Nissan's DNA develops Super evolution "a production system in harmony with Blue Earth"

Executive Officer, EVP **Hideyuki Sakamoto**

1. Introduction

Nissan Motor is a car manufacturing company where automotive engineers play a central role in manufacturing cars. Nissan's history began in 1933 with the development and mass production of domestically manufactured automobiles based on the spirit of its founder, Yoshisuke Ayukawa, to "do what others will not do." This positioned Nissan Motor as a company in the early days of the industry; presently, Nissan is a leading player in Japan's modern automobile industry.

The domestic production of automobiles marked the beginning of the evolution of automobile technologies. Since then, Nissan has followed the values and vision of its founder at the company's core and expanded their business internationally through exports and overseas production. Nissan has experienced many waves of challenges, including global social issues such as environmental and air pollution, traffic accidents, oil shocks, fuel economy regulations, and trade friction, among others. However, by using technology created by Nissan's innovative and visionary engineers, the company has continued to successfully overcome new challenges in the industry, even where other companies have faltered. Nissan's storied history is an excellent demonstration of how new innovations in automobiles and manufacturing can be introduced to the market for the first time.

Connected, automated, shared/service, and electric vehicles (EVs)—collectively referred to as the "CASE" areas—and carbon neutrality have been widely covered in the media as once-in-a-century issues for the global automotive industry. The development of future automobiles will aim to realize visions of a technologically advanced future and will rely on the large-scale and high-level development of new technologies that interact with complex social systems. Automotive engineers play a critical role in developing these technologies, and they will continue to do so in the future. The focus of technological development is on the value it offers to customers and society. With this in mind, automotive engineers should fully understand and apply market and technological trends to create the best possible technical solutions that perform key functions for customers and society. These values have been engrained in Nissan's work since its inception and will remain as a guide for the company in the future.

The special feature in this issue of Nissan Technical Review includes technical reports on the best available solutions to realize new functions and achieve high performance that will resonate with customers and society, demonstrating the value of technological evolution that has been inherited from Nissan's founder to today's engineers.

2. Societal Changes and the Automotive Industry

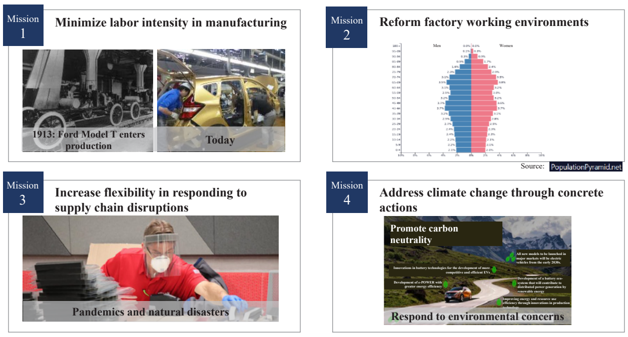
Nissan Motor envisions four missions for car manufacturing and the next generation of the automotive industry.

The first is a shift from a labor-intensive business model. The method of mass production for the Ford Model T was introduced by Ford 100 years ago. It was a revolutionary method and involved many people who worked together to efficiently produce cars. As modernization has progressed, various types of automation have been incorporated into automobile manufacturing processes, but many manually intensive methods are still used presently. However, given the recent shortage of automobile factory workers in Japan and other countries around the world, which has been exacerbated by the COVID-19 pandemic, it is becoming increasingly difficult to ensure work by many people to produce cars. Therefore, it is necessary to move away from the current production model and establish a streamlined automated production system with a reformed working environment.

Secondly, this trend is expected to worsen, given the declining birthrate and aging population, which make it increasingly difficult to provide young people with the advanced training that is necessary for challenging car manufacturing tasks.

Thirdly, additional flexibility in responding to unexpected situations is also needed in production systems. Various factors such as the COVID-19 pandemic, the shortage of semiconductors, and major disruptions in the logistics network have become extremely serious issues that can cause fluctuations in automobile production, making it crucial to develop systems that can deal with manufacturing disruptions. In addition, batteries, e-components, and their raw materials will also face issues with unstable supply in the future, which will undoubtedly cause major fluctuations in production that must be managed.

Finally, the automotive industry should take concrete actions to combat climate change and contribute to achieving carbon neutrality in conjunction with efforts that are currently underway around the world.



