



NIO Power Swap Station Technology

Europe

September 25th, 2024





Who is NIO?

Founded in 2014, NIO is driven by the mission “Blue Sky Coming” with the definition “Shaping a sustainable and brighter future together” through the creation of high-performance smart electric vehicles and an unparalleled user experience.

Through innovative technology, personalized services, and a deep commitment to environmental stewardship, NIO is not only advancing the way we move but also contributing to a more sustainable tomorrow. NIO’s journey is about more than cars; it’s about inspiring a movement toward a better, cleaner world.

The technological foundation to achieve these goals are our R&D centers and manufacturing facilities across the globe, from China to San Jose, Munich to Oxford, and Budapest to Singapore. NIO has established sales and service networks in China, Norway, Germany, the Netherlands, Sweden, and Denmark, providing products and services to users in over 300 cities worldwide.



What is a Power Swap Station?

Designed and built with more than 1,600¹ patented technologies and an entirely automated process, NIO's power swap technology is the first of its kind and offers a unique experience.

The Power Swap Station consists of a covered parking platform onto which the vehicle is automatically manoeuvred at the start of the process, and an adjacent 'battery hotel' where batteries are recharged and stored, ready for use. The Power Swap Station occupies a surface area of just 65m² with a 20m² auto-park area at the front – roughly the same space as that required for six high power charging stations.

Each station can hold up to 21 batteries² and can deliver up to 408 swaps per day at maximum capacity. Stations are located on or near major highways, where they can act as key enablers for long-distance travel.



¹<https://www.nio.com/nLNL/news/nioandchangan>
²Power Swap Station 3.0.



Development of Power Swap Stations

The first NIO Power Swap Station opened in Shenzhen, China, in 2018.

The first European station opened in Norway in January 2022, bringing NIO's power swap concept to the region. Over 70,000 swaps have been successfully conducted in Europe since.

The first European Power Swap Station assembly factory opened in Biatorbágy nearby Budapest, Hungary, in 2022. It shipped its first completed station just three months after opening.

Today, there are more than 2,500 swap stations around the world, and collectively they have provided more than 50 million total swaps – an average of 60,000 operations every single day. To put it another way, a car departs from a Power Swap Station with a fully charged battery every 1.4 seconds³.

While conventional plug-in charging remains popular with many, swapping has now overtaken it among NIO users to become the most popular form of power replenishment. In fact, by early 2023, 57 % of energy was delivered by swapping, versus 43 % by plug-in charging.

³<https://www.nio.com/news/The-2000th-NIO-Power-Swap-Station>

How to swap?

When the car's battery energy level is low, the in-car AI assistant NOMI, will notify the driver and recommend the nearest recharging option.

Users can pre-order a power swap by selecting a Power Swap Station on the navigation map of the cockpit screen, thereby ensuring the order will be automatically placed when the car is near the station.

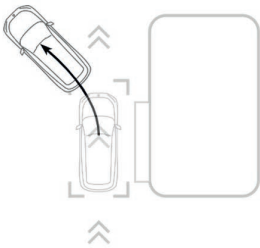
Users can also place an order in the NIO App or directly at the station. They are shown the final swap price before the swap takes place.



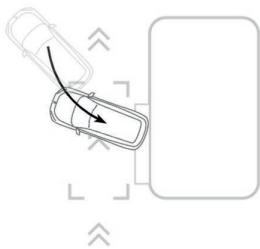
The in-car AI assistant NOMI



How does the swap process work?



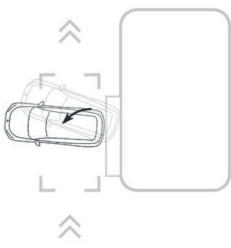
The process can be initiated either using the touchscreen interface in the car, or via the NIO app, and begins once the user arrives at the NIO Power Swap Station.



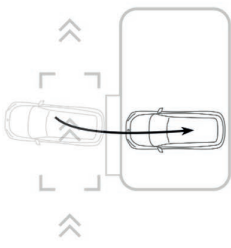
The in-car interface directs the user to stop the vehicle in the auto-park area in front of the Power Swap Station. From there, the vehicle takes over, and the process becomes entirely automatic.



The vehicle safely and autonomously reverses itself onto the parking platform within the station.



The mechanism has been designed to be highly flexible and can accommodate vehicles with a wheelbase of 2,800 - 3,300 mm, change wheel track to track width of 1,900 - 2,800 mm. As the platform opens beneath the vehicle, a motorized Rail Guided Vehicle (RGV) glides out and positions itself precisely underneath the vehicle.



