Efforts of Nissan Toward Advanced Technology Development

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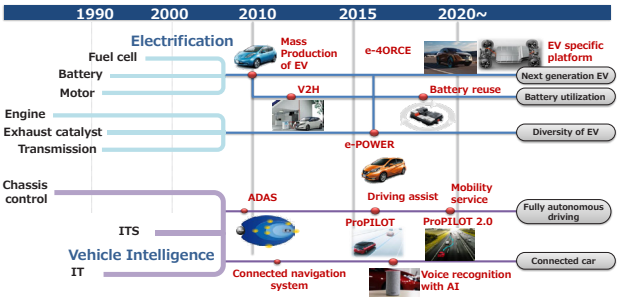
1. Introduction

The competitiveness of Nissan has always originated from advanced technologies. Since the establishment of this company, new technologies that competitors cannot achieve have consistently been developed and commercialized. Over the last two decades, research and development activities based on two pillars of advanced technologies—electrification and vehicle intelligence—have been promoted because these pillars are the key to solving social issues such as resource depletion, environmental problems, traffic accidents, and traffic congestion.

During research and development, the provision of these advanced technologies, which become valuable only when they are widespread as features in vehicles, to as many customers as possible is considered. These efforts have led to the commercialization of electric vehicles (EVs) and e-POWER from the perspective of electrification, and also diverse advanced safety technologies, ProPILOT, and connected technologies with cloud services from the perspective of vehicle intelligence. These advanced technologies have been adopted for different segments and are widely used by customers.



History of advanced technology development by Nissan

However, the decade leading up to 2030 represents an age of uncertainty in which the social environment and technology are changing significantly. In the following sections, recent environmental changes and the technology development strategies utilized by Nissan to cope with them are detailed.

2. Challenges surrounding mobility

The social environment has changed significantly over recent years. CO_2 emissions, which are known to be the primary factor causing global warming, have been increasing annually. Consequently, CO_2 regulations and selling restrictions on gasoline-powered vehicles have become increasingly stringent in major countries.

As the Japanese Government declared in October 2020 that "the Japanese Government aims to reduce greenhouse gas to net-zero by 2050," leaders in many countries have begun to refer to carbon neutrality. To respond to these social demands, it has become necessary to proliferate electrification and renewable energy on a global scale.

Meanwhile, the mobility efficiency in urban areas has deteriorated owing to the overconcentration of population, while the mobility disadvantage has become more severe in rural areas owing to the reduction in public transportation services and infrastructure, resulting from the decrease in population. In developed countries, the societies of which are aging, the number of traffic accidents caused by elderly people is increasing; thus, driving assist technologies are necessary to help everyone move with more confidence and in a safer manner.

To respond to such environmental changes, technological evolution is promoted by swiftly adopting diverse and advanced technologies, such as new surrounding environment recognition technologies, data science, and artificial intelligence.

3. Advanced technology strategy of Nissan

3-1. Electrification technologies

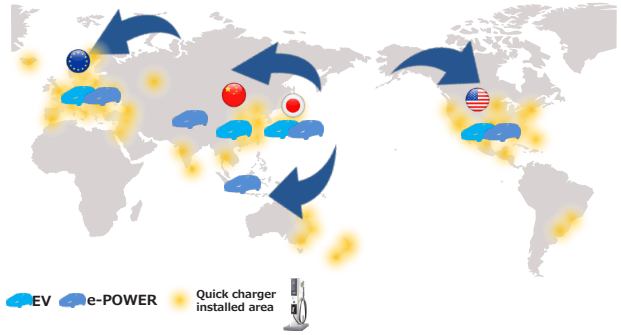
Around the 1990s, Nissan pioneered the research and development of batteries and motors for EVs and launched the industry-first mass-produced EV, Nissan LEAF, in 2010. In addition to vehicles, diverse technologies have been introduced in the market with the objective of making EVs usable with more confidence, such as by considering the usage environment and eco-cycle. For instance, charging infrastructure standards have been established, such infrastructure has been deployed, a vehicle-to-home system has been developed, and the battery reuse business 4R Energy has been established. This abundance of real-world accomplishments and the accumulated data of vehicles and customers at Nissan significantly promote electrification.

Nissan has two major goals regarding the expansion of electrification. One is the realization of its mission to achieve a zero-emission society, and the other is to provide customers with secure, safe, and comfortable means of mobility by utilizing the significant potential of the motor drive.

