

Activities Regarding the Development and Design of Environmentally Friendly Products

H. SEGAWA

We JTEKT have established six specialized environmental subcommittees under the Global Environmental Conservation Committee, through which our entire company promotes environmental conservation activities. The Environmental Responsive Products Subcommittee, which is one of these subcommittees, promotes conservation within the development and design stages of environmentally friendly products. In 2003, this group laid down a "basic type of environmental efficiency" as the common benchmark for all JTEKT group products, and in 2016 the group changed the base year from the initial 2003 to 2010 when formulating the JTEKT mid-term target plan, which has stricter targets to be fulfilled. The report introduces the activities within the Environmental Responsive Products Subcommittee geared towards the fulfillment of the Environmental Action Plan 2020.

Key Words: Development, design, environment, products

1. Introduction

In recent years, there has been a growing interest in planet environmental issues due to factors such as the Kyoto Protocol, which was adopted in 1997 at Conference of Parties to the UN Framework Convention on Climate Change (UNFCCC) III (COP3) entering into force in 2005 and the establishment of legislation regarding environmentally hazardous substances¹⁾. Moreover, at the 21st Conference of the Parties to the UNFCCC, or COP21, held in Paris in November 2015 each member country submitted their CO₂ reduction targets to the UNFCCC secretariat. In Japan, an international commitment to reduce CO₂ by the year 2030 by 26% compared to 2013 levels (25.4% compared to 2005) was submitted, and a long-term target of achieving an approximate 80% reduction by FY2050 was established. Of this, the 20% of Japan's CO₂ emissions is estimated to be produced by the transport sector, which includes automobiles. Each automotive manufacturer and car parts manufacturer considers response to environmental issues as a major issue and engages in initiatives to broadly assess the impact of corporate activities on the environment, as well as contribute to the sustainable development of the planet and society. Automotive manufacturers are exerting maximum effort to improve fuel efficiency of cars as the most effective means of reducing CO₂ emissions. Car fuel efficiency is improving more and more each year with the average fuel efficiency of gasoline-driven passenger vehicles at 22.4 km/L in 2014, which greatly exceeds the

2015 fuel efficiency standard equivalent level (17.4 km/L) and even the 2020 one (20.7 km/L)²⁾.

JTEKT also delivers a high number of products to the automobile industry and is being required to develop and design environmentally friendly products to help further improve vehicle efficiency. As part of this, in March 2011 we formulated JTEKT Group Environmental Vision, which comprises of an Environmental Philosophy and Environmental Policy which stipulates the content of initiatives for conserving the planet's environment. JTEKT has established an action plan for achieving targets and is promoting ongoing activities with the aim of realizing a sustainable society.

2. JTEKT Initiatives

2.1 Promotion systems relating to JTEKT's environmental management^{3),4)}

As one initiative to achieve our Corporate Philosophy of "Seek to contribute to the happiness of people and the abundance of society through product manufacturing that wins the trust of society.", JTEKT established the Global Environmental Conservation Committee, which is chaired by our president, in the 1990s and engages in environmental management. The committee promotes environmental conservation activities by discussing and determining targets based on company policy and establishing six specialized subcommittees in order to promote, and monitor the progress of, major themes raised in our Environmental Policy (Fig. 1).

One of these is the “Environmental Responsive Products Subcommittee”, which is comprised of members across the development and design departments, and has promoted initiatives from the development and design stages of environmentally friendly products from the perspective of reducing environmental burden, in particular, prevention of global warming.

