2023

Activity Report

Hitachi-AIST Circular Economy
Cooperative Research Laboratory

A “circular economy” is a flexible economy in which each individual is involved in their own way in keeping products and materials constantly in circulation.

By generating new added value while keeping resources in circulation, it contributes to sustainable economic development that does not depend on wasting resources.

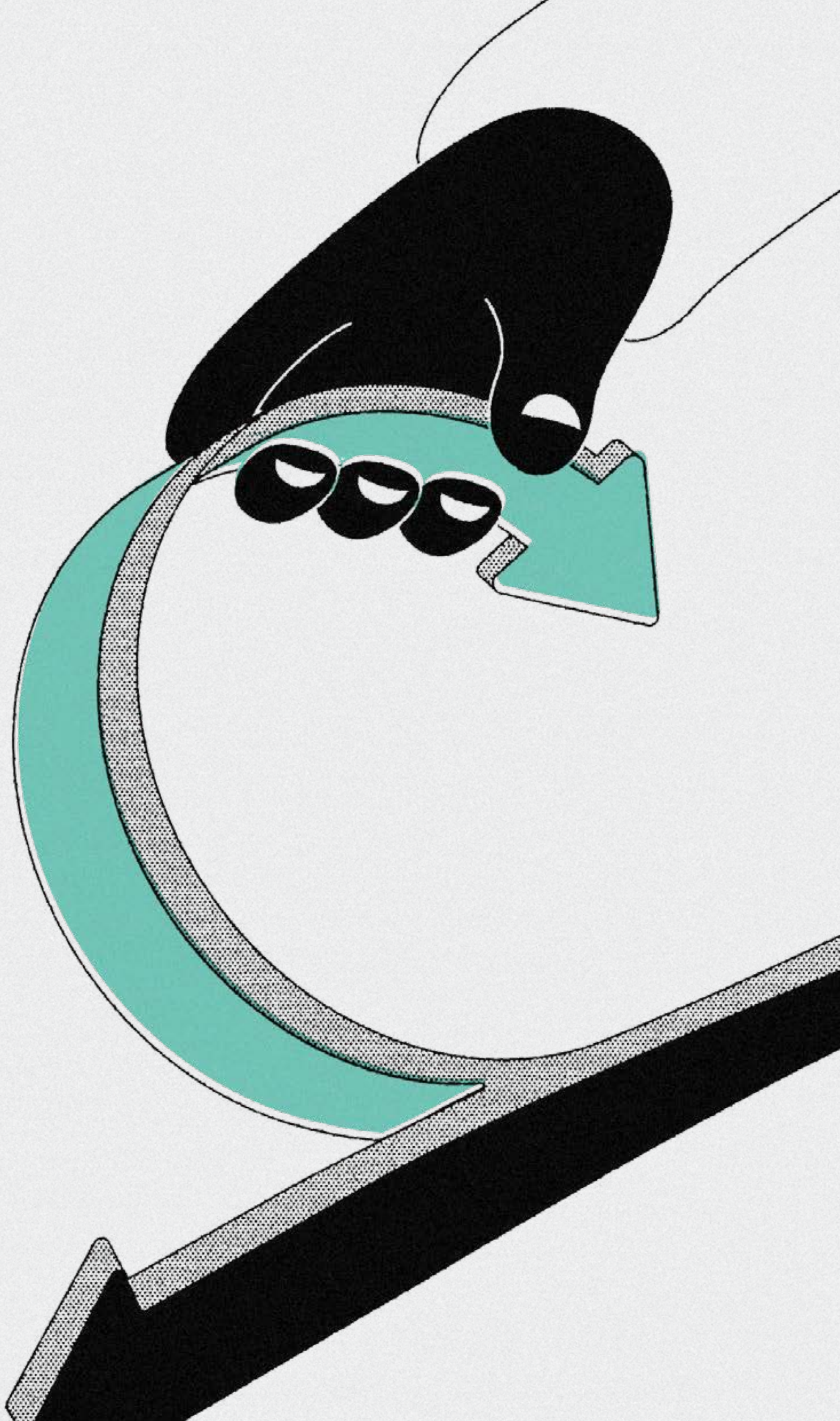
About H-AIST Circular Economy Research Laboratory

The World Is Headed Towards a Circular Economy

Recent years have seen great changes in the environment in which we live. Environmental issues attributable to global warming, including rises in sea level, the exacerbation of natural disasters, and water shortages, as well as the increased waste generated by industrial growth, will only become more serious in future. Higher resource prices due to rising resource consumption and resource localization will necessitate resilience with respect to procurement difficulties.

To resolve these problems, we will need to switch away from the "linear economy" predicated on mass prodauction and massive waste, to a "circular economy" that pursues minimal environmental impact and resilience.

In response to these issues, regional environmental actions and local resource procurement that takes account of social attitudes, political trends, and legal revisions are picking up speed throughout the world.



In Japan, in 2023 the Ministry of Economy, Trade and Industry launched the "Circular Partners" initiative as an industry-government-academia partnership with the aim of achieving a circular economy. We consider that Japan currently faces the following three issues in the push to establish a circular economy.

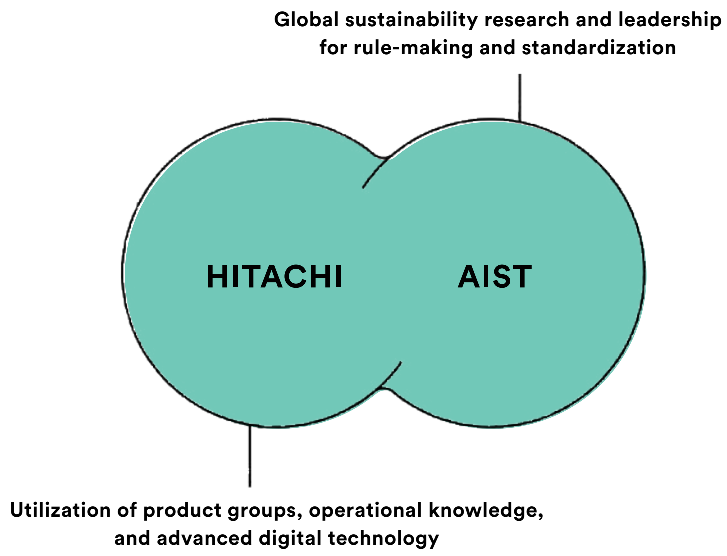
1. **Sharing a vision for society that delivers economic growth without resource recycling becoming a drag on the market**

2. **Collecting and using data across product life cycles (LCs) to create use cases for practical digital solutions that can improve the delivery of environmental and economic value**

3. **Formulation of a rule-making strategy based on trends in global standardization that recognizes the distinct characters of different regions, without putting Japan at a disadvantage.**

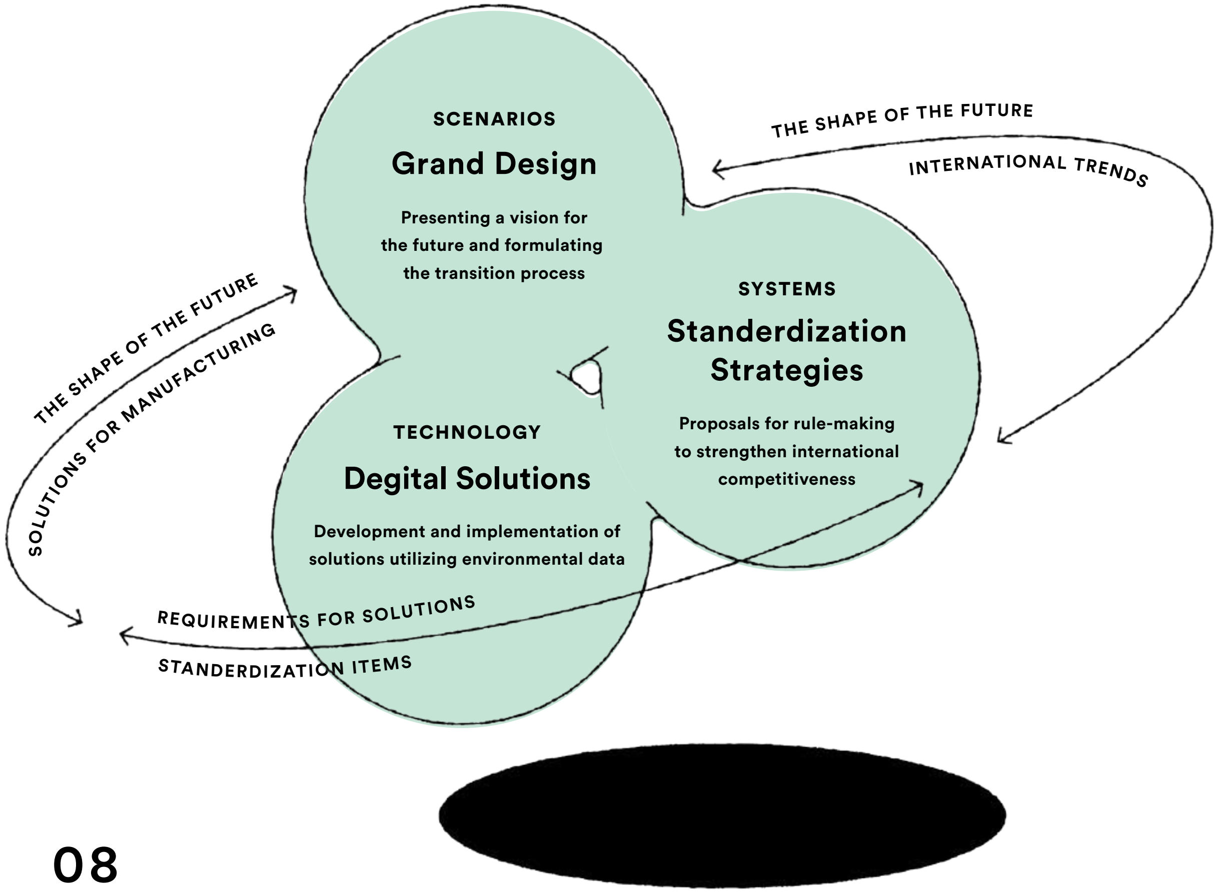
Supporting the Planet Through Innovation

To help achieve "Society 5.0" Hitachi, Ltd. (Hitachi) and the National Institute of Advanced Industrial Science and Technology (AIST) have established the Hitachi-AIST Circular Economy Cooperative Research Laboratory in AIST Tokyo Waterfront.



In the context of the recent demand for the transition to a circular economy, and in the belief that understanding and valuing "things that are genuinely good for the environment and the economy" and "the most effective measures for transitioning to a circular economy" are important, the goal is to combine Hitachi's operational technology (OT), information technology (IT), and product know-how, with AIST's strengths, including its capacity for R&D and activities toward standardization, in order to generate innovation to support resource recycling.

In this laboratory, around 40 specialists in areas including life cycle assessment, resource recovery, monozukuri (design and manufacturing), and service engineering from both institutions are engaged in joint research. They are putting forward a vision for society and carrying out research and development on the policies and solutions required to achieve a circular economy.



Three Research Themes for Creating a Roadmap

The roadmap for achieving a circular economy is divided into three parts: Scenarios, Technologies, and Systems. These are distributed between the laboratory's main research themes: "Formulation of grand design for a circular economy-based society," "Development of digital solutions for circular economy," and "Planning of standardization strategies/proposal of measures."

Under the Grand Design research theme, we will set out the form the circular economy should take, the journey for transitioning from our current state to the circular economy of the future, and the methodology and rules for this transition. Under the Digital Solutions research theme, we will utilize sources including environmental data on carbon dioxide emissions to develop solutions for corporate environmental report preparation and the preparation of production schedules with low environmental impact, and go ahead with their social implementation. Under the Standardization Strategies theme, we will propose measures including data collection and utilization methods, and press ahead with rule-making and standardization originating in Japan.

