the Southern Hemisphere in 2024

2.7 Chinese Micro Hybrid Market (12V Automotive Start/Stop System)

Chinese Micro Hybrid Market (12V Automotive Start/Stop System) - Installation Rate of Start/Stop System

Energy-saving Effect and Usage Cost of Automotive Start/Stop System

2.8 Global Mild/Medium Hybrid Market (48V+BSG/ISG System)

Global Mild/Medium Hybrid Market (48V+BSG/ISG System) - Sales Volume by Model

Vehicles Equipped with 48V Mild Hybrid System on Sale in China (including imports), 2024

Gasoline + 48V Mild Hybrid System Based on Mercedes-Benz Modular Architecture (MMA)

Mazda's Gasoline + 24V Mild Hybrid System

Obstacles to the Development of 48V Mild Hybrid System

2.9 Development Forecast for Hybrid Vehicles in China

Sales Forecast for Hybrid Vehicles in China

Cost Comparison among Hybrid Vehicles/Electric Vehicles/Fuel Vehicles in China

The Comprehensive Range of Chinese PHEVs & REEVs Is Planned to Be 2,000km

Hybrid Vehicle Parts Localization Trend in China

Table of Content (3)

3 Plug-in Hybrid Electric Vehicle (PHEV) Technology and Components

3.1 Global PHEV Market

Global PHEV & REEV Market - by Group

Global PHEV & REEV Market - by Brand

Global PHEV & REEV Market - by Brand/Country

Global PHEV & REEV Market - Ranking of Models

3.2 Chinese PHEV Market

Chinese PHEVs - Monthly Sales Volume

Chinese PHEVs - Competitive Landscape

Chinese PHEVs - Sales Volume by Model

Chinese PHEVs - Hybrid Architecture

3.3 PHEV Supply Chain - Electric Drive System

Hybrid System - Key Components

Hybrid System - Electric Drive System Classification

Hybrid System - Electric Drive System: Planetary Structure

Hybrid System - Electric Drive System: Single-axis Parallel Structure (PII)

Hybrid System - Electric Drive System: Power Shunt Structure (PIII and PIV)

Hybrid System - Electric Drive System: Inter-axle Coupling Structure

Hybrid System - Motor Controller Structure

3.5.10 Hybrid System - Control Strategy Classification

PHEV System - PHEV System Summary of Major OEMs

PHEV System - Geely Leishen EM-i VS BYD DM 5.0

PHEV System - DHT Hybrid System

PHEV System - P1+P3 Configuration Accounts for the Highest Proportion

PHEV System - P2 Configuration Is Suitable for Hard-core SUVs and Sports Vehicles

3.4 PHEV Supply Chain - Drive Motor

PHEV Drive Motor - Structure

PHEV Drive Motor - Permanent Magnet Synchronous Motors Becomes the Mainstream for Hybrid Vehicles

PHEV Drive Motor - Industry Chain

PHEV Drive Motor - Installed Capacity

PHEV Drive Motor - Business and Product Progress of Core Suppliers

Dual-drive-motor Installation of PHEVs

PHEV Drive Motor - Three-in-one Drive System of FinDreams Powertrain

PHEV Drive Motor - Eight-in-one Electric Drive System of FinDreams Powertrain

3.5 PHEV Supply Chain - Generator

PHEV Generator - Classification

PHEV Generator - Working Mode

3.6 PHEV Supply Chain - Hybrid Engine

PHEV Engine - Development Trends of Thermal Efficiency of Dedicated Hybrid Engine (DHE)

PHEV Engine - Hybrid Engine

PHEV Engine - Hybrid Engine VS Fuel Engine

PHEV Engine - Unique Technology and Thermal Efficiency of PHEVs on Sale

PHEV Engine - Business and Product Progress of Core Suppliers

PHEV Engine - BYD Snapdragon Hybrid Engine

PHEV Engine - New Changan Blue Whale Hybrid Engine

PHEV Engine - Status Quo of Dedicated High-efficiency Engine Technology

3.7 PHEV Supply Chain - Hybrid Transmission

PHEV Transmission - Introduction/How it works

PHEV Transmission - Installation

Table of Content (4)

