Nissan's advanced technology development for constantly staying one step ahead

Senior Vice President **Takao Asami**

1. Introduction

The year 2023 marks Nissan Motor Corporation's 90th anniversary since it was founded in 1933. This is the 90th issue of the Nissan Technical Review. The first issue was published in 1965, before the merger between Nissan Motor Corporation and Prince Motor Company, which was the year automobile imports were liberalized. Since 1965, the Japanese automotive industry has faced global competition. The first commemorative article titled "Research on the Valve Train," introduced the research on engine technologies. Since then, various technologies have been introduced.

Some of the technologies that led to the development of the current electrification and autonomous driving technologies are highlighted in this article. For example, articles related to electrification include those on the MARCH EV concept using an AC Motor published in issue no. 10 (1984), trends in electric vehicles in a special feature highlighting the environment in issue no. 32 (1992), LEAF in issue nos. 69 and 70 (2012), and e-POWER in issue no. 80 (2017). Articles related to autonomous driving include articles on active safety technologies in the special feature highlighting safety in issue no. 33 (1993), ITS in issue no. 40 (1996), telematics development in issue no. 53 (2003), and Safety Shield concept in the special feature highlighting safety in issue no. 63 (2008). These articles confirm that R&D activities accumulated over the years have become the basis for current technologies.

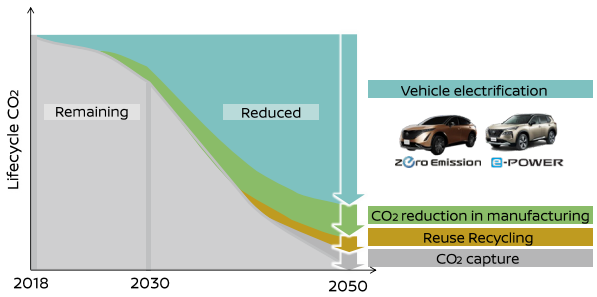
In 2023, when issue no. 90 was planned, the world economy had started to gradually shift to the recovery phase from the economic slowdown caused by the COVID-19 pandemic and semiconductor supply shortages. However, 2023 was a year of continuing international tensions, including policies on economic decoupling between countries, as well as wars and conflicts in several regions. In the automotive industry, the expansion of the electric vehicle (EV) market and significant progress of Chinese automotive manufacturers attracted considerable interest. Europe and China implemented EV promotion policies for improving the environment and stimulating the economy, which led to the ratio of EVs in new-car sales to exceed 20%. In China, automotive manufacturers funded by the local capital that managed to adapt to the new energy vehicle (NEV, corresponds to EVs and PHEVs) promotion policy gained a considerable market share. These manufacturers strived to increase exports to overseas markets, making China the largest vehicle exporter in the world, overtaking Japan. Meanwhile, in Japan, the "Japan Mobility Show," renamed from the "Tokyo Motor Show," was held with the theme of future mobility, comprising automobiles and various other means of transportation. Nissan exhibited five concept vehicles and proposed an attractive product image realized by only EVs as well as a future image of a new mobility system associated with infrastructure for information and energy.

Concept vehicles exhibited in the Japan Mobility Show 2023

In this turbulent era, as Nissan's engineers, we must follow Nissan's DNA ("Do what others don't dare to do"), develop products and services that realize our corporate purpose ("Driving innovation to enrich people's lives"), and establish innovative novel technologies and sophisticated fundamental technological capabilities supporting our purpose. This special feature introduces technologies related to three areas to which Nissan is committed: "electrification," to realize carbon neutrality; "autonomous driving," to realize a safer and more comfortable riding experience; and "connected service," to maximize the value of traveling by automobiles. This article discusses the basic concepts in each area.