The content and outcomes of this joint research will be utilized in arenas including open forums and written proposals so that this information is actively disseminated to the public, enabling us to take become global leaders in the circular economy field.

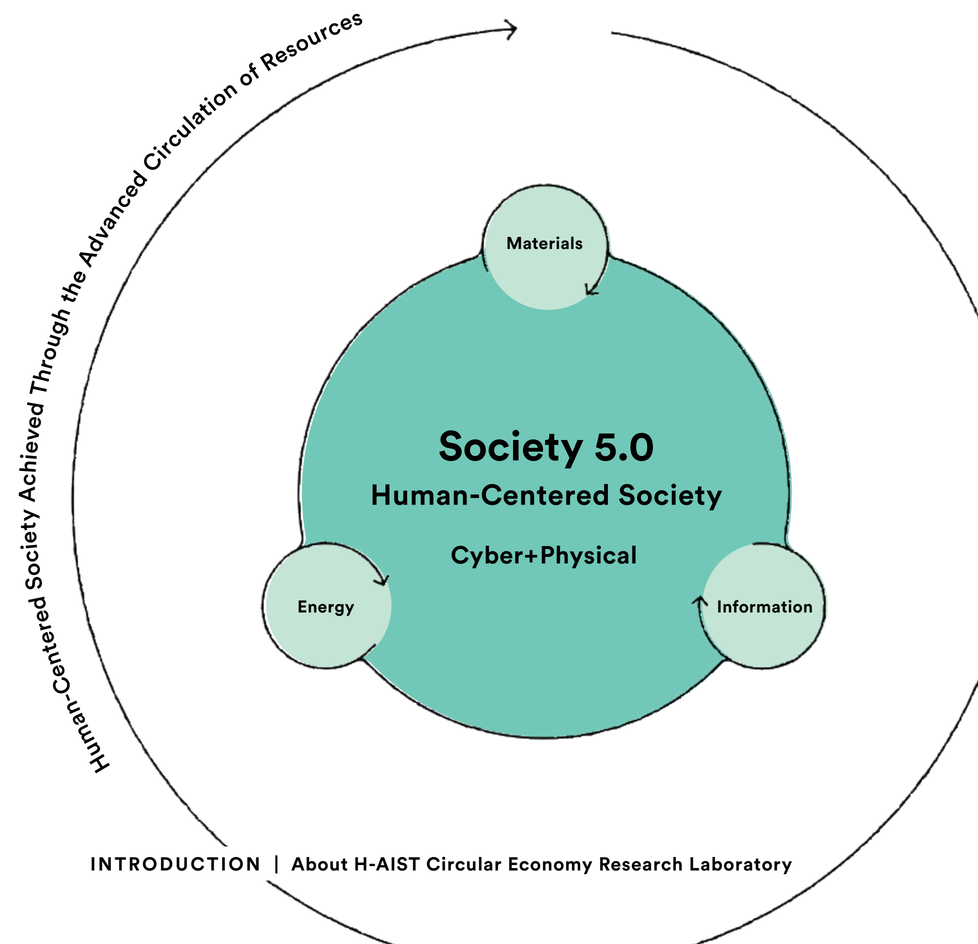
Scope of Research and Resources That Should Be Circulated in the Society 5.0 Era

In terms of the scope of our research, we understand the resources that should be circulated in the Society 5.0 era as including not just materials and energy but also information and knowledge. “Society 5.0” refers to a new phase of social organization following on from hunter-gatherer societies (Society 1.0), agricultural societies (Society 2.0), industrial societies (Society 3.0), and information societies (Society 4.0), and was first proposed as the vision of society toward which Japan should strive in the Fifth Science and Technology Basic Plan. It is described as “a human-centered society in which economic development and the resolution of social issues are compatible with each other through a highly integrated system of cyberspace and physical space.”

Here, we consider an example in which data obtained from a physical space is utilized to perform sophisticated calculations in cyberspace.
The computer required to perform such sophisticated calculations is an actual “material” resource. Then there are “energy” resources needed for the computer (the material resource) to work. The calculated results generated from these two resources, that is, “information and knowledge,” constitute a new resource. Pure data obtained from a physical space become information, knowledge, and finally wisdom thanks to material resources and energy resources. Is this not a resource that possesses new value?

If we can use this information and knowledge to eliminate unnecessary calculations and limit energy consumption, extending the ability of the computer to its utmost, this will lead to the effective use of material resources and a reduction in waste. Society 5.0 may be the era that sees the start of intense mutual interference between three different types of resource that were formerly regarded as independent of each other.

Our aim is to draw up a Grand Design from the viewpoint of the circular economy that should be achieved in Society 5.0 by utilizing these three resources effectively and ensuring their advanced circulation.

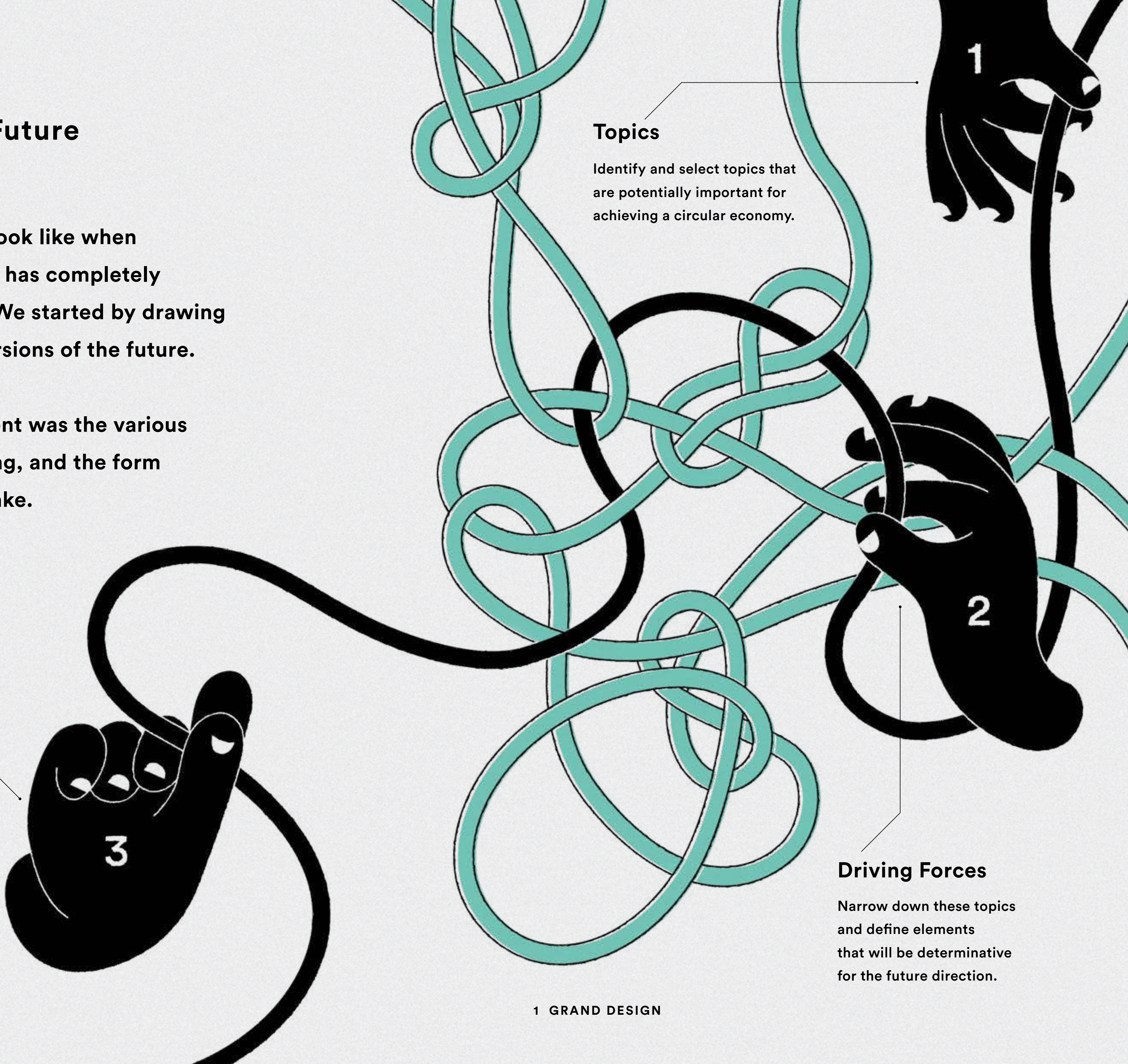


1 GRAND DESIGN

Choosing the Ideal Future

What will the world look like when the circular economy has completely permeated society? We started by drawing several “possible” versions of the future.

What became apparent was the various different ways of living, and the form the future “ideally” take.



Scenario Planning in Preparation for the Future

We attempted to depict a vision of the future circular economy-based society by using the scenario planning method, which takes account of future uncertainty while depicting multiple potential futures. Eight experts drawn from different specialist fields took part in the discussion to offer their insights. Facilitation was provided by laboratory members with experience of scenario planning, who led the discussions.

Choice of Topics

First, based on Japanese and international government reports and the opinions and advice of specialists in multiple fields, we selected 12 topics that are potentially important for the circular economy-based society of the future.

1 Integration of the economy, resources, and the environment
2 Common rule-making
3 Raising awareness among consumers
4 Corporate roles and business models
5 Circularity indicators (environmental time horizon, smoothness of flow)
6 ESG investment, financial policy
7 Environmentally friendly design, ecodesign
8 Transformation of international trade, transborder movement of resources
9 Venous corporations and human resource training
10 Information disclosure and advanced management
11 High-efficiency waste recovery
12 Consideration for local characteristics

Having envisaged Japanese manufacturing in 2040 by reviewing trends from the viewpoints of PESTLE (politics, economics, society, technology, legislation, and the environment) we narrowed down the number of topics for clarification as scenarios to six types, and it became apparent that the key issues include the transition from manufacturing to service industries, a revolution in consumer consciousness, and ways of supporting these.

P Politics

8 International Trade & Transborder Movement of Resources
Establishment of a circular economy zone. Export regulation of secondary resources (preferential domestic processing by each country).

E Economy

4 Corporate Roles & Business Models
Transition from manufacturing to service industries. Intensification of international competition in the functional economy. Progression of non-ownership, businesses managing products collectively and providing services to individuals, with manufacturing also part of these services.

S Society

3 Raising Awareness Among Consumers
A revolution in consciousness so that second-hand goods and recycled secondary products become preferred.

