Feature 1 Sustainable Product

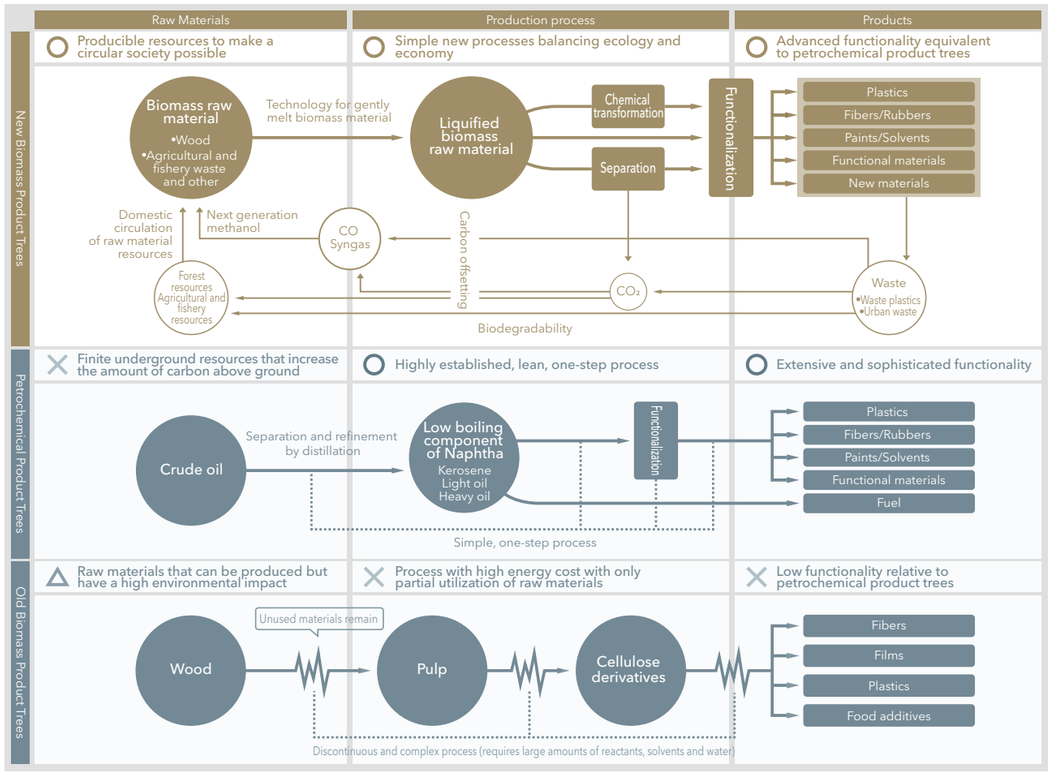
Exploring Possibilities with Technology for Melting Wood

～A Pioneer in Biomass Chemistry, Daicel Aims to Introduce New Biomass Product Trees～

Since its foundation, Daicel has always handled wood resources and has been a pioneer in naturally derived chemical products. Even during the 1970s energy crisis, we were the first to start working on the C1 Chemistry (synthesizing non-petroleum-based organic compounds from one-carbon compounds such as carbon monoxide and methanol) project to quickly break away from the over-reliance on oil. In FY2021/3, with the Long-Term Vision to contribute to creating a circular society, we started working on the "Biomass Value Chain" concept. The creation of Biomass Value Chain is centered on "New Biomass Product Trees."

In this page, we will present the overall picture of "New Biomass Product Trees" and will introduce research and development processes to commercialize the "technology for melting wood" that will accompany the realization of this concept.

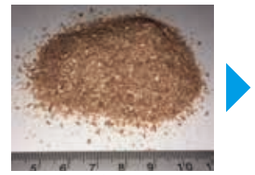
New Biomass Product Trees Envisioned by Daicel



As a Pioneer in Biomass Chemistry

Our main product, cellulose acetate, is environment-friendly because it is biodegradable and derived from wood. The process of manufacturing cellulose acetate, however, is not environment-friendly because the separation of cellulose from wood and its reaction and refinement requires a large amount of energy.
In order to solve this issue, we conducted joint research with universities and developed a new technology of gently melting wood. Our melting technology, developed by leveraging our expertise and knowledge in biomass chemistry accumulated over the years, not only saves energy in the manufacturing process but also makes it possible to achieve superior quality cellulose products with high functionality. Apart from cellulose, this technology also makes it possible to gently melt other elements contained in wood (lignin, hemicellulose), which have not been utilized so far. With this technology, these elements can be separated in an easy-to-utilize state and can be chemically modified to create new elements with unprecedented functions. In addition to accelerating our research and development in melting technology, we will also pursue the potential of biomass materials to create a new line of biomass products for a wide range of fields to develop a "New Biomass Product Trees" that will replace and complement petrochemical products.

Pick Up! Potential of "MoCA," a New Molecular Cellulose Assembly, with Technology for Melting Wood


Wood powder

MoCA: New material separated from wood powder

Through our joint research with Kyoto University, we have developed a new technology for selectively melting the lignin and hemicellulose contained in wood and separating the cellulose. Compared to conventional technologies used to separate cellulose (such as pulping under high temperature and high pressure conditions), our technology can achieve cellulose separation with a much more simple process under mild conditions and under conditions that facilitate shape adjustment and chemical modification (high functionality). Separated cellulose molecules exist in fine aggregates and are light in weight with high elasticity and high strength. Moreover, cellulose can be chemically modified and used in various functions. The core technology involves controlling the structure of cellulose (molecular assembly state and chemical structure) by adjusting the chemical reaction conditions of wood to express the target functions. This new material is named MoCA (Molecular Cellulose Assembly). We are currently in the testing phase for mass production, conducting scale-up prototyping and evaluating practical application with a view toward use in high-performance filter materials, reinforcement materials and binder applications.