PHEV Transmission - Dedicated Hybrid Transmission (DHT) Electromechanical Coupling

PHEV Transmission - Hybrid Transmission Products for OEMs

3.8 PHEV Supply Chain - Electronic Control System

PHEV Electronic Control System - New Energy Electronic Control System Structure

PHEV Electronic Control System - Hybrid Electronic Control System VS Electric Vehicle Electronic Control System

PHEV Electronic Control System - Installations in Vehicles

PHEV Electronic Control System - Dual-electronic-control Design Architecture

PHEV Electronic Control System - Business and Product Progress of Core Suppliers

PHEV Electronic Control System - BYD's Dual Electronic Control System

PHEV Electronic Control System - Inovance's Power Dual Electronic Control

PHEV Electronic Control System - Sungrow's Dual Electronic Control

PHEV Electronic Control System - VMAX's DSC Half-bridge Plastic Module

3.9 PHEV Supply Chain - Power Battery

PHEV Power Battery - Installations

PHEV Power Battery - Installations by Vehicle Model

PHEV Power Battery - Electric Charge per Vehicle

PHEV Power Battery - Energy Type or Power Type

PHEV Power Battery - Battery Overcharge Configuration for Hybrid Vehicles

PHEV Power Battery - Business and Product Progress of Core Suppliers

PHEV Power Battery - BYD's Battery for Hybrid Vehicles (1)

PHEV Power Battery - BYD's Battery for Hybrid Vehicles (2)

PHEV Power Battery - SVOLT Energy's Battery for REEVs

PHEV Power Battery - CATL's Freevoy Super Hybrid Battery

PHEV Power Battery - Power Battery Installation of Vehicle Models on Sale

3.10 PHEV Supply Chain - Low Voltage Battery

Automotive Low Voltage Battery

High Entry Barriers for Lead-acid Battery

12V Lead-acid Start-stop Battery

12V Lead-acid Battery: Performance

12V Lead-acid Battery: Naming Convention

12V Lead-acid Battery: Operating Mode

12V Lead-acid Battery: Application Scenarios

Lead-acid Battery Competitive Landscape

Low-voltage Lithium Battery Replaces Lead-acid Battery

Low-voltage Lithium Battery for New Energy Vehicles

12V Lithium Battery Structure (1)

12V Lithium Battery Structure (2)

12V Power Supply Market Demand

48V Lithium Battery

Low-voltage Lithium Battery: Business and Product Progress of Core Suppliers

Low-voltage Lithium Battery: Tesla's 12V Lithium Battery

Low-voltage Lithium Battery: 12V Lithium Battery for BYD's Hybrid Vehicles

3.11 PHEV Supply Chain - Engine Exhaust Gas Recirculation System

Exhaust Gas Recirculation (EGR) Can Reduce Vibration/Emissions/Energy

Structure of Exhaust Gas Recirculation (EGR)

Hybrid EGR: Business and Product Progress of Core Suppliers

BYD's Low-temperature Exhaust Gas Recirculation (EGR)

BorgWarner's EGR for Hybrid Vehicles

Table of Content (5)

4 Range Extended Electric Vehicle (REEV) Technology and Components

4.1 REEV Market

Chinese REEVs - Sales Volume and Market Share

Chinese REEVs - Sales Volume by Model

Chinese REEVs - Sales Volume by Model

Chinese REEVs - Sales Volume by Model

Key Component Suppliers of Major REEV Models in China

REEV Supply Chain - REEV Planning of Foreign Brands

4.2 REEV Supply Chain - Range Extender

REEV Range Extender - Extended Range System

REEV Range Extender - Control Strategy

REEV Range Extender - Range Extender Solution

REEV Range Extender - Range Extender Development

REEV Range Extender - Range Extender Technology Iteration

REEV Range Extender - Parameters of Range Extenders of REEVs on Sale of Major OEMs in China