T Technology

10 Information Disclosure & Advanced Management
Establishment of third parties to conduct supply chains, information management, and maintenance. Establishment of platforms (using the blockchain)

L Legislation

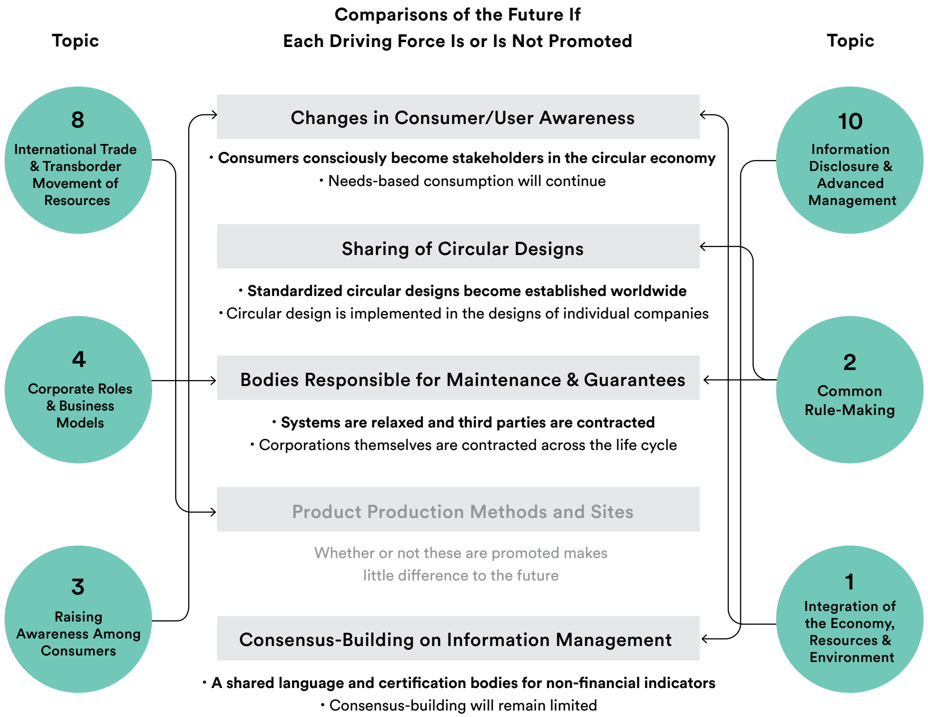
2 Common Rule-Making
Formulation of rules for sharing data between value chains.
Development of verification, appropriate value setting, and shared prerequisites.

E Environment

1 Integration of the Economy, Resources & Environment
Expansion of biomaterials use. Progress in high-efficiency separation, removal of impurities, and utilization of side-products.

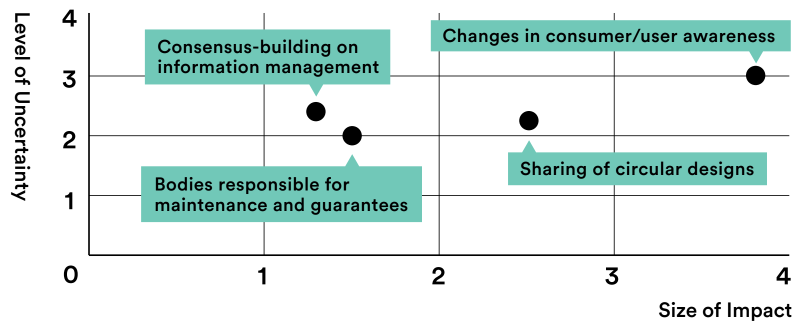
Driving Forces and Key Driving Forces

From the six topics identified, four "driving forces" were defined as factors determining our future direction. We have also set out hypotheses for future phenomena if each of these is or is not promoted.



Expert consideration found that whether or not changes in "product production methods and locations," which are part of manufacturing, were promoted made little difference, and these were not included among the driving forces.

The next step was to narrow these down to the particularly important "key driving forces." They were assessed for uncertainty and size of impact, and those driving forces considered to be of relatively high value were scored by the experts.



- **Changes in Consumer/User Awareness**
  Unanimously selected as a key driving force.

- **Sharing of Circular Designs**
- **Consensus-Building on Information Management**
  It is difficult at this point to define the meanings of "design" and "information" and to set their scope, and deciding the bodies responsible for maintenance and guarantees is also considered to determine the scope of circular design and the information that can be managed.

Bodies Responsible for Maintenance and Guarantees

- Selected as a key driving force for the reasons above.

Four Scenarios & Visions of the Future

To choose for ourselves the future that we will face. We derived the forms that society might take.

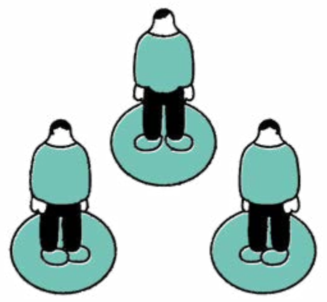
By placing the key driving forces along vertical and horizontal axes, we formulated possible future scenarios for manufacturing in each quadrant. These scenarios represent possibilities for the future that might arrive if measures are not taken. These realistic possibilities should help us consider the future that we should be aiming for, as well as concrete measures for achieving it (or avoiding the risks in this process).

If We Dig into These Scenarios...

Example: Expansion of Third Parties

Under this scenario, people will still continue to own goods in future, and demand products that are cheap and convenient. The interests of consumer needs and third parties are in agreement with respect to such consumption, and third parties will gradually intensify their involvement on the arterial side of the circle.

From the manufacturers' standpoint, the main question is thus how to develop survival strategies with respect to a future in which manufacturers and third parties are in competition with each other. For example, possible measures might include manufacturers forming alliances or other relationships that include third parties, making allies for the provision of financial and environmental value. Based on these hypotheses, should this strategy succeed, what sort of "ideal future" would be achieved? We will investigate roadmaps for this destination and indicators that could function as conditions for the transition.

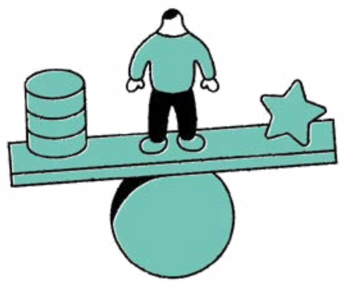


Third Parties

Alliances between multiple corporations, service functions held by trade organizations

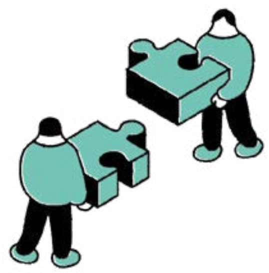
Standardization & Specifications

Some intellectual property loosened, and consumers and users would not need to bear the costs of meeting standards



Information Management

Incentives and social systems to collect data from the venous side of the circle will be required



Business Model

Develop a model of product specifications and information transmission in which third parties take the lead in sharing knowledge on repair and remanufacturing

’22 Definition of Scope

Identification of 12 hot topics concerning the circular economy by means of literature review and interviews with experts.

’23 Future Scenario Analysis

Definition of four different possible future scenarios.
1 Environmental identity
2 Expanded role for third parties
3 Manufacturer branding
4 Manufacturer-driven decoupling

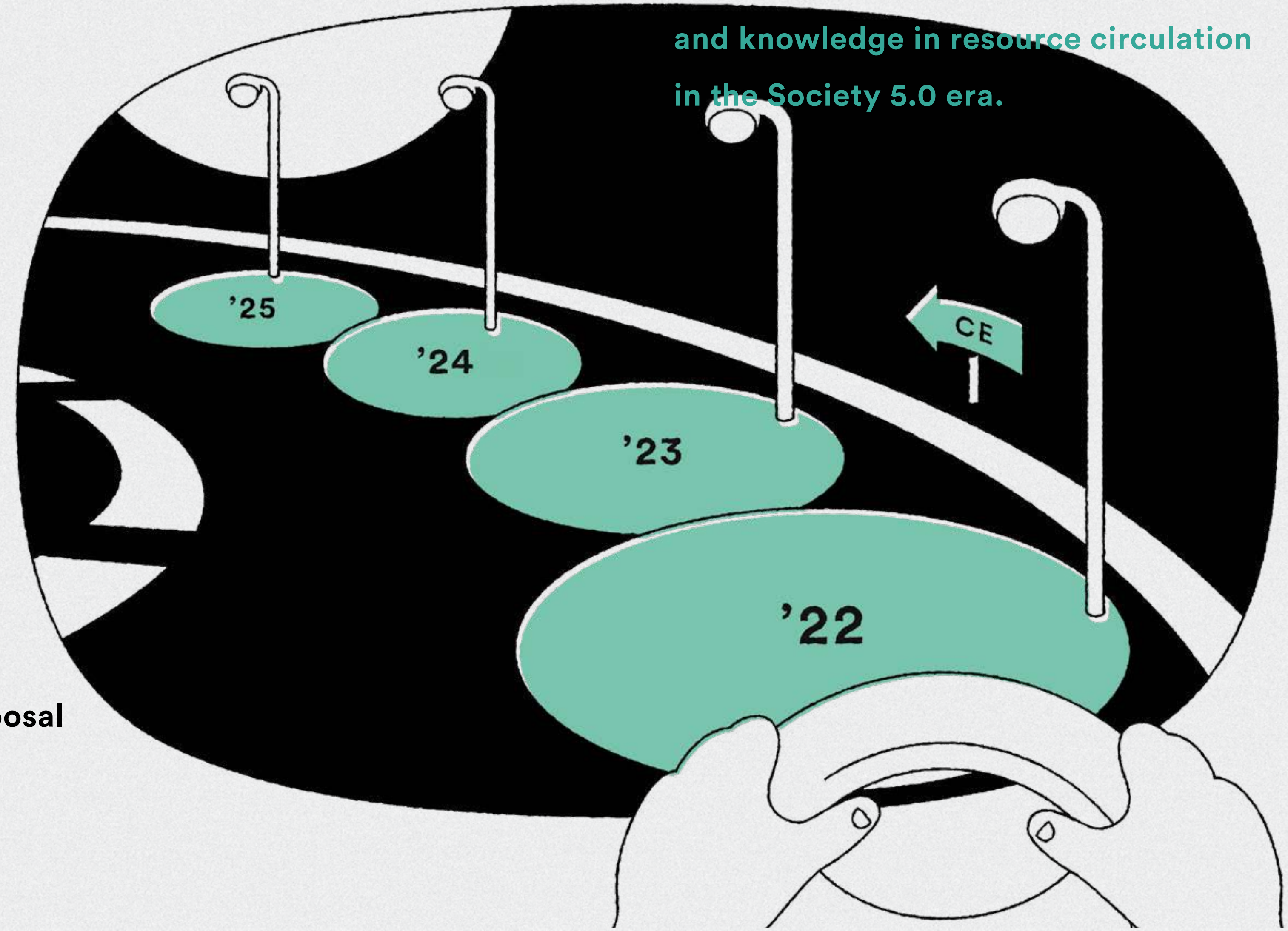
’24 Substantiation of Visions of the Future & Definition of Requirements

Bring to light the dynamic “ideal future scenario” toward which we should intentionally be aiming, and the conditions for achieving the transition.

’25 Roadmap Formulation & Proposal

We will propose a roadmap for reaching the ideal future and indicators for its achievement as a Grand Design, and generate support.

We will depict the “ideal future” that we will progress toward, from the standpoint of interdependence of materials, energy, and information and knowledge in resource circulation in the Society 5.0 era.



A DAY IN
A CIRCULAR SOCIETY

A DAY IN A CIRCULAR SOCIETY

Out of the four potential futures, this section describes a little of what the desired future will look like. Here, two scenarios are depicted in terms of two characters.
What will be the effects on circulation on each of the societies depicted of underpinning by digital solutions and the finalization of rules?

Scenario 4
Manufacturer-Driven Decoupling

Kenji

Interested in using environmentally friendly services that incorporate the natural world into his busy everyday life.

Scenario 1
Environmental Identity

Rina

Uses old, good items with care.
Enjoys engaging with environmentally friendly activities with friends, highly motivated.

Scenario 4 | Manufacturer-Driven Decoupling

Kenji's Day

07:30 Leaves Home

He always takes his keys, phone, and battery.

07:45 To the Community Center

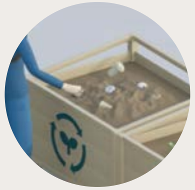
He walks to a nearby community center.

07:50 Rents a Bike

An app chooses a bike that meets his needs. This morning he commutes to work on a recycled electric bike. He plugs in the battery he has brought with him and sets off.