VOICE

Hiroyuki Matsumura
Principal Researcher
Technical R&D Institute
Biomass Innovation Center

In recent years, refined cellulose (e.g. microfibrillated cellulose and cellulose nanofiber) has garnered attention due to its high functionality and superiority as a resource, and a lot of research and development is being conducted surrounding it. The common challenge with regard to MoCA and refined cellulose is to establish applications that are appropriate for their cost and functions. Daicel has cultivated a wealth of cellulose-handling technology, knowledge and connections with its customers over the years. We further hope to combine our advanced research findings from our joint research on catalytic technology with Kyoto University and on cellulose homogenous reaction technology with Kanazawa University to leverage our strengths in further improving the functionality, reducing costs and working on practical application of the technology.

Pick Up! Cellulose Absorbents to Circulate Scarce Resources


Palladium extracted by metal absorbents

In recent years, the demand for rare metals used in semiconductors and batteries has been on the rise owing to the economic growth of developing countries and the popularity of electric vehicles for achieving a decarbonized society. In order to secure a stable supply of these resources, metal recycling, which involves recovering rare metals from discarded electronics, has been gaining attention.

Leveraging its specialized expertise in cellulose, Daicel is utilizing its knowledge and molecular designing technology to develop a new cellulose material that can effectively absorb and recover gold ions from discarded electronic boards and discarded plating solutions. This technology takes advantage of the properties of cellulose polymers, which can be easily chemically modified, to selectively absorb the target metal. In addition to gold ions, we are also conducting research on absorption of other rare metals such as platinum, copper and palladium in collaboration with Kanazawa University, with focus on practical applications such as recovery of rare metals from urban mines and restoration of contaminated soil.

Pick Up! New Manufacturing Method for Cellulose Derivatives


Twin-screw extruder with excellent performance in mixing high-viscosity substances and heat removal

The cellulose is a natural polymer that is difficult to melt. In the past, unreacted raw materials would remain even after a long reaction process, and byproducts and thermally degraded products were generated. As a result, the refining process to remove impurities would be long, consuming a lot of energy. By utilizing the homogenous melting technology for cellulose researched by Kanazawa University, we are developing a process to melt and react pulp, of which cellulose is the main component, in an environment-friendly manner. With the homogenous melting technology, pulp can be melted without any irregularities, yielding liquid cellulose that easily reacts with other substances. Since this cellulose reaction is highly viscous and exothermic, a twin-screw extruder is used as the equipment because it excels in heat removal and allows continuous mixing of substances with high viscosity.

This combination of technology and equipment makes it possible to shorten the time and save energy in a series of processes from cellulose melting to reaction. At present, the combined research using the above technology and the twin-screw extruder is in the implementation stage. We aim to use this new method to increase the competitiveness of Daicel's existing products and create new high value added products.

Feature 2

Sustainable Process

Daicel Group's Challenge to Achieve Carbon Neutral

～Establishing innovative technologies and realizing manufacturing that is both ecological and economical～

The chemical industry provides beneficial materials that also contribute to reduction of environmental impact; however, the manufacturing processes of these materials require a lot of energy. The Daicel Group has taken this challenge head-on and is working on creating highly effective solutions that will not only reduce the environmental impact of the manufacturing processes but will also help in achieving carbon neutrality.

In this page, we will introduce the Daicel Group's initiatives being implemented from three angles, reducing costs, improving productivity and enhancing competitiveness as a manufacturing company with a view toward achieving manufacturing that is economical as well as ecological, while at the same time reducing its environmental impact.

Medium- and Long-Term Reduction Targets for GHG Emissions

The Daicel Group has set a medium- and long-term reduction targets in line with the standard of SBT*1.5°C.

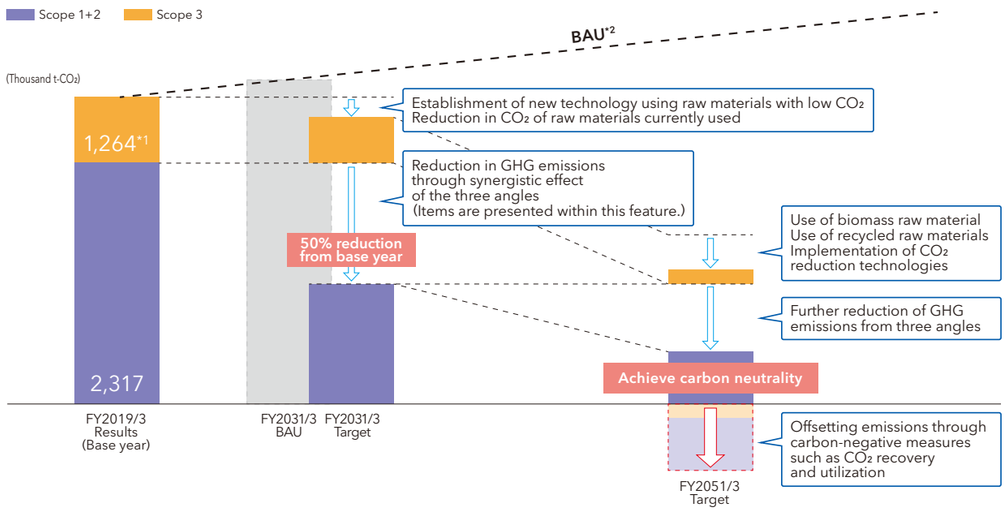
FY2051/3: Achieve carbon neutrality; Scope: 1, 2, 3 of the Daicel Group
FY2031/3: 50% reduction in GHG emissions (compared to FY2019/3); Scope: 1, 2 of the Daicel Group

* Science Based Targets: Goal setting consistent with science

Approach and Roadmap for Achieving Carbon Neutrality

Over the years, the Daicel Group has been working toward reducing the use of energy and cutting down GHG emissions from three angles (See the next page for details). To achieve the medium and long-term reduction targets, we have employed three angles to identify the items that will contribute to reduction of GHG emissions. We have calculated the specific reductions and have begun creating a roadmap. Although the individual items and reductions are undisclosed, we will start with the most feasible items and move on to the implementation, taking into account the return on investment. Some of the reduction items include technologies and materials that are still under development. We expect to achieve our medium– and long-term targets by putting them to use steadily.