REEV Range Extender - Three-in-one Range Extender Assembly

REEV Range Extender - AITO's Range Extender

REEV Supply Chain - Range Extender Development Trend: Integration and Lightweighting

REEV Supply Chain - Range Extender Development Trend: High Vibration Resistance

REEV Supply Chain - Range Extender Development Trend: High Reliability

REEV Supply Chain - Range Extender Development Trend: High NVH Quality

REEV Supply Chain - Range Extender Development Trend: High Electromagnetic Compatibility

4.3 REEV Supply Chain - Engine

REEV Engine - Fuel-to-electricity Conversion Rate

REEV Engine - Engine for REEVs

REEV Engine - Technology Iteration

REEV Supply Chain - Engine Selection

REEV Engine - Four-cylinder Gasoline Engine

REEV Engine - Engine Parameters of Models on Sale

REEV Engine - Business and Product Progress of Core Suppliers

REEV Engine - Engine for REEVs

4.4 REEV Supply Chain - Generator

REEV Generator - Generator for REEVs

REEV Generator - Generator for REEVs

4.5 REEV Supply Chain - Drive Motor

REEV Drive Motor - Extended Range Drive Motor System

REEV Drive Motor - Drive Motor Installation of Models on Sale

4.6 REEV Supply Chain - Electronic Control System

REEV Electronic Control System - Vehicle Electronic Control System

REEV Electronic Control System - Functional Requirements

REEV Electronic Control System - Main Technical Indicators/Control Signals

REEV Electronic Control System - Energy Management Strategy Design

REEV Electronic Control System - Features of SERES' Electronic Control System

4.7 REEV Supply Chain - Power Battery

REEV Power Battery - Battery Capacity Will Be Greatly Improved

REEV Power Battery - Battery Capacity by Model

REEV Power Battery - Power Battery Installation of Vehicle Models on Sale

4.8 REEV Supply Chain - Thermal Management System

REEV Supply Chain - Thermal Management System Case

Table of Content (6)

5 Hybrid Electric Vehicle (HEV) Technology and Components

5.1 HEV Market

HEV System

Global HEV Market - by Group

Global HEV Market - by Brand

Global HEV Market - by Brand/Country

Global HEV Market - Ranking of Models

5.2 HEV Sales in China

Chinese HEVs - Sales Volume

Chinese HEVs - Sales Volume by Brand

Chinese HEVs - Sales Volume by Model

Development Trends of China's HEV Policies

HEV SWOT

5.3 HEV System

HEV System - Power Transmission System

HEV System - Comparison between Domestic and Foreign HEV Systems

HEV System - HEV System Installation

HEV VS Fuel Vehicle

HEV System - Dual Electronic Control System Case

5.4 HEV Supply Chain -Transmission

HEV - Transmission

HEV Transmission - Toyota's Hybrid Transmission Products

HEV Transmission - Honda's iMMD Hybrid E-CVT Transmission

HEV Transmission - Toyota VS Honda

5.5 HEV Supply Chain - Power Battery

HEV Supply Chain - Battery

HEV Power Battery - Price

HEV Power Battery - Structure

Battery Installation of HEVs on Sale in 2024 (1)

Battery Installation of HEVs on Sale in 2024 (2)

HEV Power Battery - Business and Product Progress of Core Suppliers

CPAB PRIMEARTH - NiMH Battery Pack

Webasto's Next-generation HEV Battery System

5.6 HEV Supply Chain - Energy Recovery System

HEV Energy Recovery System

HEV Energy Recovery System - Toyota's Brake Energy Recovery and Hydraulic Braking