08:00 Buys Coffee

Using his own battery in an electric bike earns eco-miles, which he chooses to use on his coffee.



08:10 Disposes the Cup

Rather than a waste bin, the empty cup goes into a compost box.

The community center is where local people come together. It has cycle share ports, a café, a community vegetable garden, a bike shop, and event spaces.

08:45 To the Office

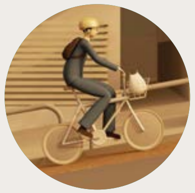
He gets there on his rented bike.

17:15 Leaves Work

17:35 To the Supermarket

Prompted by the app, he switches to Health Mode, which does not use electric power. He hasn't taken much exercise recently, and it charges the battery too.

17:50 Grocery Shopping

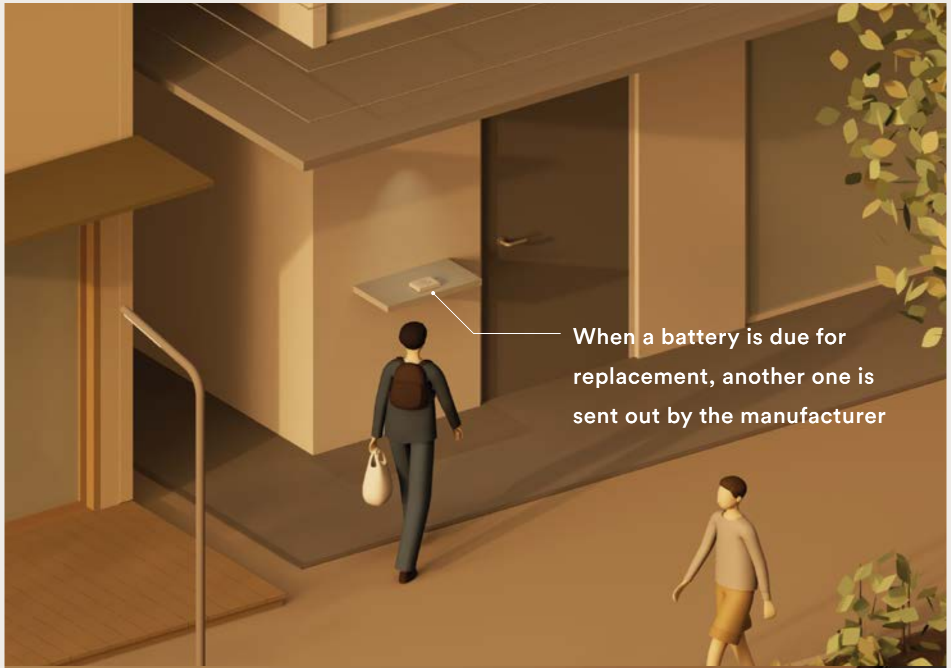


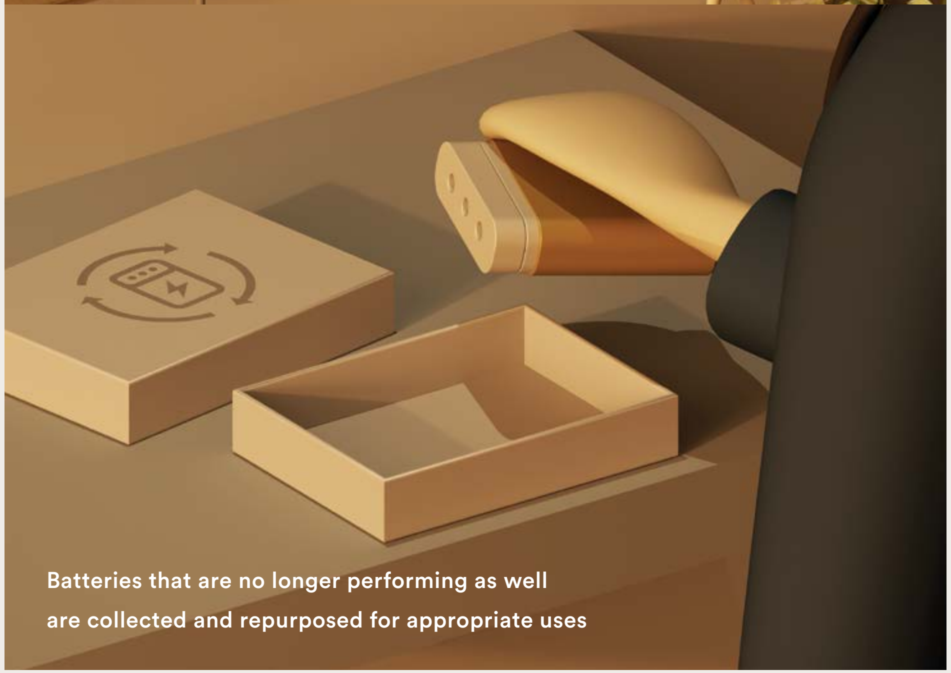
18:00 Homeward Bound

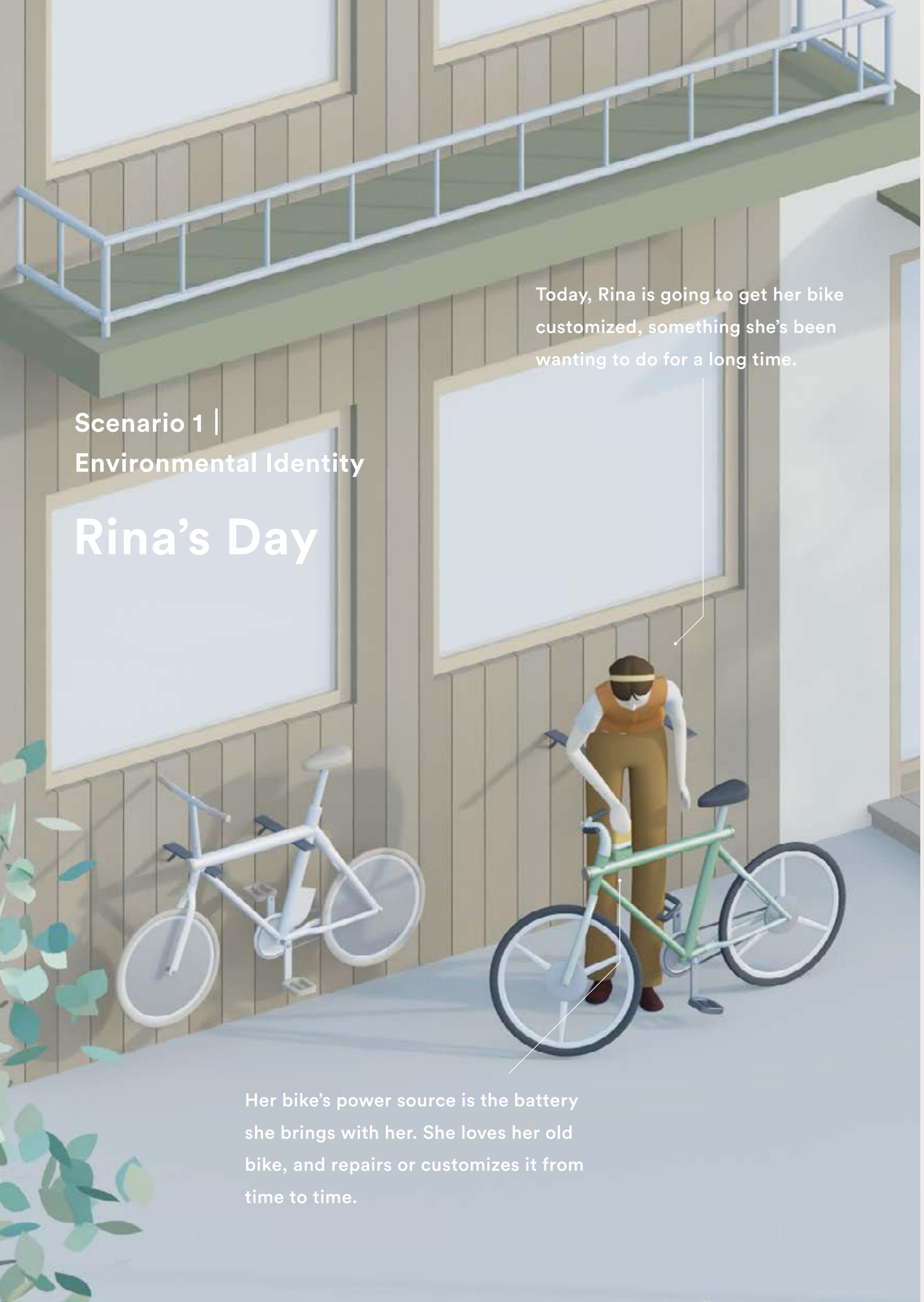
Because he'd turned the power off, the battery is now fully charged, ready to power him up the hill.

18:20 Home

He gets a notification that a replacement battery has been delivered. The one he's using at the moment no longer performs very well with the bike, so it's time to change it.







Scenario 1 |
Environmental Identity

Rina’s Day

Today, Rina is going to get her bike customized, something she’s been wanting to do for a long time.

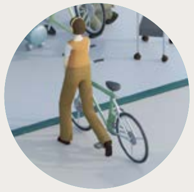
Her bike’s power source is the battery she brings with her. She loves her old bike, and repairs or customizes it from time to time.

09:00 Leaves Home

She always takes her keys, phone, and battery.

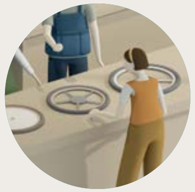
09:30 Takes Her Bike

She plugs her battery into her beloved electric bike, which she keeps at home.



09:40 Arrives at the Community Center

Today’s goal is to get her bike customized.



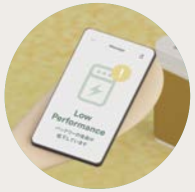
10:30 Buys Parts

She consults a bike expert at the Center, and buys recycled wheels and tires. The parts on sale here all meet standardized specifications irrespective of the brand.

11:00 Customizes Bike

She fits the parts she’s bought, with support from the other people at the community center.

12:00 Finishes Bike



12:05 Receives a Notification

She fits the parts she's bought, with support from the other people at the community center.

12:10 Consults the Others

She asks the other people at the community center what she should do with the battery, and decides to repurpose it to power a watering system in the vegetable garden.

12:45 Assembles the Watering System

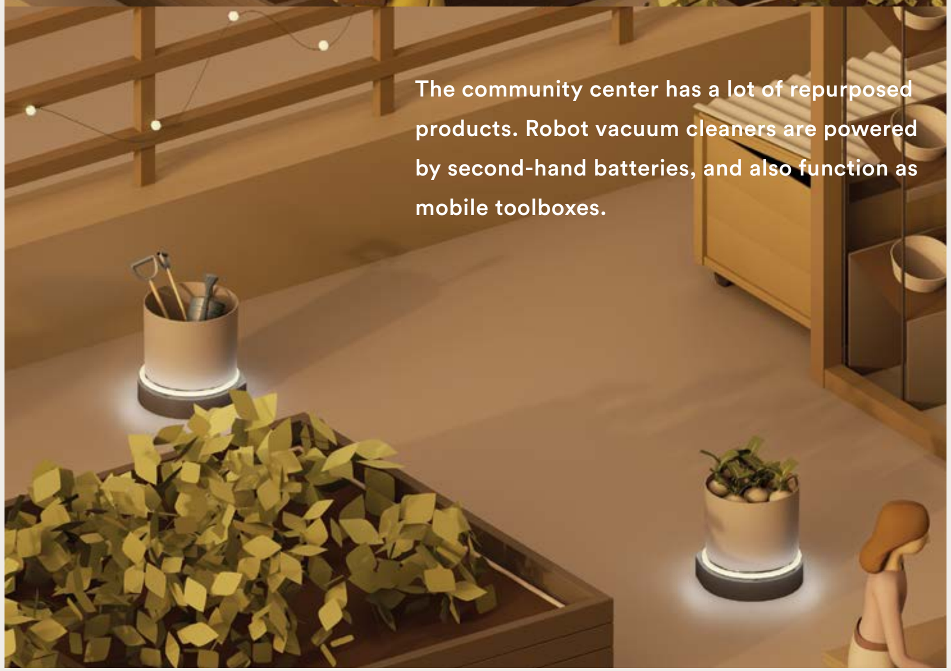
She checks the app to see what other parts she needs to set up the system.