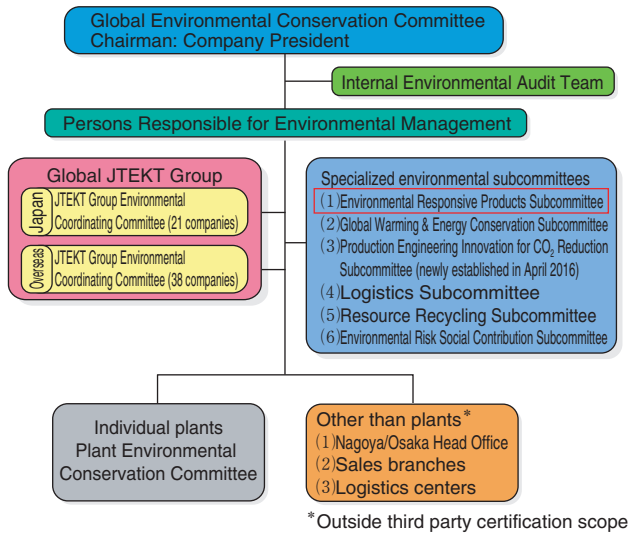


Fig. 1 Promotion structure of JTEKT's environmental management

2. 2 Environmental Challenge 2020⁴⁾

In May 2016, in line with the slogan of “For future children”, JTEKT formulated Environmental Challenge 2050 as a new initiative guideline aimed at minimizing environmental burden by the year 2050, and Environmental Action Plan 2020 - a 5-year activity plan to serve as the first step (Table 1).

Table 1 Environmental Action Plan 2020

Area	Initiative item
Products/technologies Develop and design environmentally friendly products	(1)Develop new technologies and products to lead the way in reducing environmental burden
	(2)Promote the 3Rs (reduce, reuse and recycle) considering effective utilization of resources
	(3)Manage and reduce environmentally-burdensome substances contained in products
	(4)Conduct environmental assessments in the design and development stages
	(5)Contribute to CO ₂ reduction through products

This section will introduce the content of the items (1), (2), (4) and (5) below which are being engaged in by the Environmental Responsive Products Subcommittee in order to achieve Environmental Action Plan 2020 from the perspective of taking on environmental issues related to development and design divisions.

3. Initiative Content

3. 1 Transition of environmentally friendly products

Through its day-to-day activities, the Environmental Responsive Products Subcommittee promotes development and design to help improve the environment in JTEKT's four business areas (steering, driveline, bearings, machine tools & mechatronics) and offers several environmentally friendly products to customers around the globe. Below introduces an example of the transition of environmentally friendly products offered by JTEKT.

<Steering>

Of a vehicle's basic functions, “traveling,” “turning” and “stopping,” steering products serve the function of “turning.” In 1988, JTEKT developed the world's first electric power steering (EPS) which offers approximately 3% better fuel efficiency than the conventional hydraulic power steering (HPS) and greatly contributes to reduction of energy consumption. JTEKT's EPS also boasts excellent mountability and is our flagship environmentally friendly products. From the year 2000 onwards, there was a rapid increase in the number of EPS adopted, and JTEKT offers EPS tailored a variety of needs. As a result, in FY2015, EPS accounted for approximately 75% of all steering product shipments (Fig. 2).

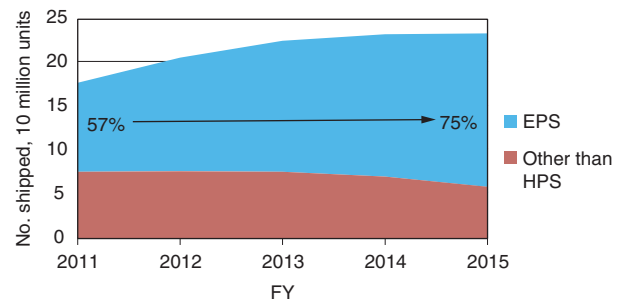


Fig. 2 Transition of environmentally friendly products within the steering business

<Driveline>

Since JTEKT developed the ITCC (Intelligent Torque Controlled Coupling) in the 1990s as a product to appropriately distribute drive torque to the rear wheels of all wheel drive (AWD) cars depending on their travelling

status, this product has been adopted by many vehicles. As efforts to improve fuel efficiency in consideration of the environment have progressed over the years, a demand has emerged for better fuel efficiency in AWD vehicles also. In order to meet such needs, JTEKT has made its ITCC increasingly environmentally-friendly through improvements such as low viscosity of the internal hydraulic oil and reduced torque through creative clutch groove design. In FY2015, environmentally friendly product (ITCC) accounted for around 86% of all JTEKT’s ITCC shipments (Fig. 3).