HEV Energy Recovery System - Toyota's Energy Feedback Mode

HEV Energy Recovery System - Honda's Brake Energy Recovery System Control

6 Summary of Hybrid Vehicle OEMs' Routes

6.1 BYD

Hybrid Business Strategy

Hybrid Technology Iteration

Hybrid System Parameter Comparison

DM 5.0

DM 5.0 VS DM 4.0

DM-p VS DM-i

Main Features of DM-p Technology

DM-p Technology Positioning

DM-i Super Hybrid Technology Composition

Table of Content (7)

- DM-i Super Hybrid Technology Configuration
- DM-i Super Hybrid Battery
- DM-i Super Hybrid Working Mode
- DM-i Super Hybrid Power Source
- DM-i Super Hybrid Technology Advantages
- Models Equipped with DM-i Super Hybrid Technology
- Hybrid DMO Platform/Yisifang Hybrid Platform
- DMO super hybrid off-road platform
- Models Equipped with DMO Super Hybrid Off-road Platform
- Yisifang Four-motor Drive Technology

6.2 Geely

- Profile
- Hybrid Technology Iteration
- Leishen EM Super Electric Hybrid
- Leishen EM-P Super Electric Hybrid: 3-gear DHT Configuration
- Leishen EM-i Super Electric Hybrid
- Leishen Hybrid
- Next-generation Leishen Hybrid Platform
- Leishen Intelligent Engine Hi·X
- Lynk & Co - Intelligent Electric Hybrid LynkE-Motive Technology
- GHS 2.0
- GHS 1.0
- Volvo's Hybrid System
- 48V-BSG Mild Hybrid
- 7DCT/H Gearbox
- P2.5 Architecture Efficient Intelligent Hybrid Powertrain / Range-extended Hybrid Technology

- 6.3 Great Wall Motor
- New Energy Vehicle Planning in 2025
- Hybrid Route Planning
- Hybrid System Parameter Comparison
- Hi4-Z Off-road Super Hybrid Architecture
- Hi4-T Off-road Super Hybrid Architecture
- Hi4 Intelligent FWD Electric Hybrid Technology
- Hi4 Intelligent FWD Electric Hybrid Technology: Dual Motor Series-Parallel Electric FWD
- Hi4 Intelligent FWD Electric Hybrid Technology: Typical models
- L.E.M.O.N DHT System
- L.E.M.O.N DHT System: Power Form
- L.E.M.O.N DHT System: Engine Parameters
- L.E.M.O.N DHT System: Battery Electric Drive Parameters
- L.E.M.O.N DHT System: Working Mode
- L.E.M.O.N DHT System: Control Logic
- L.E.M.O.N DHT System: Application Scenarios
- L.E.M.O.N DHT System: Models Supported
- L.E.M.O.N DHT Suppliers
- L.E.M.O.N DHT Gearbox
- P2 Hybrid System
- Global R&D and Production System

6.4 GAC

- Hybrid technology
- Hybrid Route Planning
- Super Extended Range
- Julang Power Hybrid System
- Julang Power Hybrid System: Platform Composition

Table of Content (8)

GAC Julang Power Hybrid System: Engine
Julang Power Hybrid System: Technical Advantages of the Fourth-generation 2.0ATK Engine
Julang Power Hybrid System: Engine Thermal Efficiency
Julang Power Hybrid System: Transmission
Julang Power Hybrid System: Hybrid Transmission
Julang Power Hybrid System: Models Supported

6.5 Chery

Hybrid Technology Planning
Kunpeng Fuel and Hybrid Development Strategy
Hybrid Route Planning
Kunpeng Power
Kunpeng Super Hybrid C-DM Technology
Kunpeng Super Hybrid C-DM Technology: Models
Star Core Power ET-i Full Engine Super Hybrid
Kunpeng DHT
Kunpeng DHT: Key System
Kunpeng DHT: Hybrid Engine
Kunpeng DHT: DHT Gearbox
48V BSG Micro Hybrid System
Automatic Start/Stop Models
Plug-in Hybrid Models
Hybrid System Development Plan