19:30 Success!

With everyone's support, she successfully installs the system. Little by little, the community vegetable plot is getting closer to what the group envisaged.

20:30 Gets Home

She shares some of the vegetables she's picked with her neighbor.



2 DIGITAL SOLUTIONS

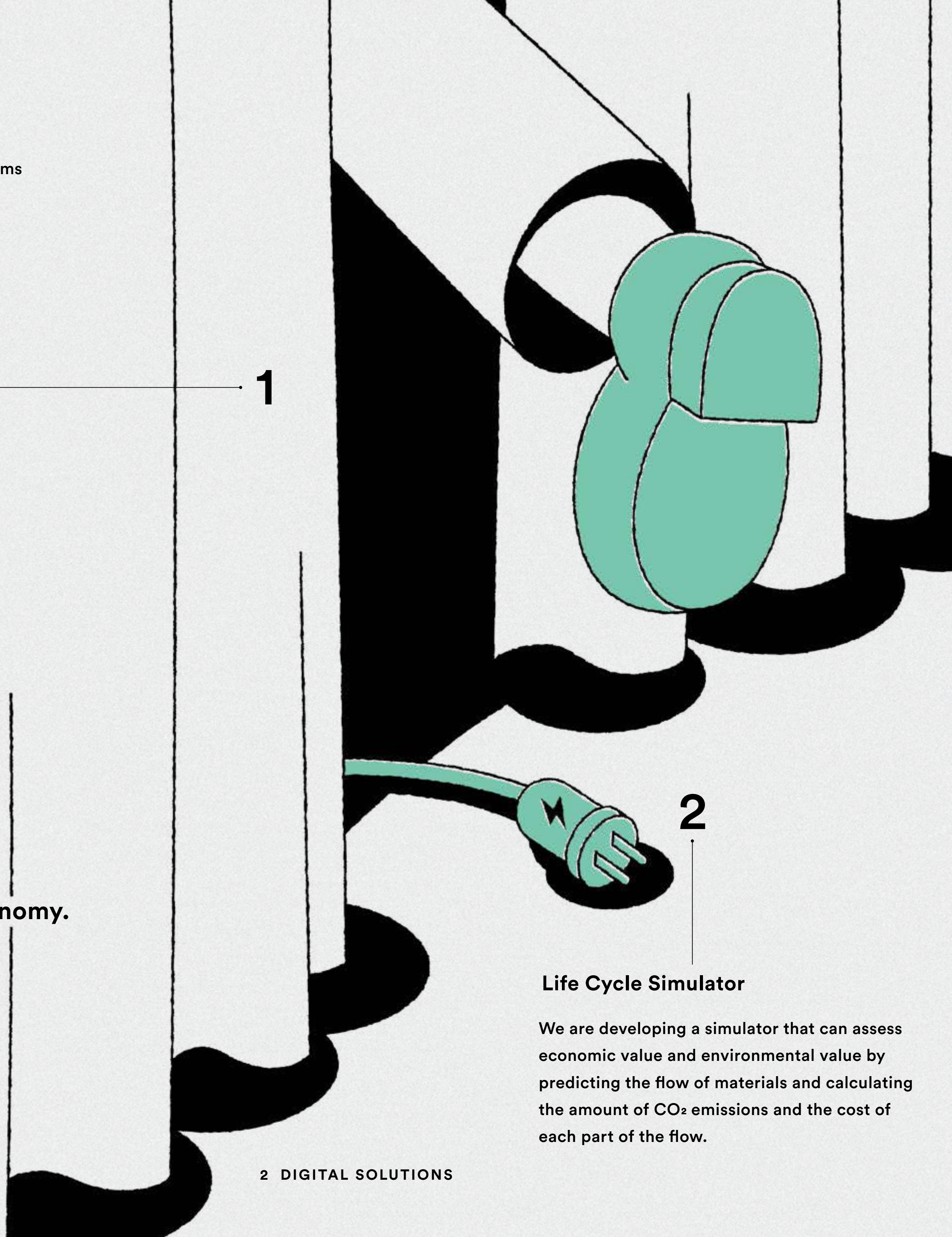
Fundamental Issues

We have drawn up six use cases for systems that can be used to make product life cycles transparent throughout the cycle. By analyzing the issues when each of these proposals is implemented, we have defined two fundamental issues.

Make Product Life Cycles Transparent

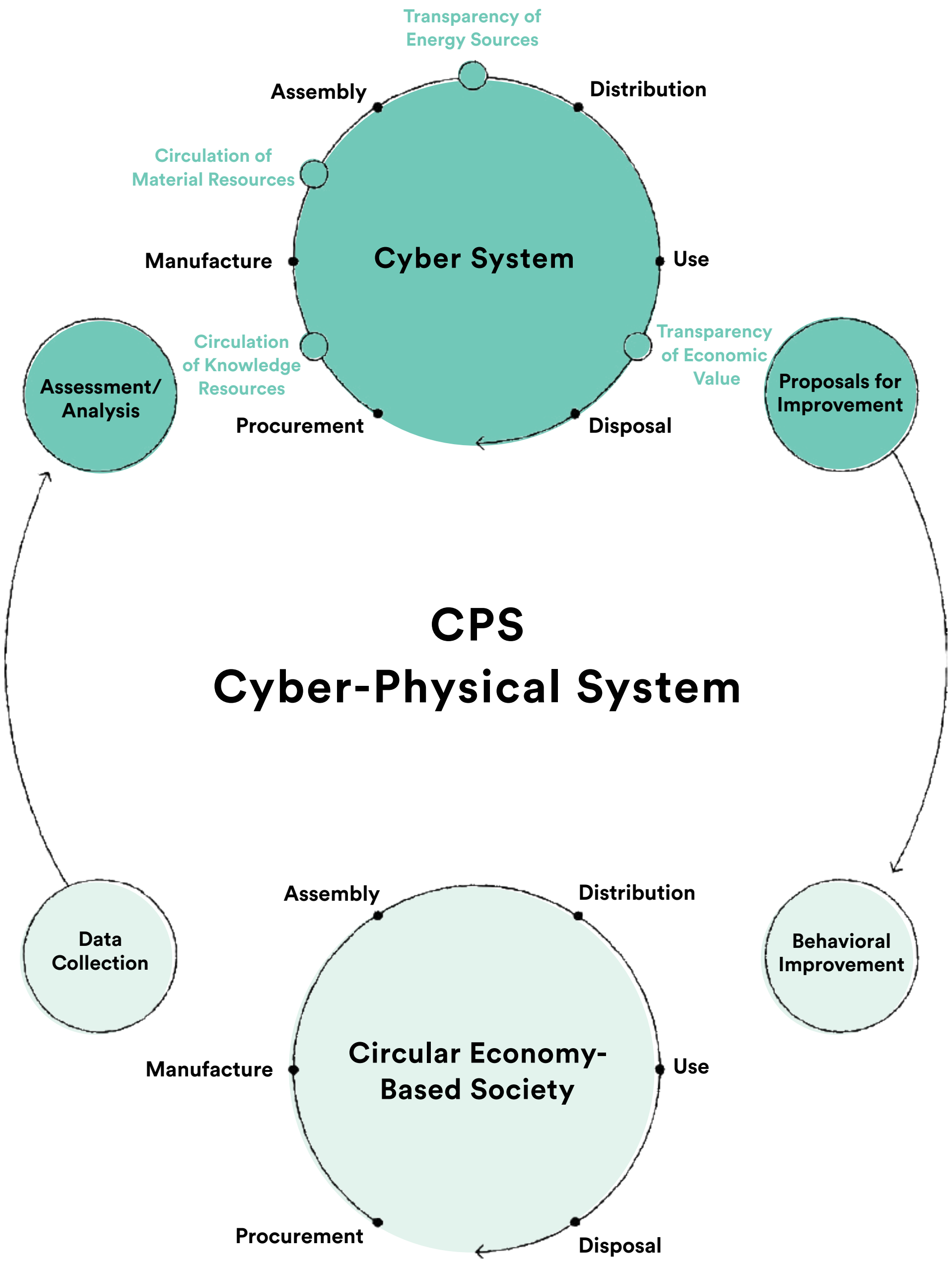
How are products made, used, and come to the end of their roles? Making their life cycles transparent means that their CO_2 emissions and other factors can be predicted more accurately, enabling correct feedback on the behavior of corporations and users.

Make product life cycles transparent. This could encourage spontaneous action toward a circular economy.



Life Cycle Simulator

We are developing a simulator that can assess economic value and environmental value by predicting the flow of materials and calculating the amount of CO_2 emissions and the cost of each part of the flow.



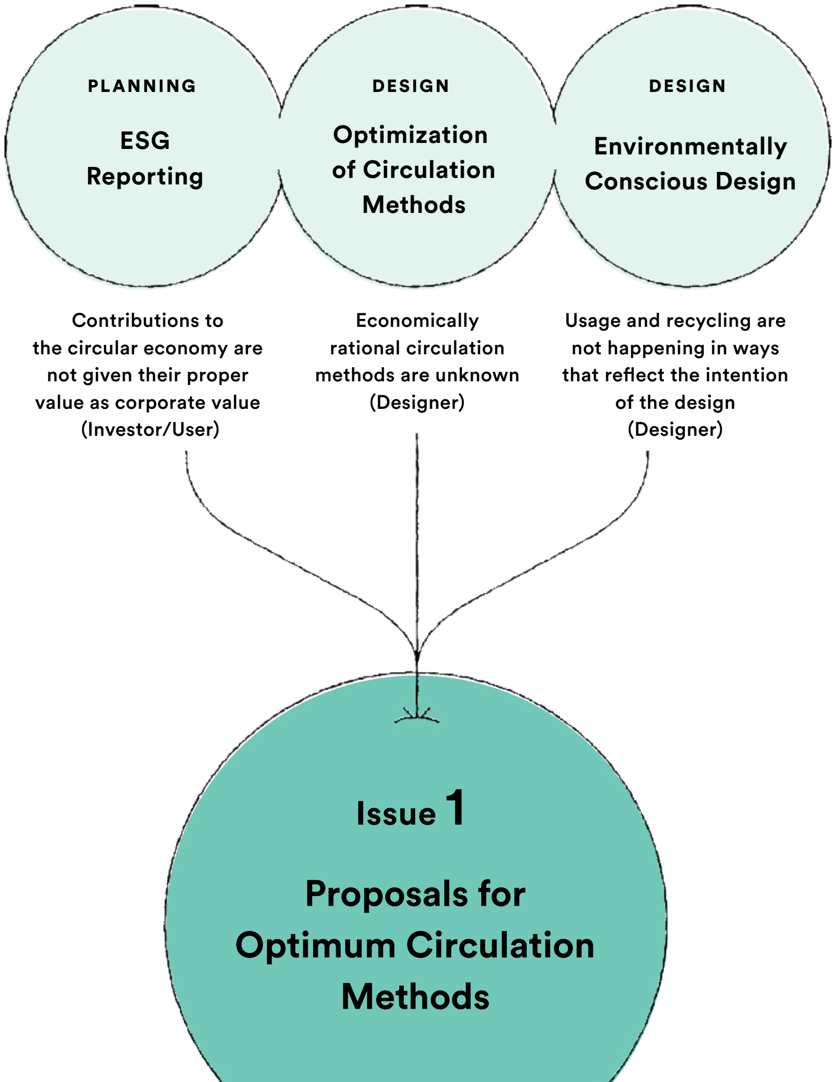
Roadmap Review by Cyber-Physical Systems