Roadmap



*1 Since the calculations for Scope 3 were started from FY2020/3, we have tentatively shown the results for FY2020/3. We are working on gradually expanding the categories and boundaries in Scope 3 calculations.
*2 Business as Usual: GHG emissions without additional measures

Reduction of GHG Emissions from Three Angles

Angle① Reduction in GHG emissions in the current production processes

Data on factory operations (including status of energy use such as heat balance) is collected through DAICEL Production Innovation to visualize the wastage and loss in the use of energy and eliminate these thoroughly. P.29

Angle② Reduction in GHG emissions in innovative technology

Once the wastage and loss in the use of energy in the current production process is eliminated, we implement innovative technology to significantly reduce energy use by reusing low-temperature exhaust heat, which could not be utilized earlier, and by changing the manufacturing method to reduce the distillation process, which consumes a large amount of energy. P.30-31

POINT **The use of detailed data on factory operations visualized through DAICEL Production Innovation makes it possible to identify points for improvement, study innovative technologies and simulate the effects of their introduction with a high level of accuracy.**

Repetition of Angles ① and ②

With the equipment and method employing the new technology implemented in Angle②, the wastage and loss in the use of energy of Angle① are identified and reduced. We then repeat Angle① and Angle② by applying the innovative technologies implemented as per Angle② to the newly identified points of improvement. We continue to improve the level of our efforts, while creating manufacturing processes that minimize use of energy.

Angle③ Reduction in GHG emissions in the energy supply divisions

By minimizing energy use through Angle① and Angle②, eliminating excess energy capacity in energy supply facilities and downsizing them as much as possible, GHG emissions can be significantly decreased. P.32

Initiatives for Reduction of GHG Emissions

Angle① Reduction in GHG emissions in the current production processes

The main sources of power for our chemical plants are steam and electricity. In order to use these energies in the current production processes without any wastage, we are expanding the scope of overall optimization from an energy perspective based on DAICEL Production Innovation.

DAICEL Production Innovation **Eliminating wastage and loss in factory operations, contributing to stability of production, standardization of high quality operations and DX**

Established in FY2001/3, DAICEL Production Innovation begins with a comprehensive review of a series of operations related to safety, stability, quality and costs in the factory, then thoroughly eliminating production loss caused by wastage and troubles, and establishing a standardized operation flow with no wastage and loss. In that regard, we collected approximately 8.4 million pieces of operation-related know-how in the minds of skilled operators, visualized this information and incorporated it in the operation support system. As this system enables anyone to perform high-quality factory operations, it leads to fewer production troubles and more stable operations that are energy efficient and cost-competitive. We have established this system at our Aboshi, Ohtake and Arai plants and are in the process of establishing it at Polyplastics' Fuji Plant. P.36 Sustainable People

Grassroots Energy-Saving **Utilizing the data visualized through DAICEL Production Innovation to implement energy saving and cost reduction and achieve horizontal development**

We use the energy-related data obtained through DAICEL Production Innovation to understand the areas where wastage and loss occurs and its impact, and perform steady energy conservation activities based on the findings. The "Plant Energy-Saving Action Team" deployed at each plant implements these activities. These activities are horizontally implemented across different plants of the Group to achieve maximum effect.

Feature 2

VOICE

(Left)
Norihide Horikawa
Manager
Autonomous Promotion Group, Technical Department
Himeji Production Sector, Aboshi Plant

(Right)
Kosuke Terai
Autonomous Promotion Group, Technical Department
Himeji Production Sector, Aboshi Plant

In FY2023/3, we worked on energy conservation at the carbon monoxide plant, which is a raw material for acetic acid at the Aboshi Plant. Focusing on the deterioration seen in the data on the usage of raw material air, we conducted an on-site verification based on equipment modulation and operational data accumulated with skilled operators and equipment managing department. It was found that a small amount of air was leaking from the control valve. The load on the air compressor was greater than expected to compensate for the volume of air required in the next process. Replacing the valve with a proper one eliminated air leakage and achieved energy saving in the air compressor (Reduction in GHG emissions: Approximately 202 tonnes per year; Cost reduction benefit: Approximately 16 million yen per year). We will continue to promote the use of DAICEL Production Innovation and its more evolved version Autonomous Production System by utilizing the operation-related know-how and vast amount of data accumulated from skilled operators to achieve environment-friendly plant operation.

Autonomous Production System Using AI to assist in deriving optimal solutions for plant operation

In FY2021/3, we developed the Autonomous Production System, an evolved version of DAICEL Production Innovation. Developed using AI, this system has two applications—one which further improves productivity and one which further stabilizes production (Plant Capacity Maximizer and Advanced Prediction System). This makes it possible to achieve highly efficient operational support that pursues quality and cost more than ever before. Additionally, use of AI has made it easier to introduce DAICEL Production Innovation through dramatically streamlining the visualization of skilled operator's know-how, which is indispensable to the introduction. By introducing this system in the companies in our supply chain, we can achieve synchronization of information throughout the organization and realize a virtual company that has an expanded optimal range of energy use. This system is currently operational at some of our plants in Aboshi and Ohtake.
P.36 Autonomous Production System P.23 Virtual Company

Angle② Reduction in GHG emissions in innovative technology

From a different viewpoint, the operation-related skills of the operators extracted during the introduction of the DAICEL Production Innovation in Angle① are points to be improved which cannot be covered by equipment design and rely on human know-how. Our basic approach for process innovation is identifying such points for improvement in the equipment and working to solve them by enhancing process technologies.