Four priorities for the future of automotive manufacturing

How should production activities be developed for the new car of the future with these four conditions met? Cars and their production will become highly sophisticated in the coming years as "Electrified", "Intelligent", and "Connected" become the industry standard. Similarly, manufacturing is becoming increasingly demanding as guaranteeing the functionality of various systems becomes more complex. For example, modern manufacturing requires a large amount of software to be installed simultaneously, many sensors to be calibrated, and advanced self- cddiagnostic systems and fail-safes to be verified, which poses challenges for manufacturing. As an additional layer of complexity, a wide range of customizations is required in car manufacturing, including large batteries with long-range and standard types for EVs, highly automated driving technology that enables hands-off driving, and standard driver assistance systems for automated driving intelligence technologies. Resilient production facilities and technologies to manufacture such complex and advanced vehicles are critical to Nissan's future success.

Meeting the needs of increasingly advanced products

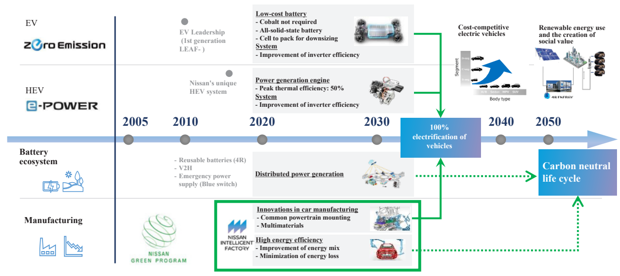
3. Initiatives to Address Climate Change and a Carbon Neutral Life-Cycle

3.1 Nissan Green Program

Countries around the world are now committing to achieving carbon neutrality by 2050 and implementing various policies to tackle climate change.

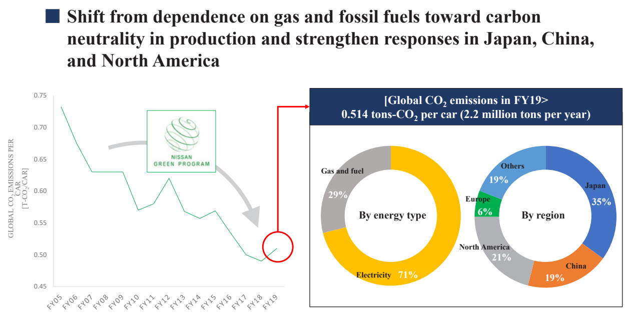
Nissan has also committed to achieving carbon neutrality by 2050 by electrifying vehicles in major markets in the early 2030s and by promoting innovation in production technology to achieve carbon neutrality in car manufacturing processes. Nissan was among the first companies to take action in reducing CO_2 emissions through the Nissan Green Program starting in 2005. Under the program, the company began the mass production of its first-generation EV, "LEAF," in 2010, offering it to the mainstream market as an EV for daily use. Subsequently, e-POWER was launched with the aim of helping customers feel the joy of driving an EV and promoting the commercialization of EVs.

In addition, efforts have been made to reduce CO_2 emissions by reducing the amount of energy used to produce these vehicles. Further innovations will be made in the future to make this a reality.



Initiatives for life-cycle carbon neutrality

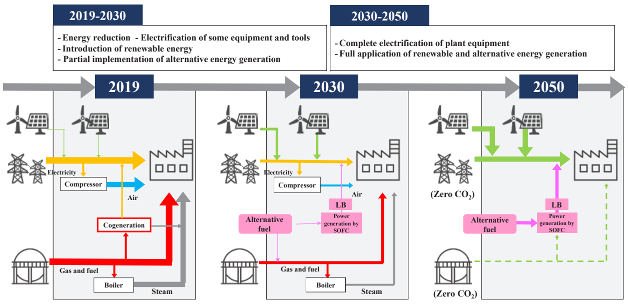
Under the Nissan Green Program, the CO_2 emissions from car production were successfully reduced by 30% per car from 2005 to 2019. The current energy used in manufacturing is composed of 71% electricity and 29% gas and fossil fuel. Finding an approach to reduce this gas and fossil fuel usage to 0% will be a priority in the forthcoming years, and future innovations will be invaluable in making carbon-neutral manufacturing and vehicle life-cycles a reality.