Owing to its excellent controllability, the motor drive affords ideal acceleration, deceleration, ride comfort, and

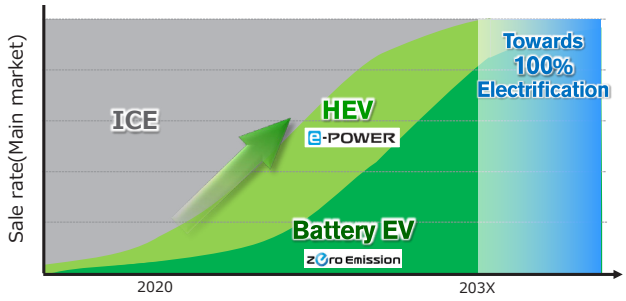
quietness in accordance with the driving environment and the intention of the driver. In addition, motor drives are highly compatible with advanced safety technologies, such as ADAS (Advanced Driver-Assistance Systems) and autonomous driving technologies. Thus, the unique appeal of motor drives will be increased further.

Nissan will continue to offer motor drives to customers worldwide, including regions where the charging infrastructure has not been deployed adequately, by supplying not only EVs but also motor-driven e-POWER, which does not require external battery chargers.



Market deployment of electric powertrain vehicles

According to its business transformation plan, Nissan plans to sell more than 1 million EVs per year by the end of FY 2023, expand the lineup of EV models by more than 8 models, and broaden the segment coverage of e-POWER in the global market.



Future expansion plan for electrification technologies

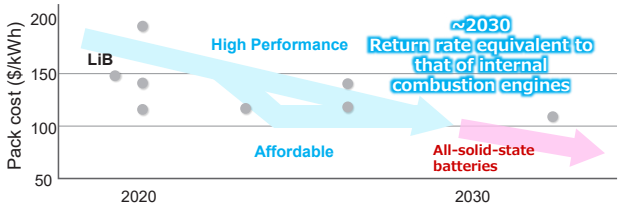
3-1-1. EVs

Safety is one of the requirements that Nissan emphasizes when developing and offering EVs. When increasing the battery energy density for higher performance, safety and reliability are ensured by conducting tests under severe conditions, prior to launching the vehicles in the market.

This emphasis on safety is demonstrated by the fact that, as of the end of December 2020, 510000 units of LEAF have been sold, and thus far, there have been no cases of serious battery-induced accidents. Based on market driving data, severe usage environments continue to be forecasted, and these environments are considered for the high-level reliability designs, test standards, and development.

Furthermore, technology development is promoted to enhance the attractiveness of EVs. One of the essential technologies for this purpose is the unique vibration-damping control technology, realized through the development of a motor for LEAF. The highly responsive electric powertrain has a higher potential in terms of controllability than an internal combustion engine; however, there are issues such as the jerk experienced by occupants due to a sudden torque increase, and the vibrations caused by torque fluctuations. Vibration-damping control technology plays an important role in precisely controlling these vibrations and generating smooth acceleration. Combining this technology with the knowledge of all-wheel drive and chassis control accumulated over the years has yielded the integrated vehicle control technology e-4ORCE, which will be installed in the Nissan Ariya unveiled this year. Each motor at the front and rear is controlled during both braking and driving and combined with the chassis control in order to achieve a stable and comfortable ride, while also preventing the occupants from recognizing slipping or changes in vehicle posture. Such technologies enable everyone to drive with confidence and comfort.

For the proliferation of electrification, it will be necessary to reduce the cost of electric powertrains and to particularly address the challenge of innovation in battery technology. Specifically, the development of battery materials in cooperation with suppliers to accelerate the research and development of cobalt-free batteries will be promoted, thereby reducing the use of expensive cobalt. For the battery pack, a structure referred to as Cell-to-Pack is also being developed in cooperation with suppliers; in this structure, the cells are directly installed in the pack without modules and the manufacturing process is streamlined. Through these technological innovations, the return rate of these vehicles will be brought to a level equivalent to that of internal combustion engine vehicles before 2030.

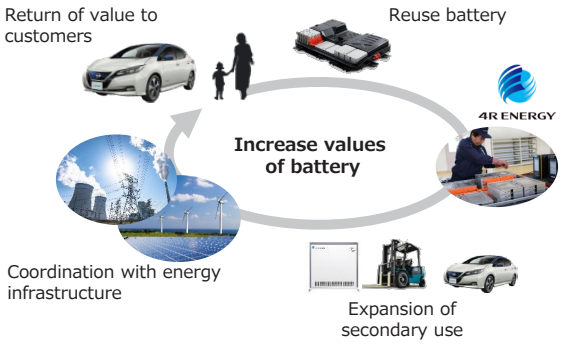


Battery cost reduction

The research and development of all-solid-state batteries that will drastically improve safety and cost competitiveness even further are also being promoted, in cooperation with organizations such as Tokyo Institute of Technology. The most significant challenges associated with this development are the enlargement of batteries applicable to vehicles and their production processes. Material selection and technology development in the manufacturing process will be expedited to achieve early mass production.