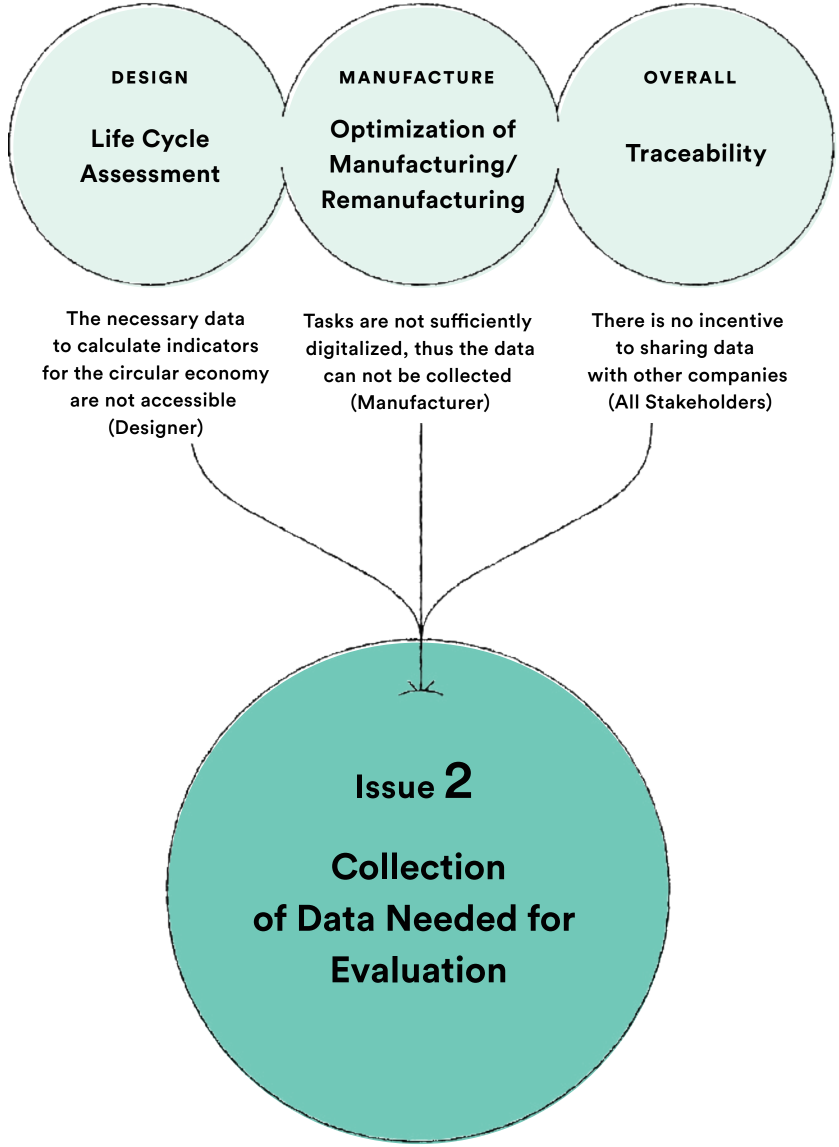
In this laboratory, our aim is not just to assure the transparency of the flow of materials, but also to create a society in which spontaneous behavior leading to a circular economy is encouraged by means of fair and proper digital evaluation of the behavior of consumers, manufacturers, recyclers, and other stakeholders so that they can be given appropriate feedback. What is needed for this is the development of cyber-physical systems with a view to a circular economy.

These cyber-physical systems are systems that can make transparent the flows of financial and material resources and energy by collecting, evaluating, and analyzing data on factors such as CO_2 emissions from product life cycles in real life. This will lead to real-world behavioral improvements through the proposal of improvement measures while utilizing shared knowledge.

Identification of Issues

To start with, we held workshops and other events to draw up six use cases using cyber-physical systems from the behavior required of stakeholders in order to achieve the circular economy-based society that is our goal.





In addition, we also conducted interviews with business divisions of Hitachi to identify and explore the issues faced by stakeholders if these use cases are to be put into practice, and identified two fundamental issues that need to be resolved.

Value-Adding Solutions That Circulate Both Resources & Money

We defined the elements required for the issues identified and the issues that have become evident and should be resolved. First, to show the optimum circulation method, we will develop life cycle simulations to evaluate circular economy indicators and economic value by modeling the flow of materials and business activities during the life cycle on the basis of domain knowledge and data.

To ensure the utilization of data on collection, disassembly, and recycling (the tasks in inverse manufacturing that make up the most important aspect of the circulation of materials), we are computerizing these tasks to lay the foundations for data collection.

By conducting the above two tasks in tandem, we will develop a cyber-physical system with a view to a circular economy that combines resource circulation with economic benefits for stakeholders, and aim to work with stakeholders to create a circular economy in which sustainable business growth is feasible.

HITACHI × AIST

Mobilizing the strengths of Hitachi and AIST, we conduct research to develop solutions.

HITACHI

Hitachi has the knowledge developed in its manufacturing sites and in collaboration with its customers, and a track record of solutions in the environmental field.

IoT (Internet of Things)

Modeling Real-World Know-How High-quality, highly reliable manufaturing can be achieved by utilizing real-world data.

Customer Collaboration Approach

Navigating Customers' Resolution of Issues

Analysis of issues across stakeholders' entire businesses.

EcoAssist-Pro/LCA

Calculating CO_2 Emissions at the Product Level

Calculating CO_2 emissions using actual procurement and manufacturing data.

AIST

AIST has a track record of solutions that utilize its strengths in digitalization at manufacturing sites.

Circulation Process Simulator

Modeling the Disassembly of Devices

AIST's groundbreaking CEDEST model.

Connected Factory Research Team

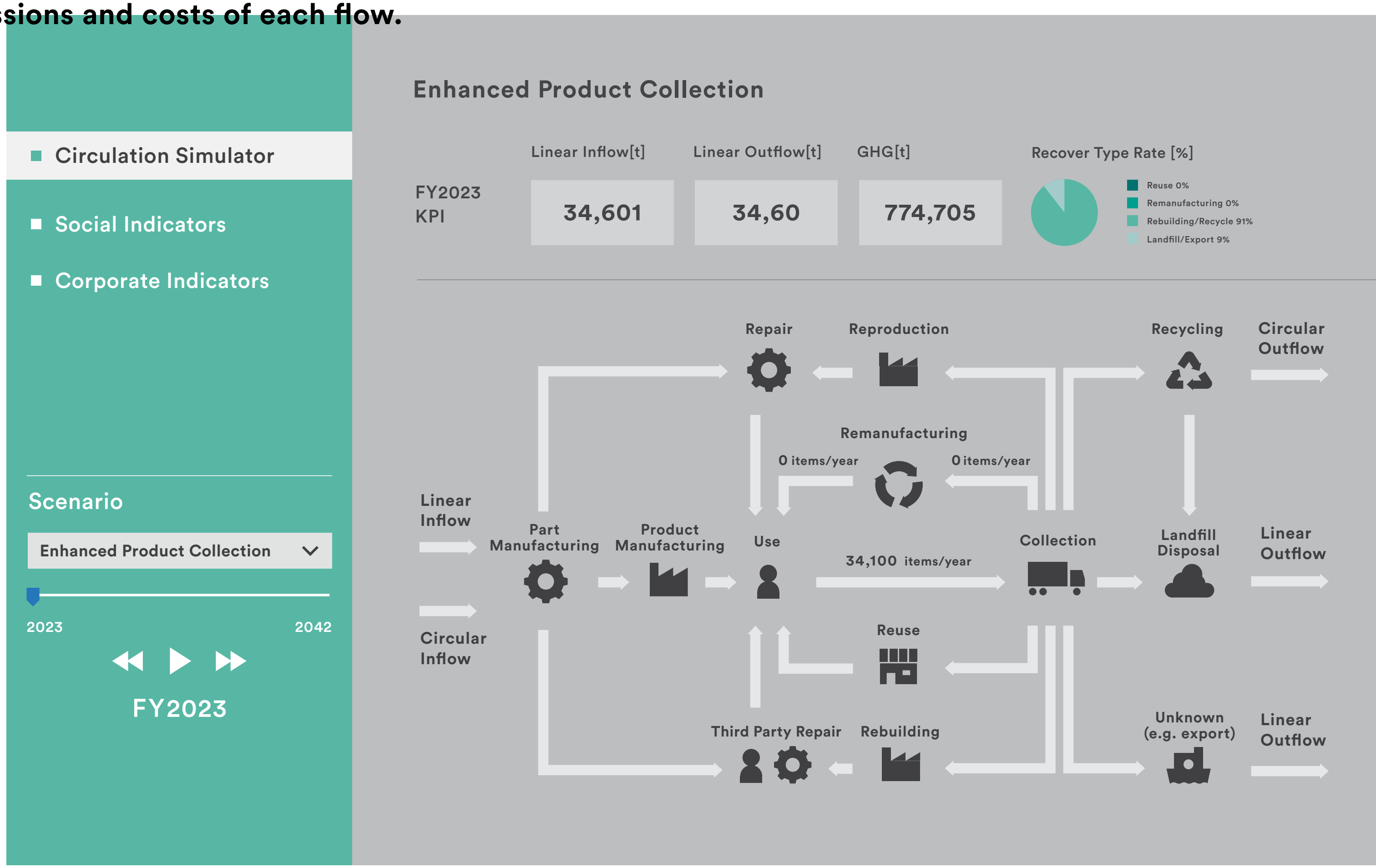
Factory IoT System Developed with the industrial sector over 20 years, with repeated testing in verification environments.

Simulating Circulation

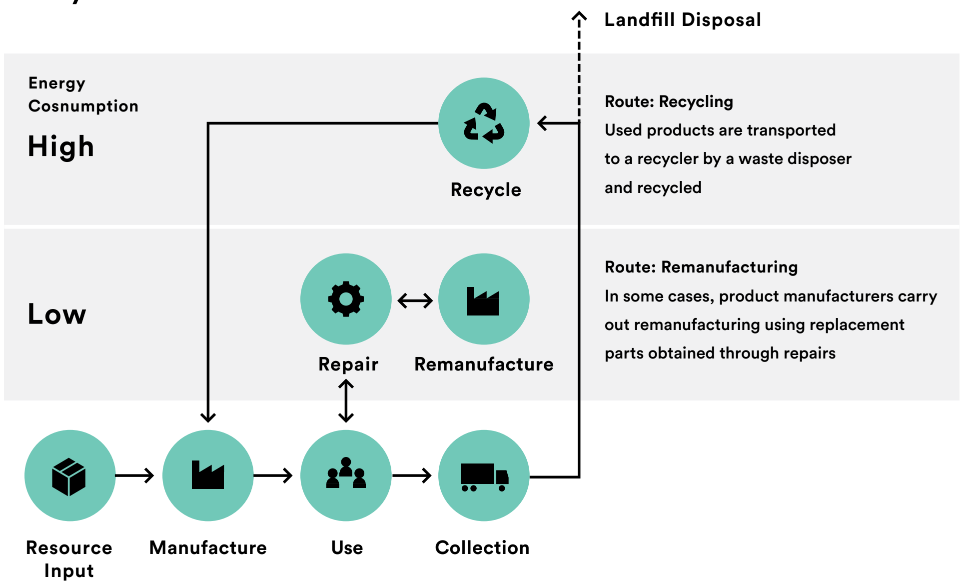
How are resources introduced, and how do they proceed through manufacturing, use, and recovery? We are developing a simulator that can evaluate economic value and environmental value by predicting flows of materials that diverge in a variety of ways, and calculating the CO_2 emissions and costs of each flow.

