

Collaborative Value Creation and Beyond

– Contributing to the Resolution of Social Issues While Realizing the Company’s Sustainable Growth –

Special Feature 2. Contributing to Technological Innovation –Aiming for Sustainable Growth–

In the business environment surrounding NSK, technological innovation is rapidly advancing in all industries, including the spread of AI, IoT, and 5G, as well as automotive electrification and automation. In particular, the issues that NSK is working to address are ever expanding. These include efforts in the renewable energy field and the accelerated shift to eco-friendly electric vehicles given the increased importance of addressing climate change and environmental issues, as well as rapidly increasing remote and non-contact needs due to the COVID-19 outbreak. NSK aims for sustainable growth by contributing to technological innovation in these areas.

Collaborative Value with Stakeholders





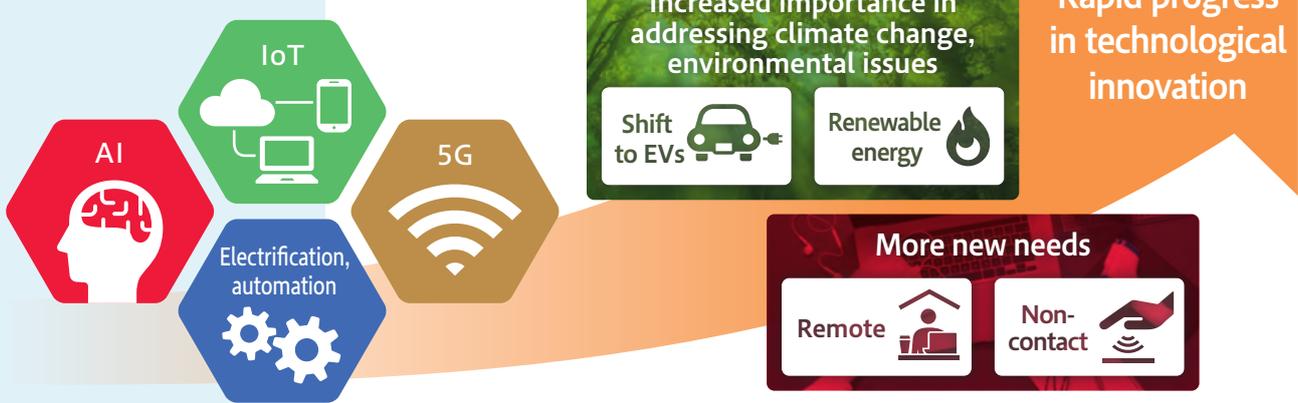


Sustainable Development Goals Addressed by NSK









Further Growth via “Electrification,” “Automation, Labor-saving,” and “Environment”

Technological innovations such as AI, IoT, and 5G are transforming the world into a safer and more comfortable place. With awareness of climate change and environmental issues increasing globally, NSK believes that “electrification,” “automation, labor-saving,” and the “environment” will be the keywords for further growth. To realize a decarbonized society and safe, comfortable, and convenient lifestyles, the “electrification” of automobiles and various other items is progressing, and this is expected to lead to an explosive increase in demand for motors. In addition, “automation and labor-saving” at facilities is accelerating to meet increased efficiency needs and enable sophisticated manufacturing. In the “environment,” we see a greater need for renewable energy such as wind power and mass-transport railways that contribute to decarbonization. Together with stakeholders, NSK will achieve further growth through the collaborative creation of value that contributes to the environment, an advanced technological society, and growth in a wide range of industries.



Key Points

- ▶ Higher demand for small motors mainly for automotive and cooling fans
- ▶ Rapid responsiveness by establishing E&E DHQ
- ▶ Contribution to further ball bearing growth and electrification

The “electrification” of various applications is progressing with the automotive industry shifting from conventional gasoline and diesel vehicles to hybrid and electric vehicles. For example, just as power steering has switched from hydraulic to electric power, electrification is expected to progress in brakes and other areas. Elsewhere, higher demand for onboard motors looks promising as functions increase in such areas as headlights that change lighting direction while driving and electric sliding doors. In the field of industrial machinery, automation and electrification are advancing based on overall connectivity through the spread of 5G

and IoT. As a result, cooling fan demand is expected to rise as data centers and communication base stations increase.

Against the backdrop of this demand growth, NSK expects demand for small ball bearings to increase. NSK established the E&E DHQ to expand its core ball bearings business. In so doing, NSK will integrate production, sales, technology, and management departments to keep up with its rapidly changing customers. Along with strengthening its supply system, NSK will contribute to electrification by improving product appeal, cost competitiveness, and quality.