Reduction of CO_2 emissions during production

3.2 Initiatives for Carbon Neutrality in Production

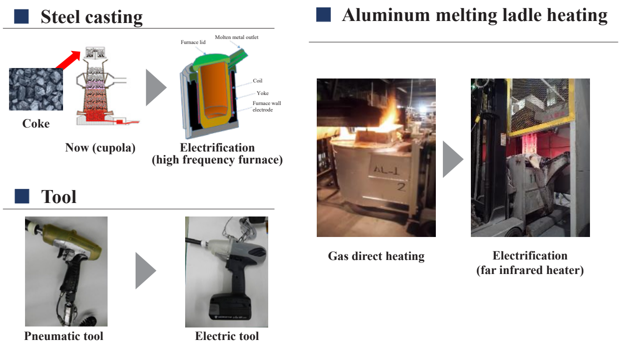
A roadmap to achieving carbon neutrality in Nissan's plants by 2050 has already been determined with ongoing technology development. Current plants operate with electricity and high-pressure air from compressors as power sources, as well as steam, heat, and electricity converted from gas and fossil fuel. Energy consumption is planned to be drastically reduced by 2030. Moreover, solid-oxide fuel cells (SOFCs) using clean alternative fuels will be used to generate carbon-neutral power, expanding the trial of clean energy generation in combination with renewable energy sources, such as solar radiation and wind. All production equipment running in the plants will be electrified by 2050, and all energy sources will be replaced by renewable and clean energy generation.



Roadmap for reducing CO_2 emissions from production

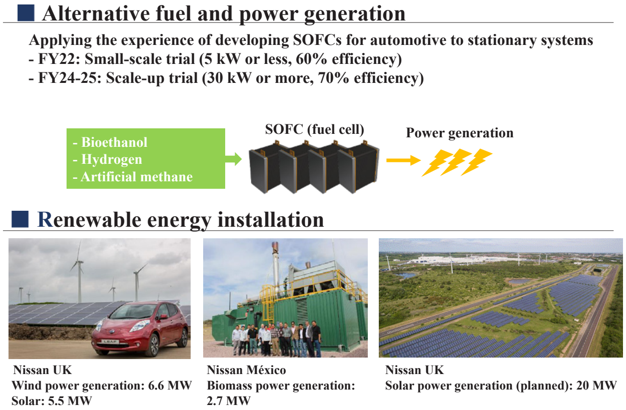
One of the most difficult production processes to electrify is the casting process, especially for carbon steel commonly used for drivetrains, where coke is used to carburize steel while it is melted. Further technological developments are required to use high-frequency furnaces for the electrification of this process. This technology will also be valuable in the efforts to completely electrify the melting process of aluminum alloys commonly used for powertrains. Furthermore, the tools used in factories will also be replaced by electric tools instead of air tools.

It is important to note that the trends in the development of advanced technologies in the energy industry need to be closely monitored, as the future development of new alternative clean fuels capable of directly providing thermal energy as an alternative to conventional fuels (light oil, natural gas, etc.) will require us to pivot our technological development.



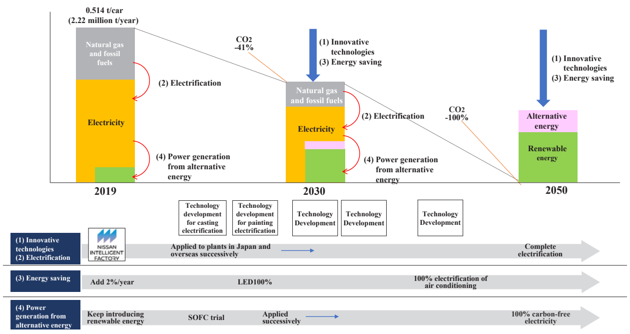
Ongoing efforts to reduce CO_2 emissions during production through electrification

Relying solely on external sources for clean energy poses challenges to business continuity due to unstable supply and the inability to control costs. Therefore, plans are being developed to test and implement clean energy power generation in Nissan's plants. Carbon-neutral power generation from bioethanol using an SOFC will be tested at the Tochigi Plant with plans to implement this strategy worldwide. Nissan's Sunderland plant in the UK has already begun to use solar and wind power and will further incorporate large-scale clean energy supplies and solar power generation via microgrids in the future.



Alternative fuel and power generation strategies

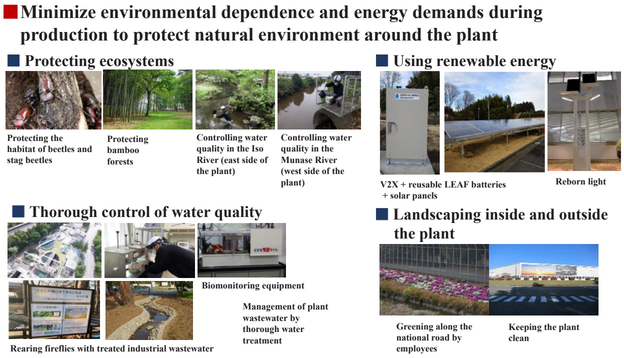
Nissan is aiming to reduce CO_2 emissions by 41% by 2030 by drastically reducing the energy required to manufacture cars at Nissan's plants and by trialing carbon-neutral power generation strategies. Carbon-neutral power generation and renewable energy procurement will enable 100% carbon neutrality by 2050. The R&D and production technology departments are already collaborating to develop the necessary technologies to achieve this ambitious but critical goal.