A feature of this simulator is that it utilizes knowledge from design and manufacturing through to recycling, meaning that it can closely model a large number of businesses engaged in circulations. This may make it possible for customers and stakeholders together to propose circulation methods in which growth is feasible.

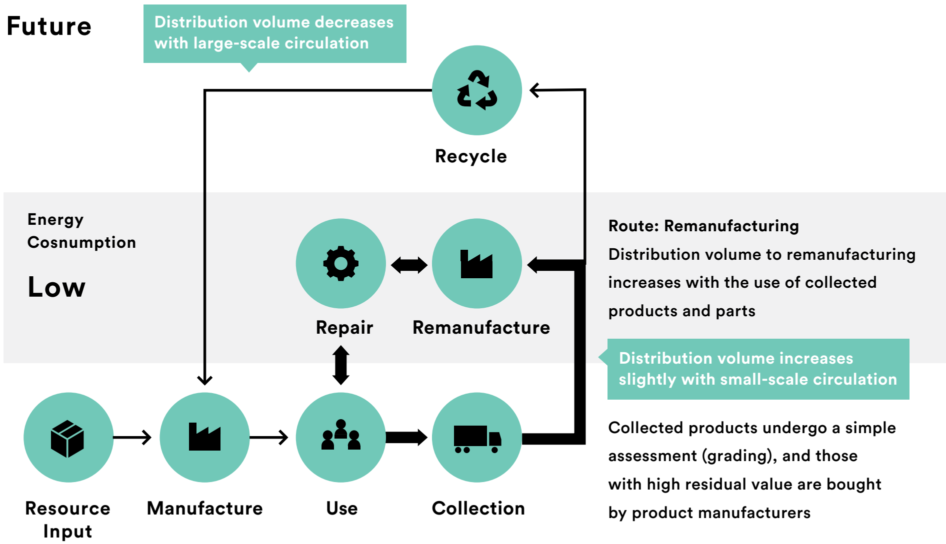
In future, we will link systems to upload the data required to calculate a range of different indicators and aim to appeal more effectively to customers to increase their circularity by calculating and disclosing suitable circular economy indicators for regions, societies, and businesses. We will also go on to update these models with data obtained from the digitalization of tasks, developing a system that can respond flexibly to changes in the social or business situation.



Today



Future



Example of a Simulation: Circulation Rroutes for Industrial Machinery

Present and Future Comparison

We modeled and compared the present and future life cycles of machinery in the industrial sector. In the present life cycle, used products are transported to a recycler by a waste disposer and recycled. Although recycling is the basis of resource circulation, this circulation method has high CO_2 emissions.

However, in some cases product manufacturers carry out remanufacturing using replacement parts obtained through repairs. Remanufacturing is a circulation route with low CO_2 emissions, but as it is based on repaired parts, low circulation volume can be expected to be an issue.

By creating a route whereby products are returned to their manufacturers by waste disposers, the distribution volume via small-scale circulation for remanufacturing increases. If the waste disposers also conduct a simple assessment of the condition of the recovered products, the manufacturers can purchase products that are in good condition, and as a result energy and resource loss decreases and the distribution volume in the high value (relative value) loop increases, which may lead to growth for both product manufacturers and waste disposers.

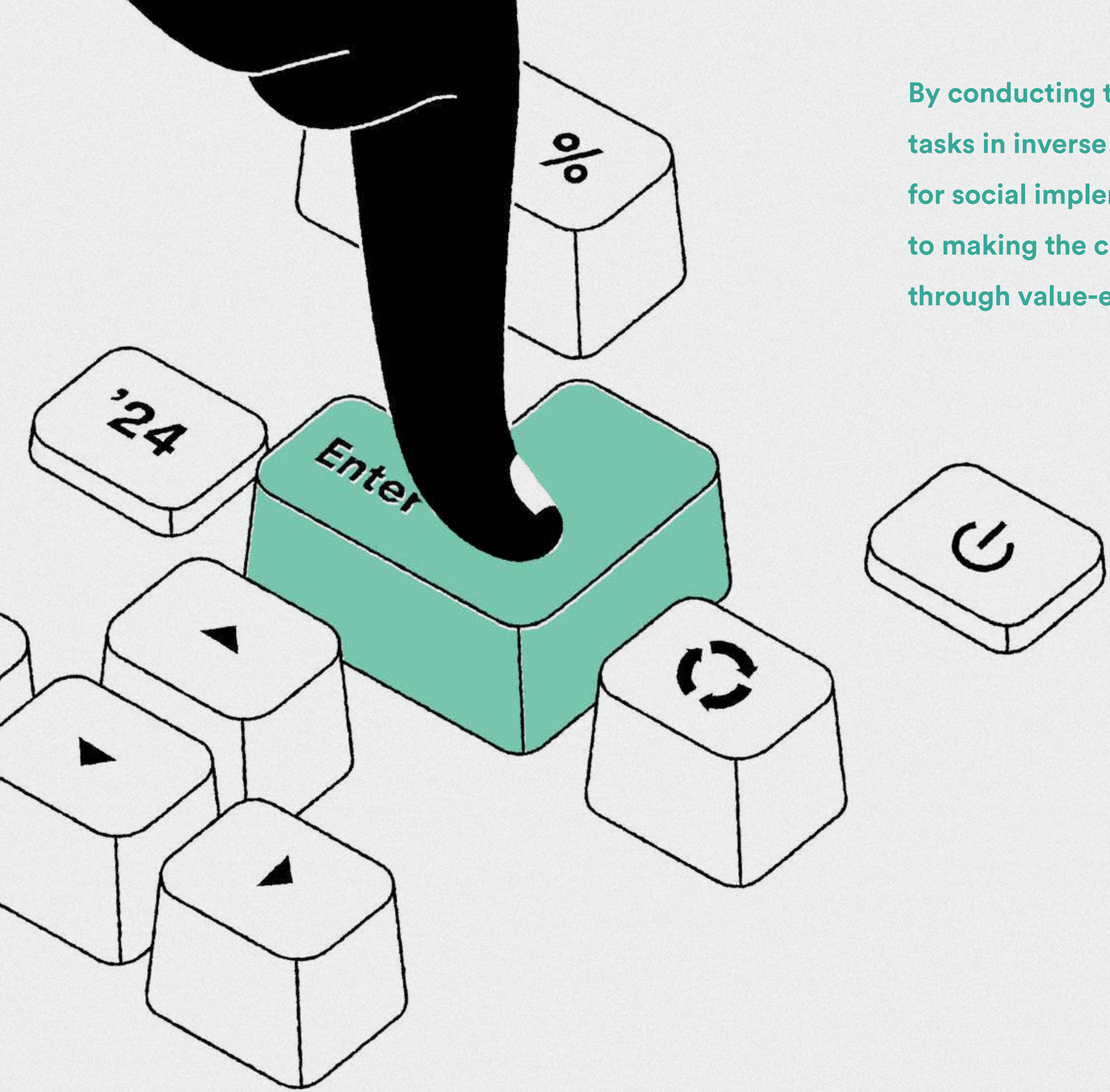
Estimates

We found that reducing resource inputs and CO_2 emissions, which are a burden on the environment, increased the profits of both product manufacturers and waste disposers. Because it offers an opportunity for business growth for recovery contractors, they may voluntarily cooperate in the creation of a smaller loop for remanu-facturing, and this circulation method may enable sustainable growth for both.

	Recycling-Based	Remanufacturing-Based
Resource Inputs 10,000 tons/year	3.4	3.1 ⬇ -10%
CO_2 Emissions of Procured Materials 10,000 tons CO_2/Year	11.5	10.4 ⬇ -10%
Manufacturers Gross Profit 100MM Yen/Year	363	370 ⬆ +2%
Waste Disposers/ Disassembly Contractors Gross Profit 100MM YenYyear	5.7	6.8 ⬆ +19%

This case is just one example, and by envisaging various methods of circulation and evaluating their circularity and economic value, we will go on to explore methods that both offer high environmental value and enable business growth.

*Note: Estimates for industrial sector machinery, using Scope 3 Category 1 CO_2 emissions calculations.



By conducting testing/trials and digitalizing tasks in inverse manufacturing to prepare for social implementation, we are contributing to making the circular economy a reality through value-enhancing solutions.

’22 Definition of Issues

Identification of use cases through workshops and definition of issues to be resolved with a view to implementation; 1. Proposal of optimum methods of circulation. 2. Digitalization of tasks.

’23 Development of Solutions

Development of a “life cycle simulator” to model the tasks and circulation routes involved in the cycling of materials and enable methods of circulation to be proposed. Laying the foundations for data collection by digitalization and use of the Internet of Things (IoT) in relation to collection, disassembly, and recycling, which are the aspects of inverse manufacturing.

’24&25 Testing & Expansion

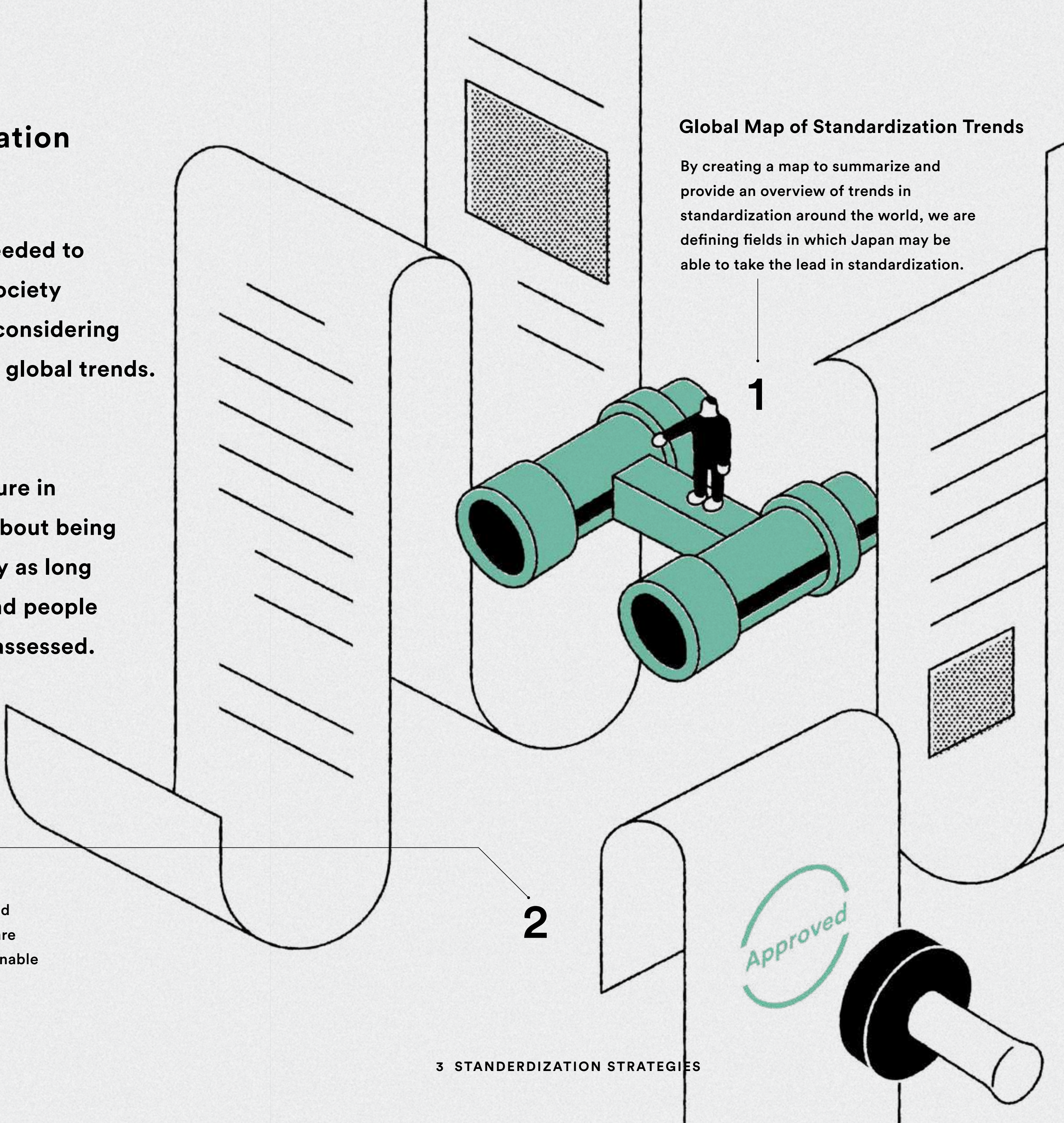
In preparation for social implementation, conducting testing and trials in actual operations and inverse manufacturing and digitalizing the recovery side of the circle. Expansion of scope of modeling to include generative AI and quantum computing.