Owing to the increased proliferation of EVs, the market for used batteries is expected to expand in the future; therefore, it is necessary to implement measures for their appropriate utilization. Nissan has pioneered the establishment of a company to develop technologies for reused batteries, known as 4R Energy, which was launched in Namie-machi in Fukushima Prefecture. A suitable business model is also being developed; this

model entails sorting the used batteries collected from the market according to their conditions and performances in order to supply them to various secondary users, such that the value of reused batteries can be returned to customers. This model will be expanded as a business to reduce the burden on EV owners, aiming at the further proliferation of EVs.



Return of value through battery reuse

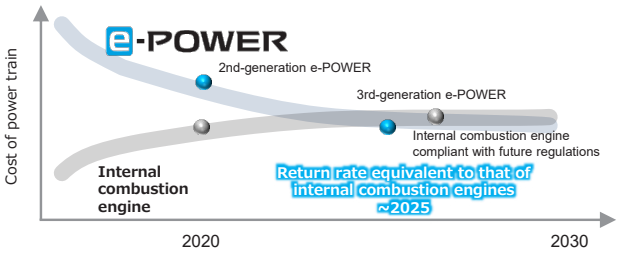
3-1-2. e-POWER

The most notable characteristics of e-POWER, which utilizes the same core technology as EVs, are quietness and smooth EV-like driving achieved using a 100% motor drive that yields the maximum torque from the start.

The launch of the new KICKS designed for the Asian market this year represents the first deployment in overseas markets, and local media and journalists have responded positively. For the new NOTE in the Japanese market, a novel powertrain integrated with an inverter and a motor has been implemented in order to further improve the efficiency, acceleration, and quietness.

In addition, a system is being developed for the premium segment by utilizing the characteristics of e-POWER to achieve exceptional quietness by ultimately reducing the vibration transmission from the power-generating engine.

Another challenge in the proliferation of e-POWER is the cost of the powertrain. In addition to developing the battery technology, as in the case of EVs, a simplified system is desired, in which the engine is dedicated to power generation and operation under limited conditions in order to achieve a return rate equivalent to that of internal combustion engines by 2025.



Evolution of e-POWER technologies and cost reduction

3-2. Vehicle intelligence technology

Nissan designs and engineers cars that prioritize a high level of safety. The goal is to reduce the number of deaths due to accidents involving Nissan vehicles to virtually zero. To this end, the safety of Nissan vehicles is continually being enhanced, partly through the development and adoption of autonomous driving.

Nissan has led the industry by launching various world-first technologies based on its concept of reducing the various risks surrounding vehicles; these technologies include Lane-Keeping Assist, Around-View Monitor, and Emergency Assist for Pedal Misapplication. The competitiveness of Nissan originates from such accomplishments and the high reliability of the systems, similar to the case of electrification technologies.

The objective is to provide all customers with less stressful and more secure, safe, and comfortable driving through autonomous driving technologies, as typified by ProPILOT, as well as connected technologies that deliver diverse information and services to the vehicle occupants. By the end of 2023, it is expected that at least 1.5 million vehicles equipped with autonomous driving technologies will be launched per year.

3-2-1. ProPILOT

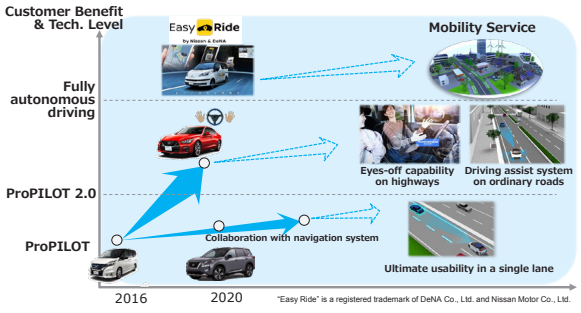
ProPILOT, which was launched in 2016, evolved into ProPILOT 2.0 in 2019. This system offers navigated single-lane highway driving with hands-off capability, the first of its kind in the world. When designing the autonomous driving technologies of ProPILOT, consumer usage on highways was analyzed and examined. This system provides appropriate driving assistance for a wide range of scenarios on highways, from the mainline through the exit, to ensure that customers experience less stress.

This performance and marketability are supplemented by the long-time advantages of Nissan technologies, such as surrounding environmental recognition and control as well as the accumulated technological capabilities for advanced driving, such as redundancy design to ensure safety in the case of a system failure.