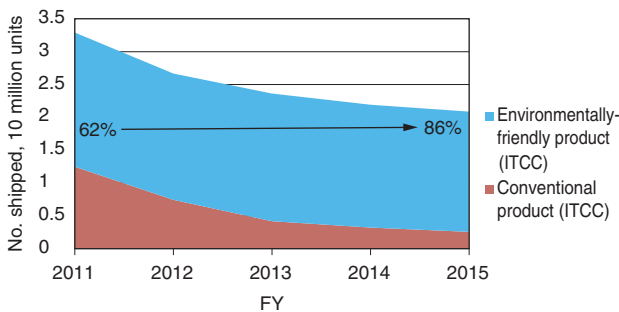


Fig. 3 Transition of environmentally friendly products within the driveline business

<Bearings>

Bearing products contribute to “movement” in all industries. JTEKT provides many environmentally friendly products leveraging low-friction loss technology targeting industrial machinery such as wind power generation and high-speed rail, and the automotive industry.

In regards to tapered roller bearings (TRB), through the control of lubricant amount and optimization of internal design, we have developed the 4th generation TRB-LFT (LFT: Low Friction Torque), which achieves a reduction in friction loss as much as 50% compared to 2nd generation TRB-LFT through implementation of low torque measures. This product was added to the lineup in October 2015 and is greatly contributing to society through helping to protect the environment, in particular in terms of lowering fuel consumption and achieving high-efficiency of vehicles.

Since it was developed in 1980, JTEKT’s TRB-LFT has been improved many times and, in FY2015, accounted for approximately 50% of all TRB shipments (Fig. 4).

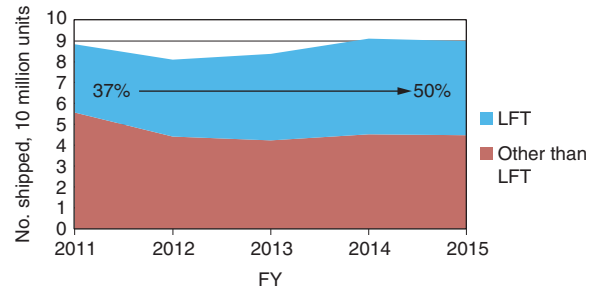


Fig. 4 Transition of environmentally friendly products within the bearing business

<Machine Tools & Mechatronics>

In the machine tools & mechatronics business, JTEKT is supporting the “roots of manufacturing” by offering grinders, machining centers, cutting machines and so forth. Based on an awareness that reducing energy consumption and conserving resources to help prevent global warming are important from the perspective of protecting our planet’s environment, JTEKT engages in the below three items as our main initiatives to promote the development and design of environmentally friendly products which incorporate energy-saving technologies to the maximum extent and such products accounted for approximately 70% of all those shipped in FY2015 (Fig. 5).

[Major initiative items]

- ① Adoption of an eco-mode control (equipment idle-stop) in order to reduce standby energy consumption
- ② Adoption of energy-saving devices such as high-efficiency variable capacity type vane pumps, etc. in order to reduce regular energy consumption
- ③ Adoption of the fastest CNC and high-speed network in order to reduce cycle time

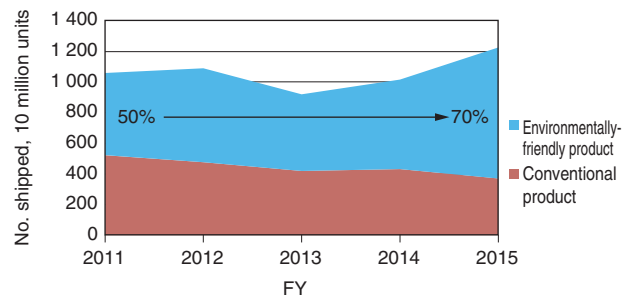


Fig. 5 Transition of environmentally friendly products within the machine tool and mechatronics business

3. 2 Develop new technologies and products to lead the way in reducing environmental burden

JTEKT has defined its own unique basic formula for environmental efficiency in order to make numerical evaluations as an indication of a product’s effectiveness in reducing environmental burden. The higher the value derived from this basic formula is, the greater the environmental burden reduction and the Environmental Responsive Products Subcommittee has focused on the environmentally friendly products developed each year to select those which lead the way with respect to the most important themes and engages in product development by establishing higher environmental efficiency value targets and evaluating the level to which this target has been reached⁴⁾. This section introduces the basic formula for environmental efficiency and some initiatives of the Environmental Responsive Products Subcommittee.