Automation, Labor-saving



Key Points

- ▶ Accelerated automation and labor-saving needs at production sites
- ▶ Provide value that leverages precision technology
- ▶ Increase the presence of precision bearings and ball screws, and contribute to sophisticated manufacturing

The need for automation and labor-saving at production sites is increasing with working populations shrinking mainly in developed countries and COVID-19 increasing the need for remote and non-contact services. Improving machine tool and robot performance is essential to achieve “automation and labor-saving.” Particularly for machine tools, there has been a progressive shift from 3-axis to multi-axis (e.g., 5-axis) and combined machine tools to consolidate processes and improve machining accuracy. Further growth looks likely as this is an area of demand where NSK can provide value by leveraging its strengths in precision technology (precision machinery products centered on precision

bearings and precision ball screws). In addition, the adoption rate of NC (numerical control) for machine tools is expected to increase in China, the largest producer and seller of machine tools. Ball screw accuracy will become more important as NC takes hold, so we expect demand for NSK products to grow further in the Chinese market.

NSK's precision bearings and precision ball screws will become important as elemental technologies for high-performance machine tools. NSK will continue contributing to advanced manufacturing by making proposals to customers that utilize its precision technology.

Environment



Key Points

- ▶ Expand wind power generation and railway markets amid higher environmental awareness
- ▶ Meet advanced technological needs that include strong durability and high reliability
- ▶ Contribute to the expansion of growth sectors and the realization of a decarbonized society

CO₂-free and highly efficient wind power generation has been growing steadily in Europe—where environmental awareness is high—and in China—where demand for electricity is brisk—while in Japan growth looks promising as one green energy growth strategy. Along with expectations over such market growth, the level of technical difficulty for bearings is also increasing. For example, wind power generation is being used on a larger scale and more offshore to improve power efficiency, but the conditions under which bearings are used have become more severe, thus requiring high durability and high reliability. To address these difficult technical challenges, NSK will apply the “digital twin” concept for proposing optimal designs not only for bearings but also for peripheral components, with the aim of realizing a decarbonized society.

Railways are also expected to grow as a market that contributes to decarbonization. Railways have established a foothold as a means of transportation with lower CO₂ emissions than airplanes and automobiles in Europe. Railways are also expanding in China and Southeast Asian countries amid economic development there. Leveraging its expertise accumulated over many years, NSK will continue to develop products and technologies that contribute to rolling stock safety, comfort, reliability, and environmental impact reduction.



Collaborative Value Creation and Beyond

– Contributing to the Resolution of Social Issues While Realizing the Company’s Sustainable Growth –

Special Feature 2. Contributing to Technological Innovation –Aiming for Sustainable Growth–

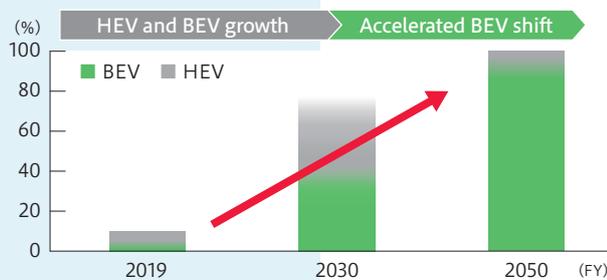
Toward the Era of Auto Electrification

Developments in Auto Electrification

In addition to the mega-trend known as CASE (C: Connected, A: Automated Driving, S: Sharing, E: Electrification), the automotive industry has seen environmental issues gather momentum. In August 2021, the European Union announced a policy to end sales of new gasoline and diesel vehicles (ICE), including hybrid electric vehicles (HEV), by 2035 to achieve carbon neutrality by 2050, and the United States has issued an executive order that more than half of new vehicle sales by 2030 be electric and fuel cell vehicles, including BEVs and plug-in hybrids. Japan and China have also announced policies to shift their new car sales to electric vehicles such as HEVs by 2035.

Against this backdrop, the global auto electrification rate is expected to rise rapidly. In 2019, the electrification rate was around 10%, but this will surpass 50% by around 2030, when regulations in various countries start to take effect, and could approach 100% by around 2050. Until 2030 or so, however, the electrification rate will likely increase due to significant growth in both HEVs and BEVs, though with some regional differences.

■ Auto Electrification Rate (NSK Forecast)



■ Trends in Individual Countries (as of August 2021)

Japan	Shift mainly new vehicles sales to electric vehicles by 2035
United States	Executive order targeting more than half of new vehicle sales be electric vehicles and fuel cell vehicles by 2030
EU	Sales of new gasoline and diesel vehicles (including HEV) will stop by 2035
China	New energy vehicles will account for more than 50% of auto sales volume by 2035

The Impact of Electrification on NSK

With the shift from ICE to BEV, the number of bearings installed in a vehicle decreases. The major reasons for this are the engine used in gasoline vehicles being replaced by a motor in BEVs, and the transmission changing from a complex multistage gearbox to a simple reduction gear. However, there are zones where the number of bearings will increase, as electrification results in the use of more on-board motors. In summary, bearings are expected to decrease by about 20% in BEV compared to ICE. While depending on the mechanism, in HEVs, however, bearings will rise by roughly 10% due to the increase in motors.

With electrification accelerating, NSK expects sales to grow steadily until around 2030 as both HEVs and BEVs increase. However, we are pursuing the development and release of new products for electric vehicles as we see potential for bearings sales to subsequently decrease as BEVs become mainstream.