3-2-2. Evolution of autonomous driving technologies

For fully autonomous driving in the future, the scenarios under which driving assist is applicable and the level of autonomy must be increased, and systems that everyone can confidently use must also be provided continually.

As a part of this technology development, Nissan has been conducting a field test on Easy Ride, in collaboration with DeNA in Yokohama Minato Mirai. In the test, customers are asked to use the vehicle such that the use cases can be determined, the issues associated with practical use can be identified, and continued development for future commercialization can be achieved.



Road map of autonomous driving technologies

In the real world, fully autonomous driving must

ensure safety in the presence of any obstacles on the road. Consequently, significant efforts are still required to achieve recognition technologies that account for a wide range of customer driving scenes and road environments. Thus, vehicle control technologies as well as the research and development of base components, such as sensors and cameras, will be prioritized.

Commercializing these technologies in the global market requires a greater understanding of the market environment. For this purpose, road environments have been modeled. Development can be streamlined by reproducing different driving scenes worldwide based on the large amounts of data pertaining to market environments and the high-definition map data obtained through the development of ProPILOT. Nissan uses a driving simulator that can reproduce both market environments and actual vehicle behaviors for the development of autonomous driving technologies.

Driving simulator at Nissan Technical Center

3-2-3. Connected technologies

For years, Nissan has also been realizing technical innovations in connected technologies that offer various services to the vehicle occupants by connecting the vehicle with cloud services. In 1998, a system known as "Com-Pass Link" was pioneered, which combines vehicles with information technology through services such as a new information service via a car navigation system and mobile phones and also Japan's first operator service. Subsequently, this system has evolved into Carwings and NissanConnect to commercialize diverse functions and services in the global market, such as the provision of information regarding the deterioration of the vehicle and batteries, location information, optimal route searching, and remote door locking.

In the future, additional services will be provided through exponentially faster communication between cloud services and the servers.

For example, the achievement of the following services is being attempted: remote control and automatic setup of various functions by using smartphone applications to enable the driver to easily perform a series of actions before entering the vehicle and the foresight of driver intentions according to the preferences and behaviors of the driver analyzed using big data in order to incorporate the results with an advanced human–machine interface, such that the driver can intuitively perform different functions during driving.

These functions are supported by alliance cloud services and on-board platforms and will be deployed and promoted globally alongside other carriers and service providers.

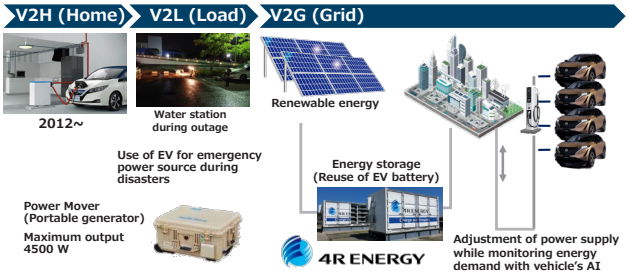
The architecture of the system software and hardware has become increasingly complex with the functional extensions. To address this issue, innovations for development efficiency are being realized by considerably streamlining the system through module design and by adopting automatic function evaluation methods using digital analysis tools.

4. Future mobility society

The advanced technologies discussed above help enrich social life, in addition to serving customers who purchase Nissan vehicles.

For example, EVs, also known as energy-stored cars, play an active role in supplying power during disasters. Through the "Blue Switch" project in Japan, Nissan contributes extensively to the society through arrangements with many local municipalities. The vehicle-to-grid system is also being studied for power supply and demand control. This system is enabled by connecting reused battery-based energy storage with existing power grids.

Further, for the mobility-disadvantaged in rural areas, an environment that helps everyone move with confidence and safety is being sought after by fully utilizing the accumulated advanced safety technologies, autonomous driving technologies, electrification technologies, and connected technologies in collaboration with the local municipalities. Simultaneously, the business models generated through these activities are being verified.



Contribution of EV technologies to the energy-based society

5. Conclusion

Nissan is working on diverse advanced technologies, in addition to the themes discussed thus far. New ideas are being embedded into different technologies, such as those for further vehicle weight reduction using different types of materials, optimizing interior environments by determining the physical conditions of the occupants based on biosignal recognition, further widening the vision of occupants by developing the Around-View Monitor, evolved autonomous parking, and low-volume multi-part manufacturing using metal 3D printers and die-less forming. The vision of Nissan is to enrich the daily lives of customers worldwide by expanding the appeal of its unique advanced technologies and to enable customers to enjoy these technologies. We are convinced that this vision will shape the future mobility of society. We at the Research and Development Division will work together to continue to embody the "Technology of Nissan."