6.6 Changan

Hybrid Route Planning
Force Super Extended Range Technology
Deepal Super Range Extender 2.0: Super Electric Drive 2.0

Deepal Super Range Extender 2.0: Intelligent Range Extender 2.0
Deepal Super Range Extender 2.0: Golden Bell Battery 2.0
Digital Intelligent Electric Drive Hybrid System
Digital Intelligent Electric Drive Hybrid System: 1.5L Blue Whale Hybrid Engine/Battery
Digital Intelligent Electric Drive Hybrid System: Working Mode
iDD Hybrid System
iDD Hybrid System: Blue Whale Engine
iDD Hybrid System: Electric Drive Transmission
iDD Hybrid System: Battery System
iDD Hybrid System: Thermal Management System
iDD Hybrid System: Working Mode

6.7 SAIC

Hybrid Business Strategy
Hybrid Route Planning
DMH Hybrid System
DMH Hybrid System: Engine
DMH Hybrid System: Controller/Battery
DMH Hybrid System: Operating Mode
Second-generation EDU Hybrid System
Second-generation EDU Hybrid System: Transmission Upgrade
Second-generation EDU Hybrid System: Intelligent Energy Management System
Second-generation EDU Hybrid System: 10-speed Intelligent Electric Drive Transmission
Second-generation EDU Hybrid System: Working Mode
Second-generation EDU Hybrid System: Model Comparison
Second-generation EDU Hybrid System VS First-generation EDU Hybrid System
Introduction to the First-generation EDU Hybrid System

Table of Content (9)

6.8 BAIC BLUE Plan Hybrid Route Planning Magic Box Electric Drive DHEV PHEVs & REEVs 1.5T Engine and ISG Starter and Generator All-in-one for REEVs	Lanhai Power Intelligent Multi-mode Hybrid Technology
6.9 Li Auto Hybrid Route Planning Intelligent REV 3.0 Extended Range System 2.0 Extended Range System 2.0: Li L9 L6/L7/L8/L9 Suppliers ONE Extended Range System	6.12 Neta Auto Haozhi Extended Range System Haozhi Extended Range System: Range Extender
6.10 SERES (AITO) Hybrid Route Planning Hybrid Range Extender DriveONE Next-generation Hyper-converged Gold Power Platform DE-i 3.0 Super Electric Drive Intelligent Technology Platform Huawei DriveONE Battery-electric Drive Range Extender: AITO M5 Huawei DriveONE Battery-electric Drive Range Extender: Oil Cooling Technology 2.0	6.13 Leapmotor REEV Models REEV Models Drive Sales Growth
6.11 Voyah Hybrid Route Planning ESSA ESSA: Drive Motor/Battery Extended Range System	6.14 Avatr Kunlun Extended Range System
	6.15 Xpeng Kunpeng Super Electric System REEV Production Base
	6.16 Xiaomi Auto REEV Model Planning
	6.17 NIO Hybrid Models
	6.18 Toyota Profile Hybrid Route Planning THS Development History Fifth-generation THS II THS: Technical Features

Table of Content (10)

THS: PHEV VS HEV
Toyota RAV4 THS II
Layout in the New Energy Vehicle Field
Global Automotive Business Layout
Hybrid Development in China
Sales Volume of HEV Models in China
Sales Volume of PHEV Models in China

6.19 Honda
Profile
Hybrid System Layout
Hybrid Route Planning
Structure of i-MMD Hybrid System
Parameters of i-MMD Hybrid System
Parameters of i-MMD Hybrid System
i-MMD Configuration: Working Mode
i-MMD Configuration: Fuel-saving Mode
i-MMD Configuration: Actual Fuel Consumption Measurement
i-MMD Configuration: Fourth-generation Dual-motor Hybrid System
Fourth-generation i-MMD VS Third-generation i-MMD
Fourth-generation i-MMD VS Third-generation i-MMD: Motor Unit Structure
Fourth-generation i-MMD VS Third-generation i-MMD: Engine
i-DCD Configuration
SH-AWD Configuration
Hybrid Battery
Global layout
Sales Volume of HEV Models in China
Sales Volume of PHEV Models in China