3. 2. 1 Environmental efficiency³⁾

In 2003, the “environmental efficiency basic formula (1)” was established as a common indicator for all JTEKT Group products. This basic formula divides a product’s performance (positive impact on the environment) with a product’s environmental burden (negative impact on the environment) to derive a weight term (W), a loss term (T) and an energy term (E) as the fundamental representative traits as it is difficult to accurately ascertain the environmental burden value for each product. Here, the level of performance improvement for products is not considered for the time being and, if the product type differs greatly, conversions are made such as replacing with other representative traits. Also, an environmental efficiency value (2) and environmental burden reduction rate (3) have been established as straightforward, quantitative indicators for the environmental efficiency improvement of environmentally friendly products. This is expressed as a ratio of the environmental indicator for a conventional product and the environmental efficiency of a new product with the same purpose of application, or a reduction ratio (percentage). At first, “conventional product” referred to products existing in 2003 prior to this formula being introduced, however when JTEKT’s medium-term targets were established in 2016, the reference point for conventional products was revised and became based on 2010 products, thus making the criteria even stricter.

By using this common indicator established independently by JTEKT Group and evaluating the achievements of developing and designing all products on an even playing field, JTEKT has endeavored to help protect our planet’s environment.

■ Environmental efficiency basic formula
 =product performance divided by product environmental burden
 $= 1/\sqrt{W^2+T^2+E^2}$ (1)

■ Environmental efficiency value
 =New product’s environmental efficiency divided by conventional product’s environmental efficiency (2)

■ Environmental burden reduction ratio
 =(1 – 1 divided by new product’s environmental efficiency divided by conventional product’s environmental efficiency’s multiplied by 100
 =(1 – Conventional product’s environmental efficiency divided by new product’s environmental efficiency) multiplied by 100 (3)

3. 2. 2 Introducing leading activities

This section introduces an example of a theme-focused activity engaged in over the past three years for each JTEKT business area (steering, driveline, bearings, machine tools & mechatronics) (Table 2).

<Steering>

JTEKT’s column-assist type electric power steering (C-EPS) is suitable for compact cars with minimal engine room space as its power assist unit is situated in the vehicle cabin. JTEKT engaged in an activity to reduce weight by primarily focusing on the composite components of this power assist unit. By revising the internal structure and components of the MCU (Motor Controller Unit) and making the intermediate shaft and column intermediate shaft hollow, we succeeded in reducing weight without losing rigidity. Compared to the conventional product, weight reduction of 8% and energy-consumption reduction of 83% were achieved, which in turn achieved an environmental burden reduction ratio of 21%.

<Driveline>

The ITCC, which controls distribution of front/rear wheel torque, conveys torque to the rear wheels by controlling the main clutch via the control clutch and JTEKT successfully improved the operating efficiency during low temperatures by improving the control clutch groove. We appropriated the maximum load capacity that driveline components should possess and made components smaller and lighter (13% mass reduction). The improvement in operating efficiency resulted in a torque loss reduction of 27% and energy loss reduction of 68% in addition to achieving a 32% environmental burden reduction ratio.

<Bearings>

JTEKT enhanced its LFT series lineup with the addition of products which incorporated thorough