The RGV rises to meet the underside of the vehicle, lifting it slightly as the battery's attachment points are unlocked. The discharged battery pack is lowered on the RGV and transported on to the battery hotel for diagnostics and recharging.



At the same time, a fully charged battery (with an average state-of-charge of 90 %) is relayed to the shuttle, ready for installation in the vehicle.

The installation process is the reverse of removal, thanks to specially designed and patented attachment points that ensure the battery is precisely located within the vehicle chassis.

Once the vehicle has performed a self-check, it is all set to drive away.



How long does it take?

The battery swap itself takes only three minutes⁴. That makes a battery swap faster than refueling a conventional vehicle.

The user doesn't even need to leave their vehicle.

Compared to plug-in fast-charging, where users typically have to wait an average of almost 30 minutes to receive a charge of 10 % to 80 %, the time savings are even greater.

⁴ The fully automatic battery swap starts when the sliding floor doors are opened for the first time and is completed when they are closed for the final time.



Why is there a need for a Power Swap Station?

The growth in EV adoption required to meet future legislative targets will need a similar expansion in new infrastructure to support it.

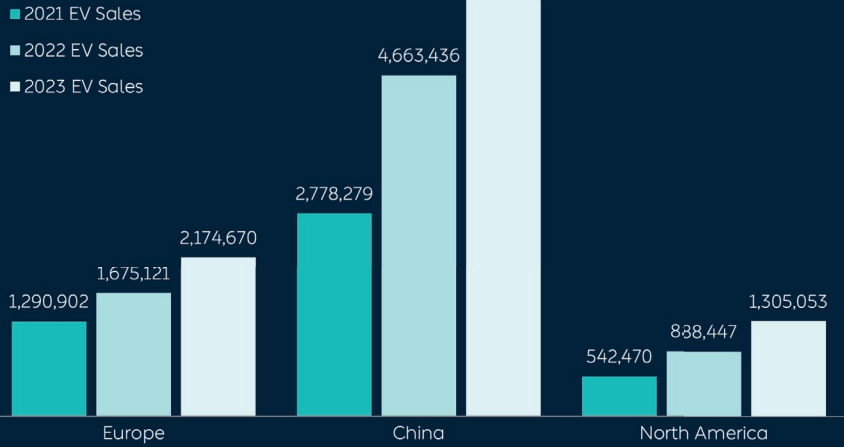
In Europe, about 65% of all charging events currently take place at home. However, as the adoption of electric vehicles (EVs) grows, particularly among those who do not have the convenience of home charging, this figure is expected to decrease.

It's also estimated that around 40%⁵ of EV drivers in Europe do not have access to home charging facilities, and therefore rely on public or workplace charging to meet their power needs.

⁵ Source: <https://shellrecharge.com/en-gb/solutions/knowledge-centre/reports-and-case-studies/ev-driver-survey-report#dawn-of-a-new-electric-era>

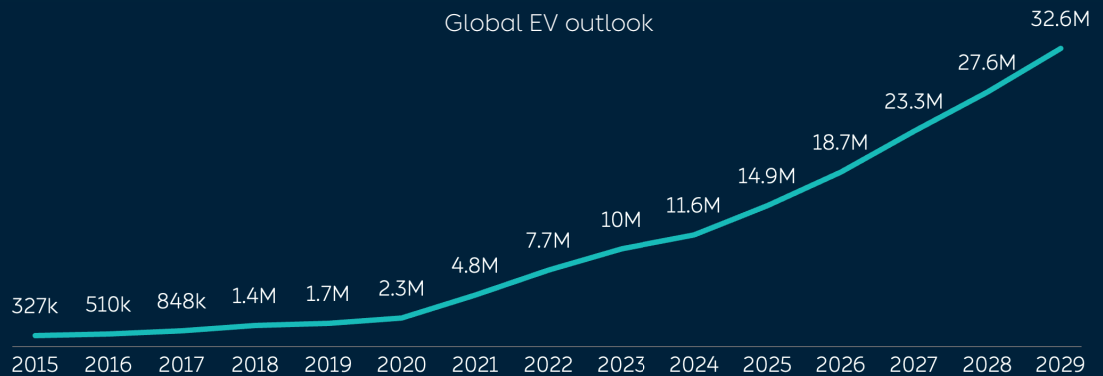
WHY IS THERE A NEED FOR A POWER SWAP STATION?

Volume of global EV sales



The rate at which this charging demand is shifting is accelerating. In fact, Europe is currently one of the fastest-growing EV markets in the world, with sales almost doubling between 2021 and 2023.

Global EV outlook



Therefore, significant investment and development are required to expand and upgrade the charging network, including overcoming technical, regulatory, and logistical challenges to ensure widespread and efficient access to rapid DC chargers.