It is said that, generally, the chemical industry consumes approximately 40% of energy in the recovery process. The recovery process is the process of removing impurities resulting from the process of manufacturing the target product and recovering the solvent by refining it through distillation. While this process uses high-temperature thermal energy, it also generates a large amount of low-temperature exhaust heat, which is wasted without being reused. Therefore, the key to energy saving is developing technology to efficiently utilize and recover low-temperature exhaust heat energy, although it is considered difficult. We have developed a Modified Petlyuk distillation process and set up VRC Technology, which enable us to utilize and recover low-temperature exhaust heat and reduce over 30% of energy required in the recovery process.

Modified Petlyuk Distillation Process Challenging improvements to existing technologies to increase efficient use of thermal energy without significant investment

Petlyuk distillation is widely recognized as an energy-saving technology and has been put into practical application as a dividing-wall column (DWC). The DWC is a revolutionary technology that can reduce the number of distillation columns, but it is difficult to adjust its operating conditions and it takes a considerable capital investment to introduce a DWC as it requires the construction of a new dedicated facility. To overcome these disadvantages, we took on the challenge of improving the basic Petlyuk distillation technology through joint research with universities, and have succeeded in establishing and implementing a modified Petlyuk distillation process that can be introduced to existing plants without major facility modifications and that utilizes the thermal energy used during distillation more effectively.

Vapor Recompression (VRC) Technology Implementing basic technology in the distillation process of organic solvent systems to realize utilization of waste heat

VRC technology compresses the exhaust heat from low-temperature vapor and turns it into high-temperature vapor to recover heat. This technology is widely used for heat recovery of water vapor. Through joint efforts with equipment manufacturer, Daicel has become the first in the world to successfully implement VRC technology in the distillation process of organic solvents.

Microfluidic Device Technology Precise reaction control that does not generate impurities and eliminates the need for separation and recovery process

We are in the process of developing microfluidic device technology that enables ideal chemical reaction control and does not produce impurities, thereby eliminating the need for the separation and recovery process that takes large amounts of energy.

In a chemical plant, a large amount of substances are reacted at once in a large reactor to increase production efficiency. This results in uneven temperature and concentration in the reactor, generating impurities (unreacted substances and by-products). The separation and recovery process is established to remove these impurities. On the other hand, a microfluidic device enables chemical operations such as mixing, reaction, and purification on a micro scale in channels of several hundred micrometers on a glass substrate the size of a business card. The narrowness of the ultrafine channels allows instantaneous mixing, has excellent heat removal capability and minimizes variations in temperature and concentration distribution. This enables substances to react evenly at the molecular level under homogenous temperature and concentration conditions. Since this generates no impurities, the separation and recovery process itself is unnecessary. This achieves a large amount of energy savings as well as shortened manufacturing process and improved product quality. Additionally, by utilizing the standardization method of operational know-how through DAICEL Production Innovation, the manufacturing process of a chemical plant can be reduced to unit operations that cannot be further disassembled, and then these unit operations can be modularized. Combinations of approximately 30 different modules can be used for the production of a wide range of chemical products. Parallelizing this will help achieve a sustainable next-generation production plant that can mass-produce products using the same manufacturing process established in the research area, while at the same time saving space, energy, and resources, and producing only the necessary amount of the necessary product.

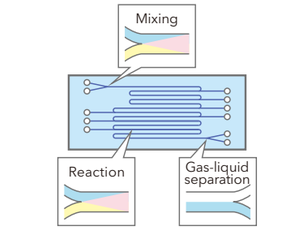
To achieve this breakthrough process innovation, we are applying our proprietary technology and conducting R&D in collaboration with National Tsing Hua University in Taiwan and other organizations, with the aim of implementing the technology in the resist polymer manufacturing plant at the Arai Plant in FY2025/3.

Features of Microfluidic Device Plant

①Micro-miniaturization of production facility
Glass substrates the size of a business card are combined together to form a single unit. Combinations of glass substrate channel designs can be used for all kinds of chemical products and production volume can be increased by parallelizing one unit. Moreover, laboratory results can be reproduced for industrialization simply by increasing the number of glass substrates.

②Energy saving
There is no unevenness in temperature and pressure in ultra-fine channels, allowing pinpoint and speedy generation of targeted reactions. Since wasteful reactions are unlikely to occur, the purity of the product is high and there is no need for post-processing to separate out the excess material. The technology to be adopted at the resist polymer manufacturing plant of Arai plant is expected to reduce both energy consumption and CO_2 emissions by more than 90%.

③Liberalization of production facility
Since this technology allows building ultra-compact, energy-saving, low-cost facilities, it dramatically increases the flexibility of production sites. Locating production sites where raw materials are available facilitates local production for local consumption and greatly reduces transportation costs and energy.



Microfluidic device


Image of microfluidic device plant experimental apparatus

VOICE

Kazuhito Takeda
Department Manager
Process Innovation Department
Process Technology Division
Production Management Headquarters

I believe realizing chemical plants which can utilize microfluidic device technology will significantly change the fundamentals of monozukuri manufacturing. We would like to contribute to carbon neutrality by realizing a plant that can manufacture only the amount needed at the place needed, and implementing the thinking of SDGs. While there are challenges, all the project members are committed to advancing research and development for early implementation. First of all, we would like to achieve this implementation and further develop this technology effectively by making the results widely known both inside and outside the company to see what can be done with the microfluidic device plant.

Feature 2

Angle③ Reduction in GHG emissions in the energy supply divisions

Chemical plants increase and decrease the amount of energy used based on production amount and products. Since these plants are in continuous operation, stopping and restarting midway temporarily require a large amount of energy. For this reason, it is a standard practice in chemical plants to design the capacity of energy supply facilities to be larger than that of energy-using facilities. Consequently, by minimizing energy use from Angle① and Angle②, the excess capacity of energy supply facilities can be reduced to the greatest degree and downsizing as much as possible, GHG emissions can be significantly decreased.