Table 2 Examples of main activities for leading products

System		Development points/technologies	Environmental efficiency value	Environmental burden reduction ratio												
Steering	<p>Column assist type electric power steering (C-EPS)</p>	<ul style="list-style-type: none"> ■①Revised MCU internal structure and components ■②Reduced weight by hollowing out of intermediate shafts and friction welding ■③Reduced weight by hollowing out column's intermediate shaft ★8% weight reduction ★83% energy consumption reduction 	1.26	21%												
Driveline	<p>ITCC</p> <p>◆Cross-sectional structure ◆Improved control clutch</p>	<ul style="list-style-type: none"> ■Improved operating efficiency at low temperatures by improving control clutch groove (reduced drag torque) ⇒Appropriated maximum load applied to driveline components ⇒Made driveline components smaller and lighter ■Reduced size and weight by optimization of component configuration ★13% weight reduction ★27% torque loss reduction ★68% energy loss reduction 	1.35	32%												
Bearings	<p>LFT series</p>	<ul style="list-style-type: none"> ■Optimization of bearing internal design ■Controlled the amount of penetrating lubricant through optimization of cage shape ■Development of new grease ■Analysis/measurement technology (visualization of grease behavior, etc.) Creation of bearing series featuring bearings with reduced torque loss through the application of various tribology technology ★Torque reduction <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>①TRB-LFT (IV)</td> <td>△50%</td> <td>TRB-LFT (II) ratio</td> </tr> <tr> <td>②HUB-LFT</td> <td>△50%</td> <td>Compared to conventional product</td> </tr> <tr> <td>③NRB-LFT</td> <td>△50%</td> <td>Compared to conventional product</td> </tr> <tr> <td>④BB-LFT</td> <td>△15%</td> <td>Compared to conventional product</td> </tr> </table>	①TRB-LFT (IV)	△50%	TRB-LFT (II) ratio	②HUB-LFT	△50%	Compared to conventional product	③NRB-LFT	△50%	Compared to conventional product	④BB-LFT	△15%	Compared to conventional product	1.16	14%
①TRB-LFT (IV)	△50%	TRB-LFT (II) ratio														
②HUB-LFT	△50%	Compared to conventional product														
③NRB-LFT	△50%	Compared to conventional product														
④BB-LFT	△15%	Compared to conventional product														
Machine tools & mechatronics	<p>Board-type safety PLC</p> <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> <p>Conventional configuration</p> <p>Input: Output = 24 points: 6 points</p> <p>POWER: 1</p> <p>CPU: 1</p> <p>S-IN-E: 1</p> <p>BASE: 2</p> </div> <div style="border: 1px solid black; padding: 5px;"> <p>Developed configuration</p> <p>Input: Output = 24 points: 8 points</p> <p>I/F unit: 1</p> <p>Basic unit: 1</p> <p>Optional unit: 1</p> </div> </div> <p style="text-align: center;">Conventional product Developed product</p>	<ul style="list-style-type: none"> ■Reduced environmentally burdensome substances through abolishing the resin housing ■Reduced power consumption through concentrating circuits ★Abolishment of amp stand: 1 308 kg/year [Reduced CO₂ emissions (for every 1 000 units)] ★Power consumption: 1.2 kWh/year 	1.64	39%												

agitating loss reduction, low viscous grease oil, optimized seal lip design and so on through the deepening of tribology technology focused on each bearing element as well as the optimization of internal design and flow control.

This achieved a reduction in torque to as much as 50% depending on bearing specifications and an average environmental burden reduction ratio of 14%.

<Machine tools & mechatronics>

The PLC (Programmable Logic Controller) serves as the brains of a machine tool and is required to be of a flexible structure to suit the equipment scale.

For the board-type safety PLC, we have simplified the structure by abolishing the resin housing and reduced the amount of materials used as well as concentrated circuits to reduce microcomputer usage. Furthermore, as a result of reducing power consumption by 1.2kWh/year, an environmental burden reduction ratio of 39% was achieved.

3. 3 Promotion of 3R (Reduce, Reuse, Recycle) design considering effective utilization of resources

The “3R” activity aims to “reduce,” “reuse” and “recycle” through environmental designs. At JTEKT, we promote development and design from the concept phase keeping in mind the following points; “reducing resource usage through making products smaller, lighter and longer lasting” and “product design enabling easy recycling.” This section introduces an example of a theme-focused activity engaged in over the past three years for each JTEKT business area (steering, driveline, bearings, machine tools & mechatronics) (Table 3).

<Steering>

The EPS is equipped with a torque sensor to detect the amount of steering force needed for the driver to turn a vehicle’s steering wheel. We improved the housing for this torque sensor, which is also attached to the EPS, by changing from the conventional aluminum die cast to a resin sensor housing integrated molding. This has achieved a weight reduction of 33% compared to the conventional product and helped to reduce the amount of steel used.