6.20 Nissan
Profile
Carbon Neutrality Goal in 2050
Hybrid Route Planning
DD-i Super Hybrid System
e-4ORCE Electric FWD System
Efficiency Comparison between the First-generation and the Second-generation e-POWER System
Parameter Comparison between the First-generation and the Second-generation e-POWER System
Structure of the Second-generation e-POWER System
Components of the Second-generation e-POWER System
Operation process of the Second-generation e-POWER System under all working conditions
Energy Utilization Rate of the Second-generation e-POWER System
Comparison between the Second-generation e-POWER System and Its Competing Products
Layout of e-POWER System in China
Sales Volume of Hybrid Models in China

6.21 Volkswagen
Profile
Hybrid Route Planning
DHT Hybrid System Structure
Core Components of DHT Hybrid System
DHT Hybrid System Adapts to HEVs/PHEVs
Plug-in Hybrid Technology Structure
Drive Mode of Plug-in Hybrid Technology
Models with Plug-in Hybrid Technology

Table of Content (11)

6.22 GM
Profile
Hybrid Route Planning
Second-generation Voltec Electric Drive System
Second-generation Voltec Electric Drive System: Hybrid Model Parameters
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Hybrid System
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Engine
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Motor
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Electronic Control
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Battery
HEVs with the Second-generation Voltec System: LaCrosse/Malibu XL - Working Mode
PHEV with the Second-generation Voltec System: GM Cadillac CT6
REEV with the Second-generation Voltec System: GM Chevrolet Volt
Buick's eMotion Drive Technology: Buick VELITE 6 PHEV

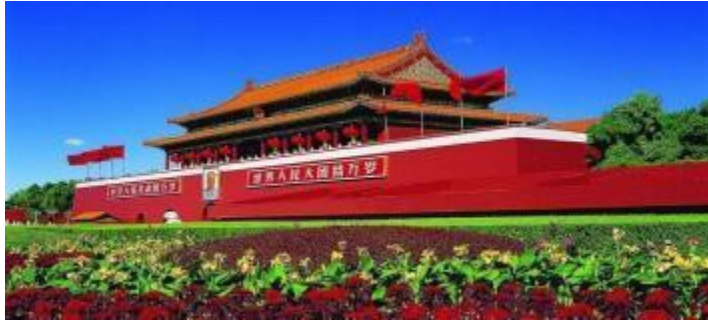
6.23 Volvo
Profile
Hybrid Route Planning
T8 plug-in hybrid system
T5 plug-in hybrid system
Plug-in Hybrid Models
48V Mild Hybrid System

6.24 BMW
Profile
Hybrid Route Planning

Plug-in Hybrid Technology
Plug-in Hybrid Models
48V Mild Hybrid System
48V Mild Hybrid Models
BMW M High-performance Hybrid
eDrive System Development Planning
Electrification Platform - Sixth-generation eDrive System
Electrification Platform - Fifth-generation eDrive System

6.25 Hyundai Kia
TMED Hybrid Technology
TMED Hybrid Technology: System Composition
TMED Hybrid Technology: TMED Working Principle
TMED Hybrid Technology: Model Configuration
REEVs

6.26 Summary of Hybrid Technology Routes of OEMs
Revenue and Net Income of Major Hybrid Vehicle OEMs
Summary of PHEV Technology Routes of OEMs (1)
Summary of PHEV Technology Routes of OEMs (2)
Summary of PHEV Technology Routes of OEMs (3)
Summary of PHEV Technology Routes of OEMs (4)
Summary of REEV Technology Routes of OEMs (1)
Summary of REEV Technology Routes of OEMs (2)
Summary of HEV Technology Routes of OEMs (1)
Summary of HEV Technology Routes of OEMs (2)



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