- **Downsizing and optimal operation of boiler equipment depending on energy use**
- **Selecting energy source material in consideration of cost and GHG emissions**
- **Improving the tire derived fuel mixture ratio of boiler equipment**

Toward Carbon Neutrality

While continuing to reduce GHG emissions from three angles, more technical breakthroughs are needed in order to realize carbon neutrality or carbon negative. The Group has sought to develop technologies to reduce CO_2 into CO and recycle it as a raw material.

Ultra Reduction Using Sunlight by Nanodiamonds **Continuous semi-permanent breakdown of CO_2 using only sunlight and converting it into a raw material**

Nanodiamonds are hard, chemically stable ultrafine particles 3-5 nanometers, and have unique characteristics, such as they do not react to acids or alkalis. Daicel has generated nanodiamonds by a method called the detonation method, which utilizes engineering knowledge of explosives developed in the manufacturing technology of inflators for airbags. We have developed the technology to generate nanodiamonds with extremely high efficiency by the detonation method. In addition, we have succeeded in establishing technology that decomposes CO_2 using only sunlight.

CO_2 reduction technologies up to now have required large amounts of electricity to break down CO_2, and to produce that electricity, CO_2 was generated. However, we have demonstrated that our nanodiamonds can continue to decompose CO_2 into carbon monoxide and oxygen with high efficiency due to the hydrated electrons generated in the surrounding space simply by irradiating sunlight. Nanodiamonds continue to react semi-permanently, and do not degrade due to their chemical stability. Furthermore, nanodiamonds can decompose H_2O into hydrogen and oxygen. So if methanol can be synthesized from the generated hydrogen and carbon monoxide, this can be reused as a main raw material for the Group and a highly competitive cyclic structure can be established.

VOICE

Taro Yoshikawa

Kanazawa University
Nanomaterials Research Institute
Project Associate Professor

Innovation and Business Development Headquarters
Business Development Center

Since FY2013/3, the company has carried out research and development of nanodiamonds with both inhouse and external partners. As a result, we have acquired a variety of world-leading technologies including generation technology by the detonation method. We are also working to implement ultra reduction using sunlight technology by connecting the knowledge and technology we have accumulated up to now. Currently, verification tests at the laboratory level have been completed, now we are preparing pilot-scale verification tests.

Most conventional CO_2 reduction technologies focus only on the catalyst and system performance. However, the real value is in how much carbon negative can actually be achieved by the overall technology which considers catalyst life and the frequency of system maintenance. If the catalyst life is short, the catalyst will be more frequently produced and disposed of, which would also be a source of CO_2 generation. A nanodiamond catalyst using highly productive detonation method, which is non-degradable and semi-permanent, would lead to a fundamental solution in the reduction of CO_2 emissions.

Information Disclosure in Line with TCFD Reccomendations

The Daicel Group has made progress in its response in accordance with the TCFD recommendations endorsed in November 2021 and has carried out information disclosure.

Governance

Discussions and management are carried out at the management level in the Sustainable Management Committee. P.20 Sustainable Management System

Strategy

In line with the TCFD recommendations, from FY2023/3 the Group has begun conducting scenario analyses assuming a temperature rises of less than 1.5°C/2°C and 4°C with a timeline of 2030. These scenario analyses largely reference the International Energy Agency and the Intergovernmental Panel on Climate Change. The following procedures are carried out.

- **Step 1** Set the scope of a scenario analysis
- **Step 2** List the risks and opportunities presented by climate change for each business
- **Step 3** Create a business scenario according to each business' external scenario and re-evaluate the magnitude of those risks and opportunities
- **Step 4** Financially evaluate each business
- **Step 5** Summarize climate change impacts and countermeasures for the entire Group

In FY2023/3, we conducted a scenario analysis for our Engineering Plastics Business (Polyplastics Co., Ltd.), which is the driving force of the Group.

Going forward, we will target the acetyls business (Smart and Materials Businesses) with a focus on cellulose acetate as well as the Safety Business, conducting scenario analyses in turn and consolidating the risks and opportunities of climate change for the Group. Furthermore, a financial impact assessment will be performed for each risk and opportunity.

WEB **Polyplastics Scenario Analysis Results** https://www.polycsr.com/en/assets/pdf/tcfd.pdf

Risk Management

The Risk Management Committee has overseen and promoted all aspects of risk management of the Company and its Group companies. Furthermore, the Group regards climate change as a major risk in sustainable management, and risk assessment, response and confirmation of the implementation status are carried out under the management system led by the Risk Management Committee. Such important issues are considered in detail by the Sustainable Management Committee.

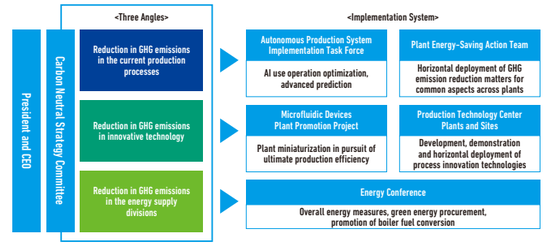
WEB **Risk Management** https://www.daicel.com/en/sustainability/governance/risk-management.html

Metrics and Targets

The Group has listed Response to Climate Change as one of its 15 key sustainability issues (materiality), and has set GHG emission reduction rates as a KPI. We have also set KPIs for our materiality issues of Provide Environment-Friendly Materials and Technology and Contribute to the Development of a Circular Society. Further discussions will be held on products and services that contribute to a low-carbon economy, and we will consider setting better indicators and targets. P.21 List of Materiality

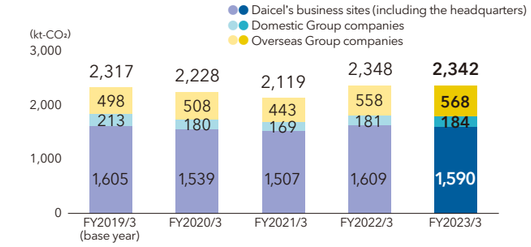
Promotion System for GHG Emissions Reductions and FY2023/3 Results

The Carbon Neutral Strategy Committee has been established under the direct control of the President and CEO to promote energy conservation and GHG emissions reduction in the Group. The Committee is chaired by the officer in charge of the Production Management Headquarter and members include representatives from production, energy supply and other corporate divisions in Japan. It strives to construct a circular process that is in harmony with the global environment from the three angles introduced on P.29. In addition, introduction of internal carbon pricing has been considered in order to develop and execute appropriate investment plans which can achieve our medium– and long-term targets.