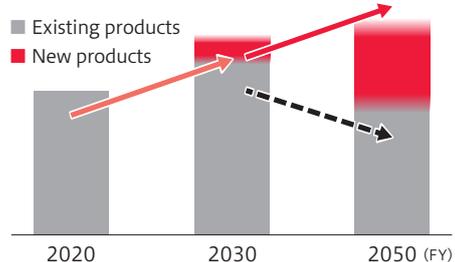
■ Bearing Swings with ICE as 100 (NSK forecasts)

	ICE	HEV	BEV
	100	110	80
Motors	→ STAY	↗ UP	↗ UP
Engines/transmissions	→ STAY	→ STAY	↘ DOWN

New Products for Growth in the Electrification Era

As electric vehicles are equipped with many batteries, technological issues and needs include “downsizing powertrains,” “improving driving power and maximum speed,” and “increasing cruising range.” NSK aims to achieve sustainable growth in the age of electrification by proposing new technologies and products to our customers that meet these needs. As the mobility society evolves, we will continue to proactively create value and, in turn, expand our automotive business.

■ Automotive Business Growth Image



Develop and release new products to hedge risks of a decline in existing products from 2030

Existing products to steadily rise until around 2030 but could decrease afterward

Traction Reducer

- Compact, lightweight, ultra-high-speed rotation EV drive units with optimized deceleration mechanism
- Quiet operation with traction drive mechanism

Instead of using gears, the Traction Reducer uses a special oil that hardens only at the moment of compression, enabling efficient power transmission through "rolling" for superior quietness. Combining a traction drive speed reducer with a high-speed motor enables smaller and lighter weight automotive electric drive systems, helping to reduce electric vehicle power consumption through the smooth transfer of power.



Non-Contact Torque Sensor

- Sensor used to measure torque without making contact while helping to deliver shock-free gear shifting
- Improves power consumption and fuel economy of automobiles and provides a smooth and comfortable ride

Automobiles transmit engine and motor power to the tires through the drive shaft. It is essential to measure the torque of the drive shaft and efficiently achieve optimal power transmission to improve environmental performance, comfort, and safety (e.g., detect malfunctions). NSK torque sensors absorb the shock of shifting gears in two-speed transmission electric vehicles to improve power consumption by 7% and softens fluctuations in torque when changing gears to achieve a comfortable ride.



Power Flow Switching Device

- Multifunctional shift actuator module
- Reduces size of 2-speed transmissions; enables design 2-speed transmission systems capable of meeting diverse customer requirements

The Power Flow Switching Device is a multifunctional shift actuator that enables three shifting modes: Low, High, and Park. In addition to the low- and high-speed shifting functions for improving cruising range and driving performance, the park function replaces parking mechanisms installed in conventional reduction gears, contributing to the development of smaller 2-speed transmission units. This device also enables the design of 2-speed transmissions to meet diverse customer requirements.



Third Generation Ultra High Speed Ball Bearing for EV Motors

- Helps meet the need for higher speeds in EV motors
- Contributes to smaller, lighter weight EV motors

Bearings used in powertrains, especially in electric motors, are being subjected to increasingly higher speeds and performance demands. NSK completed development of the second generation ultra high speed ball bearing (over 1.4 million dmN*) in March 2020. The second generation design featured significant advancements in cage and anti-seizure technology. However, NSK engaged in further development aligned with demand for bearings capable of even higher speeds in electric motors for EVs, developing in March 2021 the third generation ultra high speed ball bearing capable of operating at over 1.8 million dmN.



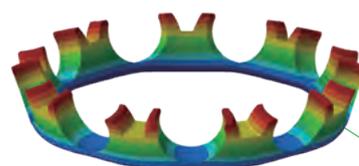
*dmN: A measure of bearing rotational performance. The product of bearing pitch diameter (dm) in millimeters and rotational speed (N).

Application of Digital Technology Bearing design and development based on the "digital twin," a concept that emphasizes the real

As performance requirements accelerate, "digital twin" is being promoted as a concept that emphasizes realism to ensure efficient and high-quality development. One such initiative is the third generation ultra high speed ball bearing for EV motors developed in March 2021. The product's cage utilizes "topology optimization" technology. Conventional cages are thick to prevent deformation and breakage due to centrifugal force. Using topology optimization, however, we have succeeded in decreasing weight while increasing strength and rigidity, potentially enabling high-speed rotation of more than 200% compared to conventional products. In addition, we were able to quickly solve problems and develop the product in a short period by conducting evaluation tests using high-speed cameras to observe the behavior of the cage during high-speed rotation.

What is topology optimization ?

Topology optimization aims to find a given product's optimal geometric shape under specific usage conditions. For example, in an airplane, unnecessary parts that do not impact rigidity can be cut down to more aerodynamic shapes that are both strong and lightweight.



Conventional cages are significantly deformed by the centrifugal force of rotation and worn out by coming into contact with the outer ring



The new cage is lighter, stronger, and more rigid to control deformation and avoid contact with the outer ring