<Driveline>

In regards to vane pumps for CVT (Continuously Variable Transmission) lubricant, we developed a stand-alone type vane pump to replace the coaxial inscribed gear pump and achieve size/weight reduction. By making the diameter of the main unit’s rotating portion smaller (52% reduction) and changing the pump case material from forged steel to aluminum, we succeeded in reducing

weight by 80%. By reducing resource usage and reducing weight through material changes, we are helping to improve the fuel efficiency of vehicles.

<Bearings>

Regarding low torque ball bearings supporting high axial loads, by adopting an oil quantity controlling cage leveraging LFT technology, we have reduced torque loss compared to conventional deep groove ball bearings. Furthermore, by increasing raceway depth on the side subjected to axial load, we have reduced the external diameter by 10% as well as improved axial load resistance (by 1.8 times compared to the conventional product). This effort is contributing to improved vehicle fuel efficiency through reduction of torque loss and weight reduction by size reduction.

<Machine tools & mechatronics>

Conventional safety PLCs used vanadium lithium secondary batteries for the backup function of internal memory and the internal clock. JTEKT has eliminated the need to use batteries by using a non-volatile memory for PLC internal data and performing backup with an IC super capacitor for the clock. This has resulted in eliminating battery waste altogether, thus contributing to waste reduction and reducing the weight of the product through removing the need for batteries.


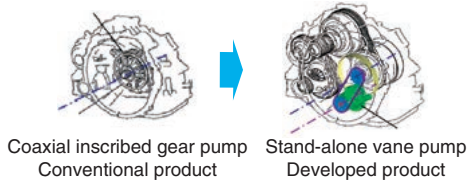
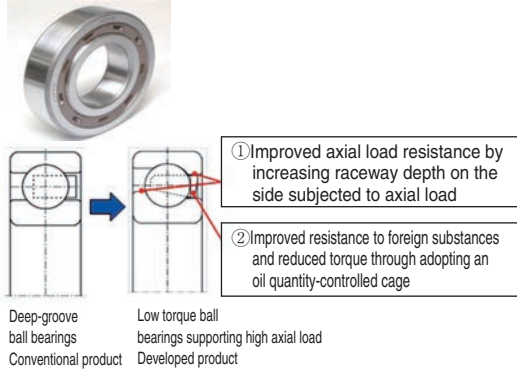
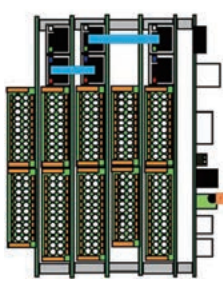
3. 4 Environmental assessments during the development and design stages

In recent years, amidst growing awareness of environmental issues, car parts manufacturers are also being required to disseminate products with as little environmental burden as possible throughout society.

As such, a trend has emerged whereby information pertaining to environmental burden throughout a product’s entire lifecycle (from raw material procurement to manufacturing, transportation, usage, disposal and recycle) known as “LCA” or “Life Cycle Assessment” is displayed so that consumers can select environmentally friendly products. Regarding LCA, ISO standards have been established amongst international standards of environmental management published by the ISO (International Organization for Standardization). As such, many Japanese businesses are also incorporating LCA in their CSR reports, etc.

JTEKT is a member of the LCA subcommittee for JAPIA (Japan Auto Parts Industries Association), which comprises of car parts manufacturers, and promotes the development and design of environmentally friendly products through examining the concept of calculating life cycle environmental burden effectively (for the manufacturing and usage stages) and establishing various internal institutions to perform checks for the proper

Table 3 Examples of main 3R activities

Category (technology)	System		3R attribute	Development points (■)/effect (★)
Reduction of resource usage (size/weight reduction)	Integrated molding	Steering 	Reduce	■ Sensor housing changed from aluminum die cast to resin sensor housing integrated molding ★ Weight reduction: 33% for torque sensor/housing portions compared to conventional structure (on type with separate aluminum housing)
	Structure changes	Driveline 		■ Changed the coaxial inscribed gear pump to a stand-alone vane pump ■ Changed pump case material (from forged steel to aluminum) ★ Reduced main unit's rotational portion diameter by 52% ★ 80% weight reduction
		Bearings 		■ Compared to conventional deep-groove ball bearings, increased depth of raceway on the side subjected to axial load ■ Adopted an oil quantity-controlling cage (LFT technology) ★ Size/weight reduction: External diameter reduced by 10% ★ Improved axial load resistance: 1.8 times compared to conventional
	Part change	Machine tools & mechatronics Battery-free safety PLC 		■ Non-volatile memory using for PLC internal data ■ 15-days backup with IC (RTC) power source for clock using a super capacitor ★ Zero battery waste ★ Weight reduction: 12 g

implementation of environmental assessments in the development and design stages.