Creating the infrastructure to satisfy this demand is a challenging process that faces a variety of complex issues.

NIO's power swap technology, by comparison, is a worry-free energy solution. It offers a cost-effective, convenient, and sustainable method of replenishing power, in a way that is beneficial both to users and site hosts alike.

Stations are entirely automated and can provide bi-directional power services that can help grid operators balance fluctuations in electricity demand⁶.

⁶ At the moment only available in China.



What is NIO's contribution to the European energy transition?

NIO's intelligent innovations together with over 50 PSS across Europe offer high utility value for a sustainable power supply.

NIO's Power Swap Stations already support grid stability in Europe today and will boost the green energy transition tomorrow.

NIO's Power Swap Stations can act as a flexible energy storage solution, compensating for fluctuations in demand and supply.

NIO supports the electricity grid by providing decentralised buffer storage. Energy storage compensates for fluctuations in electricity. This stabilises the grid and helps to reduce electricity prices.

NIO Power Swap Stations outperform high-power charging parks by providing a grid-friendly, sustainable solution that also enhances electromobility for users.



A SUSTAINABLE POWER SUPPLY

According to EU calculations, the need for flexibility in electricity grids will increase by 133 % between now (2024) and 2030⁷. Battery storage, efficient energy management, and a network of energy partners are now more important than ever before.

Energy storage is a key technology for the transition to a reliable and renewable energy system. Storage technologies offer a solution for integrating renewable energies from less predictable sources. NIO is currently focusing on the development of bi-directional technologies and plans to launch a bi-directional Power Swap Station, which will be able to feed power back into the grid to ensure grid stability. In Europe, NIO plans to deploy as many bi-directional Power Swap Stations as possible and upgrade existing third-generation stations where conditions allow.

Several pilot projects are currently being carried out to enable NIO to contribute to the energy transition by offering capacities for peak shifting during times of high renewable energy production.

This not only identifies hardware issues, but also analyzes business case models. This also includes the installation of solar cells on the Power Swap Stations, enabling NIO to produce its own energy.

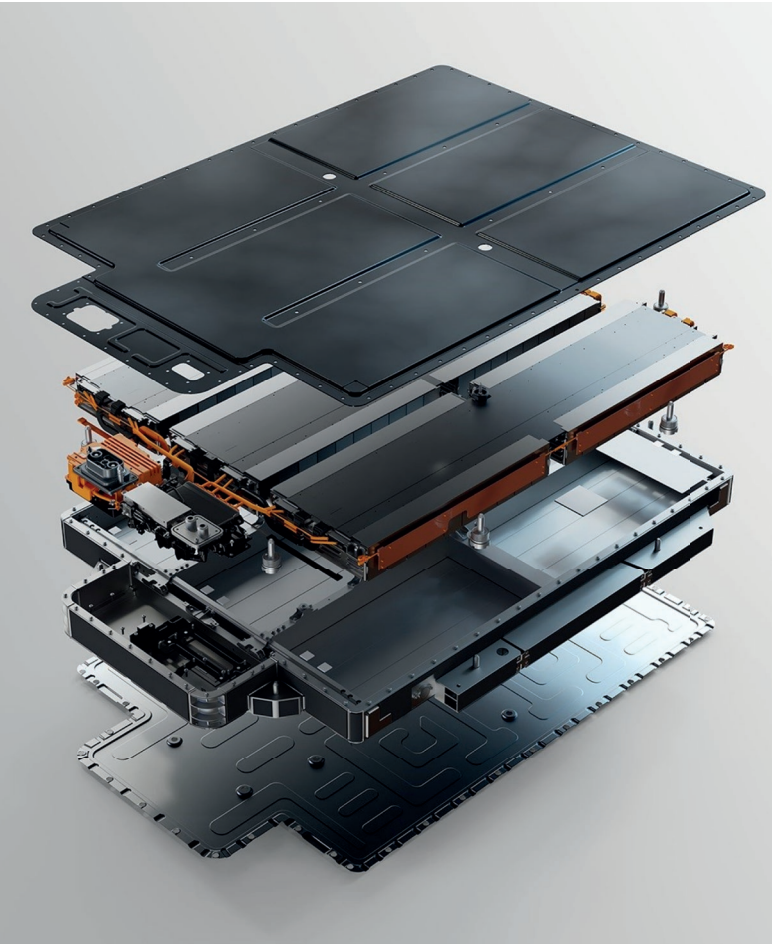
NIO is already attracting a lot of attention with the grid-friendly effect of its Power Swap Stations. In terms of hardware, a 300 to 600 kW grid connection is sufficient for the installation of a Power Swap Station. This makes it possible, for example, to supply power to local industrial consumers at much lower grid connection costs. Built on site, the swap stations help to minimize local grid bottlenecks.