Numerical targets for CO_2 emissions reduction during production

3.3 Approaches to Coexistence between Factories and the Local Environment

Coexistence with the local environment by minimizing environmental impacts is also important for production activities. The area surrounding the Tochigi plant, which implemented the Nissan Intelligent Factory initiative, is full of greenery and a variety of ecosystems. In an attempt to protect the natural environment, environmental dependency was minimized, and load during production was maintained at sustainable levels. Furthermore, the plant acts as an environmentally friendly manufacturing site by protecting the ecosystem, managing water quality, maintaining the landscape, and utilizing renewable energy. For example, the new painting booth at Nissan Intelligent Factory does not use water to collect paint mist. Eliminating wastewater from the painting booth made it possible to eliminate the need for energy for wastewater treatment. Wastewater from other processes is still thoroughly treated to control the water quality. The small stream in the factory that receives treated wastewater is inhabited by fireflies, which give off beautiful light in the summer.

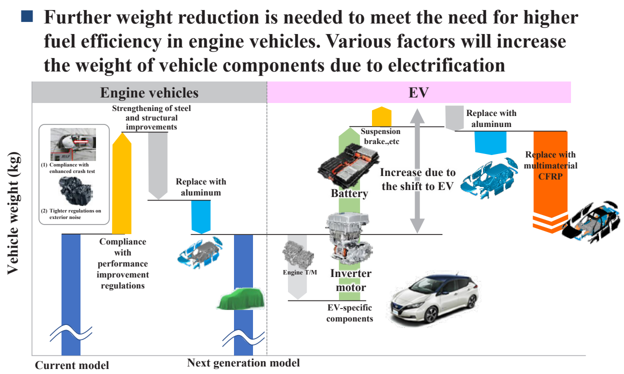


Coexistence with the local environment

3.4 Mass-producible Weight Reduction Technologies Necessary for Electrification

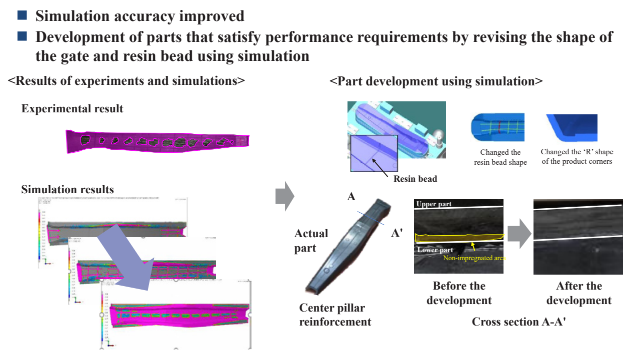
While EVs are becoming increasingly used worldwide, the technologies required for their widespread use extend beyond EV powertrain technologies, such as motors, inverters, battery materials, and other structures, to include critical mass-producible technologies for reducing vehicle weight. EVs are becoming heavier with larger batteries to ensure a longer range, demanding a drastic revision of the vehicle body structure and innovative body weight reduction strategies.

It is common to use ultra-high-tensile materials for parts that require structural strength and aluminum alloys for cover parts to reduce weight; however, the extent to which other materials can be substituted for steel is limited by material strength. The joining of aluminum alloys is conventionally performed with rivets (SPR), which increases the weight of the vehicle in accordance with the number of rivets. To overcome this challenge, welding and innovative technologies are needed for joining different materials, such as aluminum alloys, steel, and resin.



Electrification and vehicle weight

Carbon-fiber-reinforced plastics (CFRPs) have long attracted attention for their potential to reduce the weight of car bodies. Though several decades have passed since CFRPs were first launched, the establishment of mass-production technology has been a perennial issue in terms of cost and cycle time. Furthermore, breakthroughs in the production technology were insufficient to realize the mass production of CFRPs. However, Nissan introduced a mass-production technology for CFRPs in 2020 through the application of a resin flow simulation, making it feasible to achieve a cycle time of two minutes by applying the compression resin transfer molding (C-RTM) method to mass production. A rate of 2 minutes per car implies that the process can maintain a standard production speed of 30 jobs per hour (30 JPH), revolutionizing mass production for this material.