The Daicel Group's GHG emissions for FY2023/3 decreased by 0.3% year-on-year to 2,342 kt-CO_2 due to ongoing energy-saving initiatives such as improving the tire-derived fuel ratio at the Ohtake Plant, despite increased production due to demand recovery and the trial operation of a large new plant.

GHG Emissions (Scope 1, 2)



(Note) Environmental data for each fiscal year covers the period from April to March in principle. However, for overseas subsidiaries excepting the Polyplastics Group, the reporting period for environmental data is from January to December.

Feature 3

Sustainable People

Implementation of “People-Centered Management”

The Group has set the realization of a sustainable society as its Long-Term Vision. The driving force behind this is each and every employee of the Group. We have sought to create a system based on “people-centered management,” where employees can gain a sense of accomplishment and can work in a comfortable environment. By setting “people-centered management” at the core, we have been working to reform the personnel system, working environment, and work style in order to become a company where all our diverse employees can grow by establishing their own presence with a sense of fulfillment.

Daicel Group Human Resources Policy

Sustainable People

We promote “People-Centered Management” that enables all our diverse employees to grow while establishing their own presence and achieving fulfillment.

I will hone my skills and mind, achieve self-actualization by taking advantage of the opportunities at the company, and increase my happiness.
I will work creatively together with my teammates and increase our happiness.
I will also create and provide value, contribute to a more prosperous society, and increase the happiness of all.

The Human Resources System Promotes Autonomous Career Choices and Challenges

The Daicel Group has sought to reform and manage its organizational structure in order for employees to take greater initiative and challenge themselves. Employees gain experience by autonomously choosing a career and proactively taking on challenges, and increasing their own expertise and strengths. The Company then appropriately evaluates the attitude and success of each employee. Only by repeating this cycle can the strengths and creativity of each employee be developed to enhance their “individual power,” enabling them to fully demonstrate their abilities. This in turn, improves the competitiveness of the Company. The following has been set as the Company’s basic concept. The Company has reviewed its personnel system for leadership positions (managers) in FY2022/3 and its human resources system (excluding leadership positions) in FY2023/3, and eliminated age-based pay as of April 2023.

Adoption of a multiple-track job grade system	•Enable multi-track career planning by shifting from the generalist-oriented career development of the past to specialist/management career options •Clarify abilities to be developed according to individual aptitude
Elimination of seniority	•Abolish number of years of experience as a condition for promotion •Enable diverse career development
Linking appointments to compensation	•Clarify responsibilities and authority of each role based on a job-grade system •Create a link between roles and compensation to realize a system in which performance is rewarded
Establishment of a restricted stock compensation system for employees	•Encourage employees to contribute greatly to the success of the business •Improve lifetime wages

In addition, the Company has developed a system of in-house recruitment system and re-launched it as the Career Challenge System, so employees can autonomously make career choices and accept challenges. This system differs from a general personnel transfer by allowing the employees to apply for positions in departments open to them and challenge a new career path. In April 2023, Daicel established a system (Self Career Dock) for employees to proactively draw and choose their own career path at Daicel, and has established a Career Support Center as a contact point for employee consultation.

VOICE

Ippei Kinuta
Senior Manager
H. R. Development Team / Career Support Center, Human Resources Division, Corporate Support Headquarters

In Daicel, careers are not handed out by the Company, but rather, they are created and chosen by the employees themselves through conversation with their supervisors. For some employees, such as those who have only been with the Company for a short period of time, may find it difficult to think on their own. The Career Support Center is an organization to support these employees develop their own career. Through age-specific career seminars and career interviews, employees are helped to consider what they would like to do at Daicel and what kind of career they would like to build. This is then connected to the activation of a person’s “individual strength,” such as skill development and further improvement of expertise. Career seminars began in 2021 for employees in their early 50s, and in 2022, the target was expanded to persons in their 40s and then to those in their early 30s. It has been an opportunity to think about self-realization and one's own happiness through a career at Daicel.

Diversity & Inclusion

Recruitment and Activities of Expert Human Resources

Daicel proactively hires human resources with high expertise from outside of the Company to achieve its Long-Term Vision and Mid-Term Management Strategy. In particular, experienced managers who can immediately play an active role occupy 27.7% of all managerial positions (as of the end of March 2023), which is a significant increase from 15.6% five years ago (as of the end of March 2018). In order to accelerate shift to market-oriented businesses, we have increased human resources within the Company who have a deep understanding of specific industries and businesses, as well as a high level of expertise in accounting, law, digital technology, and other areas. We believe that the Company’s competitiveness is enhanced when each of our diverse employees has a strong will to utilize his/her own knowledge and experience, and works creatively together as a team, instead of completing projects on their own.

VOICE

Takeshi Ichikawa
IP Solution Group
Intellectual Property Center

“Proactive IP (Intellectual Property)” is the slogan of Daicel’s Intellectual Property Center. Our determination is to strengthen business through the use of our intellectual properties, not passively but by establishing our own initiatives. We consider how to connect “intellectual property” such as technology, design, and brand names to future business and implement it, by utilizing the expert knowledge and experience developed up to now. While this work is challenging, it is also very rewarding. When we look around the Company, many people in various departments are challenging something new. Regardless of whether the person is mid-career employee or not, the atmosphere is one that encourages challenges. Personally, I had only experienced being a player before joining the Company. But now I am enjoying my own growth as I take on the challenge of management as a team leader.