A high-power charging park with comparable energy throughput requires more than twice the grid connection power, which can mean further unpredictable stress for the power grid. While the overall operation of charging parks can increase the demand for power, NIO helps to balance this by using energy efficiently to smooth out peaks in demand.



⁷ <https://www.renewable-energy-industry.com/news/press-releases/pm-8129-em-power-europe-flexible-consumers-take-the-burden-off-the-grid>

A SUSTAINABLE POWER SUPPLY



During a power swap, as the battery is removed from the vehicle in its entirety and replaced with a pack with the same standardized design, it is possible to offer an upgrade service that responds to changes in user demand or improvements in technology. For example, users can elect to increase the maximum driving range of their vehicle by ordering a replacement battery pack with a higher capacity⁸.

This could be requested either as a permanent change to the specification of their vehicle, or perhaps as a temporary measure in advance of a long-distance road-trip.

Furthermore, as technology improves and battery chemistry evolves, the swap process permits the wholesale replacement of a battery with one of an entirely new formulation, all without any modifications to the vehicle. This type of upgrade can only be achieved in an electric vehicle that features battery-swap capability.

This approach reduces the production and underutilization of high-capacity batteries, contributing to more sustainable resource consumption in the EV industry.



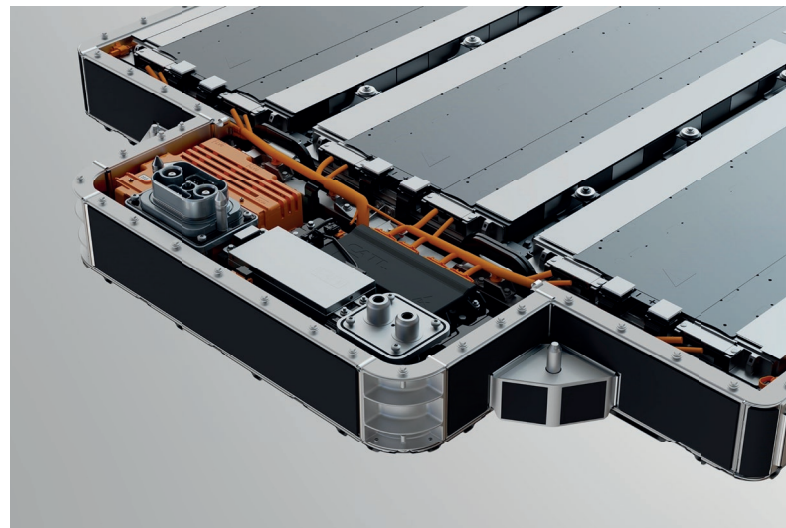
⁸ At the moment only available in China.

How is NIO pioneering battery technology?

The power swap concept is central to achieving a highly sustainable lifecycle that extends not only the lifespan of the battery, but that of the vehicle, too. This preserves the value of the vehicle and minimizes the problem of depreciation on resale.

Recharging the batteries in best-case ambient conditions and optimal charging rates helps to ensure longevity of NIO's batteries. Special servicing and analyzing procedures further enhance the batteries' state and provide a safe and reliable product to the users.

Once batteries eventually reach the end of their useful life, they can be seamlessly retired and recycled without involvement from the user.



HEALTHIER, LONGER-LASTING BATTERIES

By entering the swapping circulation, variations in usage can be balanced out as batteries will be used by a variety of users with different driving styles. This ensures car performance is maintained even for the most demanding usage profiles.

In addition, the constant monitoring and regular checks performed on each battery as it enters the battery hotel ensure that any packs requiring maintenance can be automatically removed from circulation and seamlessly returned to operation once maintenance is complete. As the lifespan of an electric vehicle is principally dictated by the health of its battery, the extended battery lifetime afforded by the power swap concept also extends the life of the vehicle.

NIO's approach is able to deliver on its sustainability promises by decoupling vehicle life from battery life, enabling the vehicle to operate for many more years to come. No NIO vehicle will ever need to be taken out of service due to a weak battery.





What happens to the batteries?

As part of the diagnostic, management and recharging process that each pack passes through while held within the battery hotel, the condition of each pack is carefully checked and its state-of-health is accurately assessed.

Battery packs that are nearing the end of their useful life can be automatically retired from circulation, all without any user involvement at all.

Batteries removed from circulation in this way are now prime candidates for redeployment in a second life, perhaps as power storage cells.

By collecting data during the battery's life in the swapping loop, batteries can be easily sorted to determine the best second-life application before recycling. This ensures an even longer, more sustainable use of resources.





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