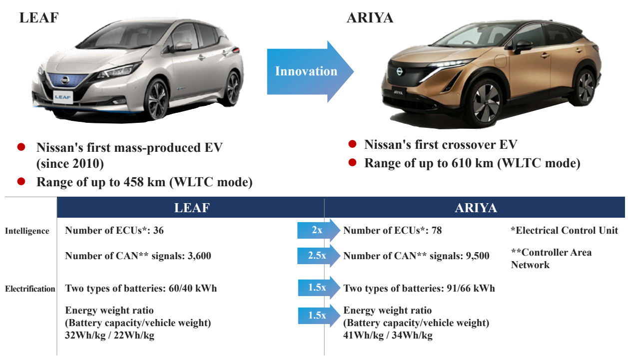


Electrification and vehicle weight

4. ARIYA: A Flagship Vehicle from the Nissan Intelligent Factory

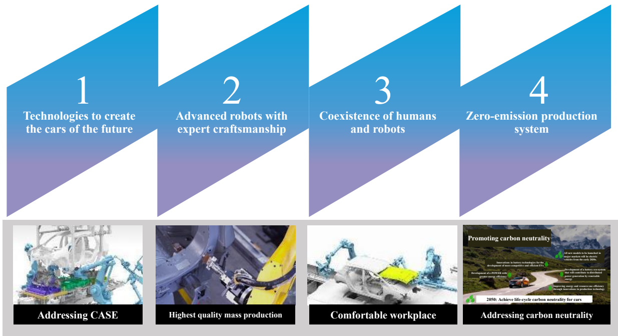
ARIYA features a design that embodies the new Nissan and Nissan Intelligent Mobility, equipped with a lineup of four powertrains to meet a wide range of customer needs, comfortable and responsive driving performance, a new generation of EV powertrains, state-of-the-art driver assistance technologies, and advanced connection technologies.

Nissan's EV innovation began with the first mass-produced EV, "LEAF," in 2010.



Nissan EV innovation

LEAF has been repeatedly improved during its model life and now has a range of 458 km. In contrast, ARIYA has a range of up to 610 km and has been significantly advanced in terms of electrification and intelligence with twice the number of ECUs installed, 2.5 times the number of signals used for communication and 1.5 times the capacity of the two types of batteries as well as the battery capacity per weight compared to those of LEAF. The four pillars of the Nissan Intelligent Factory were created to efficiently produce the complex and highly advanced ARIYA. After many years of developing basic and applied technologies, sophisticated product is now being realized.



Four pillars of the Nissan Intelligent Factory

While there have been many challenges and successes in recent years, an innovative automation line has now been completed through the efforts of many Nissan automotive engineers. It was truly a moment of great joy when the line began operating fully automatically, and this happiness and excitement was shared by everyone on-site for this momentous occasion. The Nissan Intelligent Factory will be rolled out globally, with the Tochigi plant as the pilot model.

5. Summary

5.1 Future Challenges in Automobile Manufacturing

While the future remains uncertain, automotive engineers and the broader Nissan team will undoubtedly be able to make further breakthroughs by innovating together. The following are some of the challenges in automobile manufacturing that will need to be tackled in the years to come:

- A new pandemic or friction between the US and China that would wreak havoc on the global supply chain
- Continued efforts are needed to avoid further weight increases in response to electrification, with a requirement for innovative car body weight reduction strategies relating to the use of multi-materials, joining of different materials, and innovative structures, among others
- Market cost impact and increase in risk level due to raw material procurement risk
- Intensifying competition for the acquisition of employees with strong AI and systems skills due to the emergence of new competitors amid a shortage of new talent
- Worsening global hiring environments for automobile production plants

5.2 A Message to Nissan's Automotive Engineers

Hopefully, all the Nissan engineers who are to overcome the challenges of the future will revisit the history and achievements of Nissan's past automotive engineers. These individuals have worked passionately and diligently to develop new technologies with the perspective of how their hard work and approaches have "paved the way for the times." It is important to understand this history and pass on the lessons from past visionaries to the future.

Although it takes time for a technology to mature, developing the ability to understand its purpose will enable individuals to ask what this technology is useful for, to take action towards achieving future goals, to improve quality, and to promote steady evolution of the tools and products of the industry. These efforts are essential for creating the car of the future through technological innovation alongside a production system that is resilient in the face of change, instability, and new global challenges. Furthermore, we hope that these efforts will contribute to the creation of a human-friendly workplace where people can take pride in their work. Nissan's automotive engineers are responsible for the future of Nissan, and their enthusiasm and efforts will create new ideas that would shape the industry.

Nissan's automotive engineers have always taken action in the spirit of improving and advancing the Japanese automotive industry. The products and new technologies developed by Nissan's automotive engineers have improved people's lives by enabling them to do things they could not or had given up doing before. This technical review will hopefully encourage individuals to take pride in your work, believe in their own abilities, innovate, and continue to change the industry by solving the challenges of the future.