3. 5 Contribution to reducing CO₂ emissions by product

At JTEKT, a company that promotes the development and design of environmentally friendly products contributing to reduction of CO₂ emissions, promoting improvement of products as part of the abovementioned Environmental Action Plan 2020, we have set the new environmental indicators of reducing CO₂ emissions during product use and contributing to the prevention of global warming through a product’s lifecycle. We have adopted the “carbon neutral” concept, whereby our overall CO₂ emissions is offset by the degree to which we contribute to CO₂ reduction, and we have set a goal for the degree our products contribute to CO₂ reduction to be equal to or greater than JTEKT Group’s overall CO₂ emissions by the year 2020.⁴⁾ The Environmental Responsive Products Subcommittee is diligently working to fast-track the 2020 target to 2019 (Fig. 6).

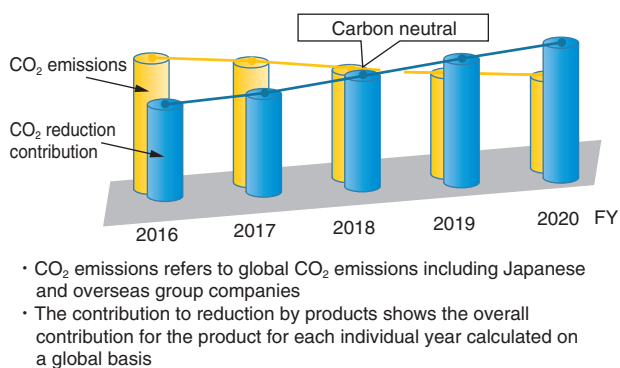


Fig. 6 Contributing to CO₂ reduction through products

4. Conclusion

This paper has introduced the Environmental Responsive Products Subcommittee’s initiatives for the development and design of environmentally friendly products.

Although not mentioned in this paper, world-wide environmental restrictions relating to chemical substances are intensifying every year. Last year, in order to properly respond to environmental restrictions relating to chemical substances contained in products, JTEKT established a Product Environmental Committee, which has begun managing chemical substances contained in products.

Section 3. 4 of this paper introduced LCA-related initiatives. However, with environmental restrictions intensifying even further in the future, companies will be under even more pressure to engage in environmentally-orientated initiatives. To meet such a demand, we need to

investigate the establishment of environmental indicators incorporating this LCA perspective.

In the automotive industry, EV (Electric Vehicles) and FCV (Fuel Cell Vehicles) are expected to increase in popularity moving forward, and, to respond to this trend, JTEKT also has an obligation of offering its customers many No. 1 & Only One products fusing the various technologies of steering, driveline, bearings and machine tools & mechatronics.

Moreover, in an effort to achieve our Environmental Challenge 2050, the Environmental Responsive Products Subcommittee is conducting technological training for its engineers and spreading the concept of development/design with an awareness of CO₂ reduction throughout the entire JTEKT Group in order to further strengthen our cohesiveness and accelerate activities to send environmentally friendly products out into the world.

*1 C-EPS, ITCC and LFT are registered trademarks of JTEKT Corporation

References

- 1) Japan Auto Parts Industries Association : Seihin kankyou shihyou guideline 2nd edition (Product Environmental Indicator Guideline 2nd edition) (2008)4.
- 2) Japan Auto Parts Industries Association : Environmental Report 2016 (2016)7.
- 3) JTEKT CORPORATION : CSR Report2008 (2008)8-9.
- 4) JTEKT CORPORATION : CSR Report2016 (2016)E_01, E_03, E_12.



H. SEGAWA *

* Executive Managing Officer