2. Electrification

The largest source of CO_2 emission during the life cycle of an automobile, from its production to disposal, is the CO_2 emitted when the automobile is used. To suppress these emissions, CO_2 emissions caused by internal combustion engine vehicles must be minimized by switching to EVs. The CO_2 emissions caused by generating electricity used by EVs must be reduced by utilizing solar power, wind power, nuclear power, etc.



Approach to reduce CO_2 emissions by 2050

After the introduction of a larger number of EVs, several problems have become apparent from the customers' perspectives, including high costs, short driving ranges, and long charging times. Many of these problems are caused by the electrical properties of the battery. For example, the energy densities of lithium-ion and all-solid-state batteries are approximately 200 and approximately 400 Wh/kg, respectively. In contrast, the energy density of gasoline is approximately 12,000 Wh/kg, which is 30–60 times higher than that of the batteries. In the current era of global competition to improve battery performance and cost, Nissan aims to increase energy density, improve charging performance, and reduce costs by utilizing battery technologies accumulated over the years to develop battery technologies of three generations: liquid lithium-ion, all-solid-state, and lithium-free future batteries.

However, developing batteries with an energy density comparable to that of gasoline can take a considerably long time. Therefore, we can work on technologies for improving the electrical energy consumption for efficient energy use. Some specific technologies that we are currently working on include those for reducing vehicle mass, reducing air resistance, comprehensive energy management systems, improving the thermal insulation performance of vehicle compartments, reducing electric power used by the electric equipment, reducing tire rolling resistance, inverters that use SiC, small-sized high-speed motors, and X-in-1 units that integrate the motor, inverter, and reduction gear. We hope to develop EVs that more customers will choose by improving their battery and electrical energy consumption.

The efficiency of electric motors exceeds 90%, which significantly exceeds the accepted efficiency limit for internal combustion engines (50%). In principle, electric motors are highly responsive and controllable, and therefore, electric motors have strong and smooth starting and accelerating performances and can be used as electric power generators when the vehicle is decelerating. An electric motor is ideal for driving power, and therefore, efficiently mounting an energy source and supplying electricity is the challenge that needs to be overcome.

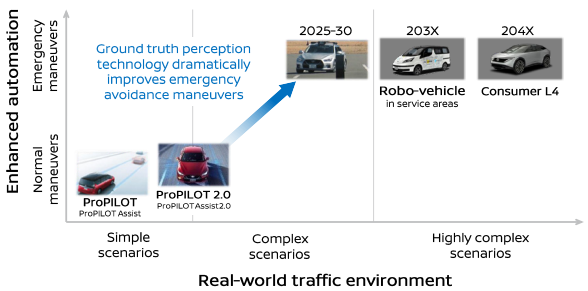
Electrified vehicles with various energy-source configurations such as HVs, BEVs, and FCEVs have emerged worldwide. These variants coexist for some time depending on their usage.

3. Autonomous Driving

Passive and active safety technologies are required to achieve Nissan's goal related to safety, i.e., "zero fatality," which involves eliminating fatalities attributed to traffic accidents involving Nissan vehicles. Nissan has an extensive experience in passive safety technologies. One example is the establishment of the Oppama Crash Laboratory in 1967. As on-board technologies, the three-point seat belt was adopted in 1967; the air bag was adopted in 1989; the "zone body concept," which is the vehicle body structure that absorbs the collision energy, was adopted in 1996; and the "pop-up engine hood" was adopted in 2007. These measures contributed to reducing the severity of injuries inflicted on the vehicle occupants and pedestrians. Meanwhile, analyzing the recent accident statistics data of various regions of the world indicated that there is more potential for contribution by implementing measures to avoid the occurrence of accidents by employing active safety technologies.

Nissan's autonomous driving technology was established based on the accumulation of active safety technologies. Since the introduction of the "safety shield" concept in 2004, Nissan introduced more than ten of the world's first technologies in 20 years. Although active safety technologies contribute to decreasing traffic accidents and the number of victims involved, these technologies contribute to expanding traffic environments and traffic scenes where the driving assistance and autonomous driving systems can perform their function. One such example is the evolution of ProPILOT Assist (2016) into ProPILOT Assist 2.0 (2019).