System and Environment Development Where Various Employees Can Play Active Roles

The Company has set “Promote Diversity and Inclusion” as a materiality, and a “ratio of women in leadership positions (managers) (target of FY2026/3: 10% and higher)” and a “continued employment rate of persons with disabilities for more than three years (target of FY2026/3: maintain at least 95%)” as KPIs. To achieve these, an environment in which all of our diverse employees can play an active role is essential. Aiming to foster an organizational culture in which diverse employees can fully demonstrate their abilities, reforms to promote diversity and flexible work styles were initiated in FY2016/3 under the catchphrase “Diversity x Flexibility.” We have improved the working environment, including encouraging remote working, improving the rate of use of paid vacation, and providing a barrier-free workplaces. The ratio of women in leadership positions has increased from 1.6% in FY2016/3 to 4.9% in FY2023/3. The rate of employees with disabilities remaining with the Company for more than three years was 96% in FY2023/3. We will continue to promote the creation of systems and environments that allow each employee to maximize his/her own individuality and abilities, and encourage them to further accept challenges and grow.

	Introductory Phase (FY2016/3 FY2017/3 FY2018/3)	Understanding and Diffusion Phase (FY2019/3 FY2020/3)	New Normal (Reform Phase) (FY2021/3 FY2022/3 FY2023/3~)
System and Awareness Reform	FY2017/3 Five days paid childcare leave FY2017/3 Started to encourage employees to take paid vacation time FY2018/3 Opening of the “Nadeshiko Seminar,” women leader development training FY2018/3 Introduction of the “working from home” system (limited to employees who are raising children or provide caregiving)	FY2019/3 Promotion of male employees taking childcare leave FY2019/3 Shortened prescribed working hours for full-time workers (Shortened: 30 min/day) FY2019/3 Revision of the “working from home” system (expanded to all employees) FY2019/3 Introduction of satellite offices	FY2021/3 Introduction of working from home allowance FY2021/3 Partial elimination of working away from family FY2021/3 Introduction of a babysitter system FY2022/3 Introduction of an executive mentoring system (targeting selected female managers) FY2022/3 Introduction of the side job and dual-employment system FY2024/3 Introduction of same-sex partnership system
Infrastructure and Environment Development	FY2016/3 Introduction of free-address within the office FY2018/3 Attendance management using PC logs (managed at entrance and exit gate within the factory) FY2018/3 Reinforcing security of backbone systems (can be used outside the Company)	FY2020/3 Introduction of office casual wear	FY2021/3 Introduction of an electrical contract system FY2023/3 Barrier-free access to some workplace areas

Feature 3

Realize Monozukuri Manufacturing Where People Can Work More Creatively and Increase Their Happiness

Fumihiro Miyoshi
Head of Monozukuri Production Innovation Center

Daisuke Ishimoto
Division Manager of Autonomy Promotion Group Technical Department, Ohtake Plant

Hiroharu Matsumoto
Manager of Cellulose Products Production Department, Ohtake Plant

DAICEL Production Innovation

DAICEL Production Innovation is sometimes viewed as “standardization of know-how accumulated through the operation of chemical plants.” However, at the heart of the matter is changing the way people work under the slogans **“visualize,” “discontinue,” “change.”**

“Visualize” We identify latent defects (waste, loss) using company-wide common standards, through an overhaul of operations, operator load analysis, and cost structure analysis.

“Discontinue” We create more time and energy to initiate reforms by implementing following actions. First, we unify the terms and centralize information so that we can eliminate complicated rereading and establish a system to ensure that the necessary information is available to those who need it, regardless of department. Next, we thoroughly correct wasteful operations, including useless meetings, and reduce the work load. As a reform to continue problem-free and stable plant operation, we clarify the decision-making process by veteran operators, organize it systematically and reflect it into the design of the production system.

“Change” Every operator can make decisions considering safety, quality, output and costs in the same way of veteran operators.

DAICEL Production Innovation established in 2000, has resulted in resource- and energy-efficiency, and high-quality plant operation. At the Aboshi Plant, we reduced total costs by 20% and tripled human productivity. In addition, by realizing decision-making based on highly reliable predictions, we could shift from a work style centered on reactive measures to a work style centered on preventive measures that is creative and rewarding.

Autonomous Production System

The Autonomous Production System was developed in 2020 and has advanced DAICEL Production Innovation utilizing AI, encouraging ways to work more creatively. DAICEL Production Innovation promotes stable operation, and reduces serious quality issues. However, all of the know-how and skills gained from veteran operators could not be utilized. In order to utilize this know-how and derive operations that would lead to optimal operations that can further save energy, resources, and costs while pursuing high quality, complex, large calculations are needed. At the time, such calculations were difficult with the computer processing capability in 2000. However, the current Autonomous Production System is equipped with AI calculation processing through joint development with the University of Tokyo. After installation, the system will further improve productivity and stabilize quality, which will not only significantly reduce costs but also reduce operator workload. In addition, the AI system is based on the know-how of the worksite, and can expose gaps between actual performance and know-how by comparing the actual performance data. In other words, it is possible to expose know-how and knowledge that people could not recognized up to now. By promptly reflecting and utilizing this new know-how and knowledge, the system can achieve even higher monozukuri manufacturing, and create a cycle in which people and the system can continue to grow together. This innovation enables us to realize “proactive production” where thinking independently and proposing solutions in advance, rather than waiting until a customer request is received.

Furthermore, the Autonomous Production System was installed at the Aboshi Plant in FY2022/3 and partially at the cellulose acetate plant at the Ohtake Plant in FY2023/3, and has contributed to a savings of 0.8 billion yen in costs by FY2023/3. In 2024/3, the system will be introduced to other cellulose acetate plants, acetate tow, and raw material of acetic acid (carbon monoxide) plants. Implementation centering on domestic acetyl chains will proceed until FY2026/3. This is expected to contribute to a cost reduction benefit of approximately four billion yen and a significant reduction of on-site workloads.

Key Points of the Autonomous Production System

①Significant reduction in the time, from the detection of an abnormality to decision-making and action

The system grasps the real-time status of the manufacturing facility and detects abnormalities before they materialize, thus reducing the need for manual monitoring and predicting operational status and leading to a dramatic reduction of the workload for onsite workers. Furthermore, since the system presents the causes of the abnormality along with countermeasures, operators can respond before the situation reaches the stage that previously required executive decisions.

②Support for taking the necessary actions to achieve production goals

Out of the many possibilities for improving plant operations, this system recognizes actions that are important to the production goals of each plant and presents only the essential alternatives, allowing operators to choose the optimal response.

To Realize “Proactive Production”

In May 2017, “The Next Generation Production System Establishment Project” centering on technicians in their 30s was established. They thoroughly discussed the future ideal of monozukuri manufacturing, and established an Autonomous Production System to achieve “proactive production.” From FY2023/3, these members has been serving as the core in the implementation of the system at each plant. Mr. Miyoshi, head of the Monozukuri Production Innovation Center which oversees company-wide deployment of the system, Mr. Ishimoto, Division Manager of Autonomy Promotion Group, Technical Department which manages system implementation at Ohtake Plant, and Mr. Matsumoto, Manager in charge of Cellulose Production, Production Department, which oversees the implemented production line, discuss how Daicel’s monozukuri manufacturing has changed from various positions, and how their work has personally changed with the introduction of the system.

■Changes in on-site manufacturing due to the adoption of the Autonomous Production System

Ishimoto: The Autonomous Production System is now able to incorporate into its programs all of the plant operation know-how of our predecessors that we have not been able to fully utilize up to now, thanks to the incorporation of AI. However, implementing a system does not mean that optimal operation can be achieved with a hands-off approach. There can be a gap between the optimal solution derived from the incorporated know-how and the actual on-site data. It is a painstaking process, but this verification is the very thing that clarifies the weak points of our manufacturing and the reaction logic that had not yet been established as a technology. The most important aspect of adopting this system is to work together with the on-site members to improve and grow our on-site capabilities.

Matsumoto: We are also beginning to see real on-site benefits. Through confronting the principles (cause-and-effect relationships) presented by AI objectively, without being bound by conventional wisdom, we were able to encourage the implementation of potentially promising ideas, which actually led to improved cellulose acetate usage. Without AI, even if we had an idea, we would have hesitated to test it on actual equipment because of the costs involved. I believe that Daicel’s manufacturing will grow stronger if operators have more and more opportunities to try out their own ideas using the Autonomous Production System.

Miyoshi: We have achieved term unification, thorough elimination of waste and loss, and stabilization of production through DAICEL Production Innovation, so there is less data that should not be seen, and I think one of our strengths is the high reliability of our data. By applying machine learning based on reliable data, only essential and latent points that need to be verified can be seen. On-site discussion of these points clarifies necessary actions and improves manufacturing. If we take action and achieve results, I believe that being proactive will become the on-site norm. We believe that the results of the adoption of the system will become apparent at an accelerated pace.

Matsumoto: I think that in a few years the operator’s job will be much different. Currently, people monitor and detect irregularities in plant operation, but I believe that the system (AI) will learn the know-how for detecting these irregularities, and we will be able to leave some tasks to the system (AI) and spend our time on more creative work that only people can do.

■Future development of the Autonomous Production System

Matsumoto: As we expand the scope of implementation to the product chain, the elements required for upstream processes have become clearer than ever. Currently, the Aboshi and Ohtake Plants are working to expand the supply capacity for acetate tow. The production department is working in unison to increase production by as much as one tonne, but it is difficult to achieve this by simply improving the acetate tow production process. Improvements are also needed in the upstream cellulose acetate production process. If the adoption of the Autonomous Production System allows products to be built in the upstream process in anticipation of the impact on the downstream process, further quality improvements can be expected in the downstream process. I feel that each and every operator has become more aware of how to create products of the quality required by the next process in the preceding process.

Miyoshi: The next process is, in other words, the user’s, or more specifically, the customer’s process. We are moving toward a market-oriented organization, starting from the needs of our customers, and this is the same at our production sites. Eventually, we aim to expand the system beyond the boundaries of the Company to upstream companies and downstream companies that are our customers, to improve the quality and efficiency of not only our own product chain but also the supply chain as a whole. Until now, the Autonomous Production System has been implemented with the operational support of operators at the production site. Next, we will expand the system’s scope of support to the production planning and logistics domains to optimize the flow of products. In production planning and logistics, the flow of products is managed in lots, but in order to optimize the flow of products, it is first necessary to make the quantity per lot smaller and more flexible. To achieve this, it is important to serialize and automate the quality analysis that is performed on a lot-by-lot basis.

Ishimoto: In quality analysis by sampling, the smaller the lot unit, the greater the number of times it is performed, and the greater the workload on the operator, so it is important to make it continuous and automated. Shifting from “representative point management” by sampling to “continuous point management” utilizing in-line sensors*1 and soft sensors*2 not only eliminates the need for operators to perform sampling and analysis, it also eliminates shipping waiting time due to waiting for inspection, leading to shorter lead time and inventory reduction. In addition, smaller lot sizes allow us to respond in detail to customer requests for electronic materials and functional materials (which have high quality requirements), thereby strengthening our competitiveness. Market needs are constantly changing, but we want to be a site where we can respond to changes and co-create value by thinking on our own and collaborating with sales, procurement, purchasing, logistics departments, and customers.

*1 In-line sensors: Sensors that can be installed in pipes or tanks for direct measurements
*2 Soft sensors: Sensors that use measurable values to calculate and predict difficult-to-measure values in real time