The emergency avoidance maneuvering technology currently under development is planned to be adopted in next-generation driving-assistance systems. This is expected to improve safety further and manage more complex traffic environments. Another activity, wherein data are collected from a traveling vehicle, uploaded to the cloud, processed in the neural network, and used to develop an AI-powered autonomous driving algorithm, has been initiated to realize fully autonomous driving in future. These technological evolutions will help come one step closer to realizing zero accidents. In future, we intend to provide mobility services to driverless vehicles and implement fully autonomous driving technology for mass-produced vehicles.



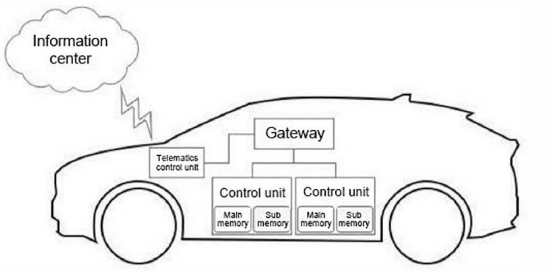
Roadmap for the evolution of ProPILOT Assist

4. Connected Service

Since the IT revolution of 1985, internet revolution of 1995, emergence of smartphones in 2007, start of 4G/5G service in 2012/2020, and generative AI revolution in 2022, the evolution of information and communication technologies appears to be accelerating. For example, the communication speed of smartphones has evolved and become 100,000 times faster in the past 30 years, enabling real-time communication of large-sized data such as videos.

Automobile functions have significantly changed because of these evolutions in information and communication technologies. In Nissan, the company's first navigation system "MULTI AV SYSTEM" was mounted in CIMA, CEDRIC, and GLORIA in 1989, and the company's first connected service "Compass Link," which was a remote-operation assistance service (assisted by a human operator), was started in 1998. Further, "CARWINGS," which provided an enhanced information service, was started in 2002. Currently, the "NissanConnect" service is provided around the globe using cloud technology. In addition to the map data update service via cloud communication, a system that sends real-time road traffic and traffic light information to vehicles has been introduced in some regions.

In recent years, various manufacturers have introduced the software-defined vehicle (SDV) concept, which is a structure that separates the software and hardware of vehicles. This has led to a significant increase in the speed of development and the deployment of software related to adding and updating various vehicle functions. Further, Nissan benefitted from this in ARIYA, where the software of 32 ECU units could be updated at any time through cloud communication.



Updating the software over the air (OTA)

In future, communication infrastructure is expected to shift from 5G to 6G, enabling us to handle data sizes that are even larger. Various data, including vehicle status and operation status, will be accumulated in the cloud, and IT technologies such as AI and neural networks will help accelerate the development and deployment of software to provide new services and improve existing services. Examples of such services include route guidance that considers road traffic conditions and charging plans, automatic settling of expressway tolls and parking lot fees, version upgrades of the autonomous driving assistance functions, and obtaining driver information from the cloud so that the same HMI can be displayed to the driver, even if the driver drives the vehicle for the first time. As described in this article, automobiles in the future will not only be a means of transportation, but also become a part of the social system, with the vehicle being connected to the information networks inside and outside the vehicle.

5. Summary

The three areas highlighted in this special feature helped Nissan differentiate itself from other companies. Automobiles, which consist of various types of technologies, are expected to adopt novel technologies originating from other industries such as software, AI, cloud, semiconductors, batteries, and electric power control, in addition to conventional automotive technologies to help accelerate their evolution to become society's mobility infrastructure system. We would like to actively develop revolutionary technologies and create innovations so that by 2050, we can realize carbon neutrality, complete recycling of resources, virtually zero traffic accident fatalities, and improvements in people's lives through the mobility provided by automobiles.