3 STANDARDIZATION STRATEGIES

Considering Rules for Circulation

What sort of conventions are needed to bring the circular economy to society at large? We are exploring and considering what we can do while assessing global trends.

**Creating the rules we need.
This is an initiative toward a future in which everyone can feel good about being involved in the circular economy as long as goods are properly reused and people and corporations are correctly assessed.**



Global Map of Standardization Trends

By creating a map to summarize and provide an overview of trends in standardization around the world, we are defining fields in which Japan may be able to take the lead in standardization.

Circular Economy Indicators

We consider that grading, which makes the value of circulation apparent, will lead to the promotion of resource reuse. We are proposing new suggested indicators to enable a soft landing in the circular economy.

Identifying Global Trends

In the circular economy, Japan has led the world in environmental activities with the three Rs (reduce, reuse, recycle), underpinned by a high level of public awareness. However, with the EU now taking the initiative in the international standardization of the circular economy, Japan must take a proactive stance in order to achieve globally sustainable economic development.

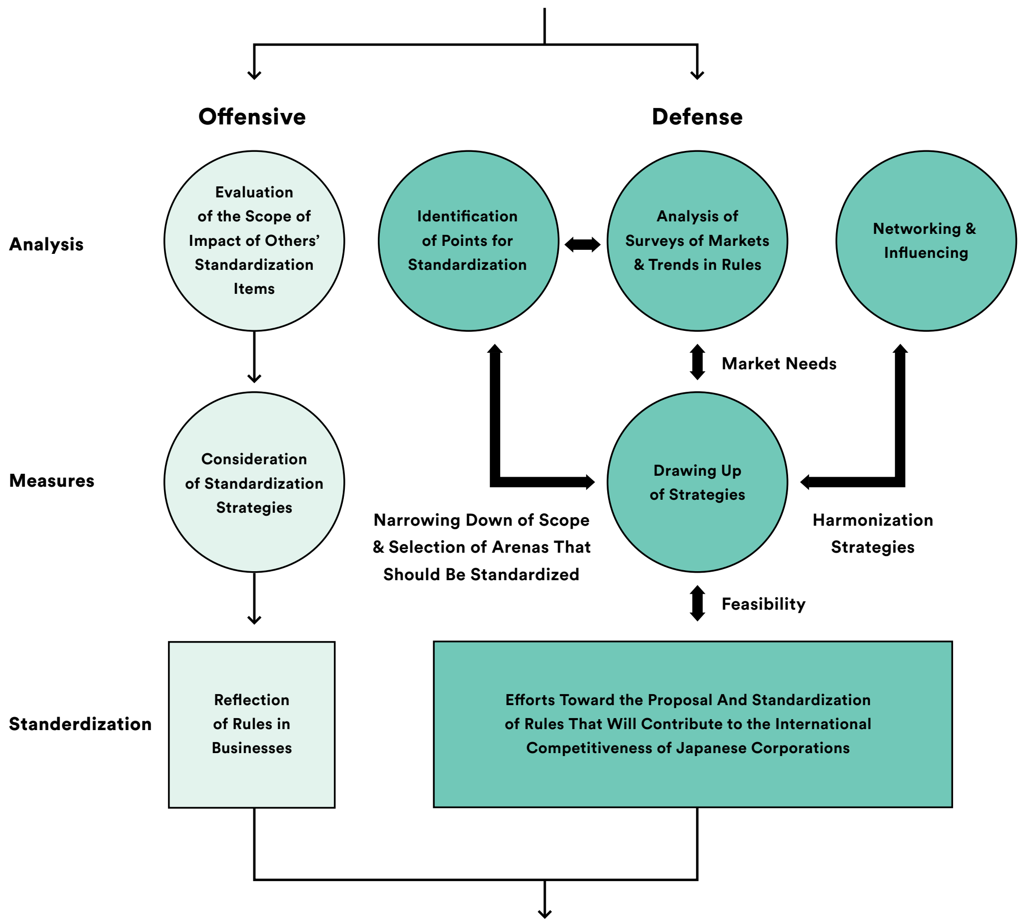
Offense & Defense

At the Hitachi-AIST Circular Economy Cooperative Research Laboratory, we understand standardization strategies with reference to the two axes of "offensive" and "defensive." Having surveyed international markets and standardization trends and understood the present situation, we believe that combining both strategies will strengthen the international competitiveness of Japanese companies while maintaining harmony on a global level.

- **Offensive Standardization Strategy**
  Take the initiative with "Japan-generated rules and standards" with the goal of standardization that does not disadvantage either this country or other countries.

- **Defensive Standardization Strategy**
  Incorporate European initiatives toward the achievement of a circular economy into Japanese practice as early as possible.

Overview of Rule-Making Trends
Surveys of Markets & Trends in Rules



Enhance the International Competitiveness of Japanese Corporations by Balancing Leading & Following in Rule-Making

Global Map of Standardization Trends

We started by creating a block diagram summarizing the world's environmental rule-making communities in order to assess the current situation. The block diagram has been organized so that the characteristics of each region are highlighted from both the cyber and the physical viewpoints.

CYBER Organize database related initiatives, with a focus on data sovereignty.

PHYSICAL Categorize into separate layers for the environment, society, economics, and products.

The objective of this overview assessment of worldwide trends is to use it in the formulation of strategies and tactics with a view to the social implementation of business models and digital solutions.

Legends

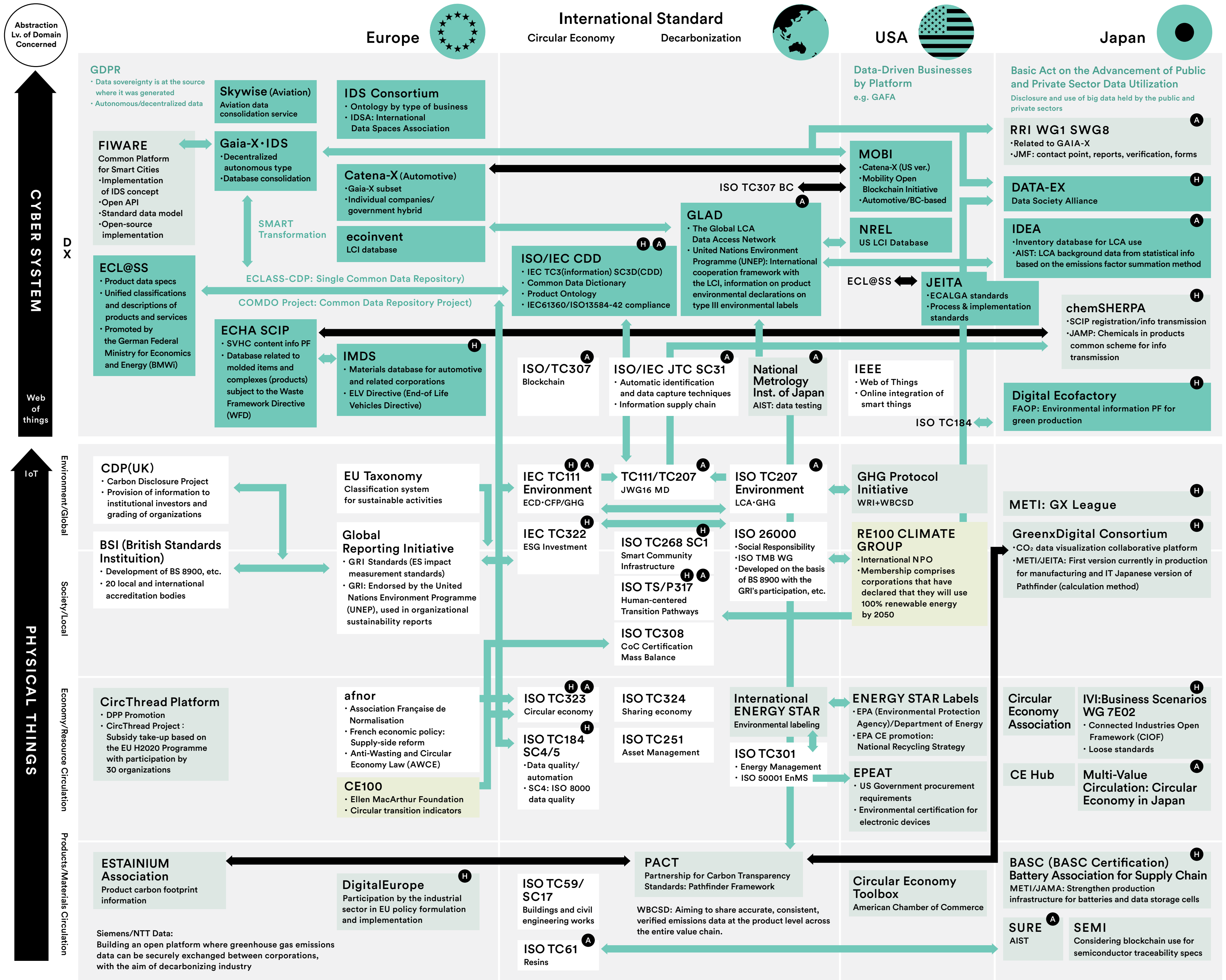
- Data Utilization-Related Activities, etc.
- Standardization-Related Bodies
- Environmental Bodies
- Other Bodies
- Related
- Similar
- H Participation by Hitachi
- A Participation by AIST

ISO·IEC·ITU (H) (A)

CEN·CENELEC

CEN-CLC SABE CE-TG

ANSI·W3C·IEEE



This diagram tells us a number of things, described below.

Today Europe is ahead in terms of the databases that constitute the infrastructure of the digital transformation (DX), including the circular economy and carbon neutrality (CN).

Hope Japan may be able to catch up by playing a role for CE transition through Japan-driven international standardization.

Reason For example, Japan is in pole position for the international standardization of online dictionaries. In ISO/TC323, the central rule-making arena for the circular economy, the connections with digital specifications are still weak, and there is scope for Japanese leadership in international standardization so that digital data can play an important role in the quality control of used products.

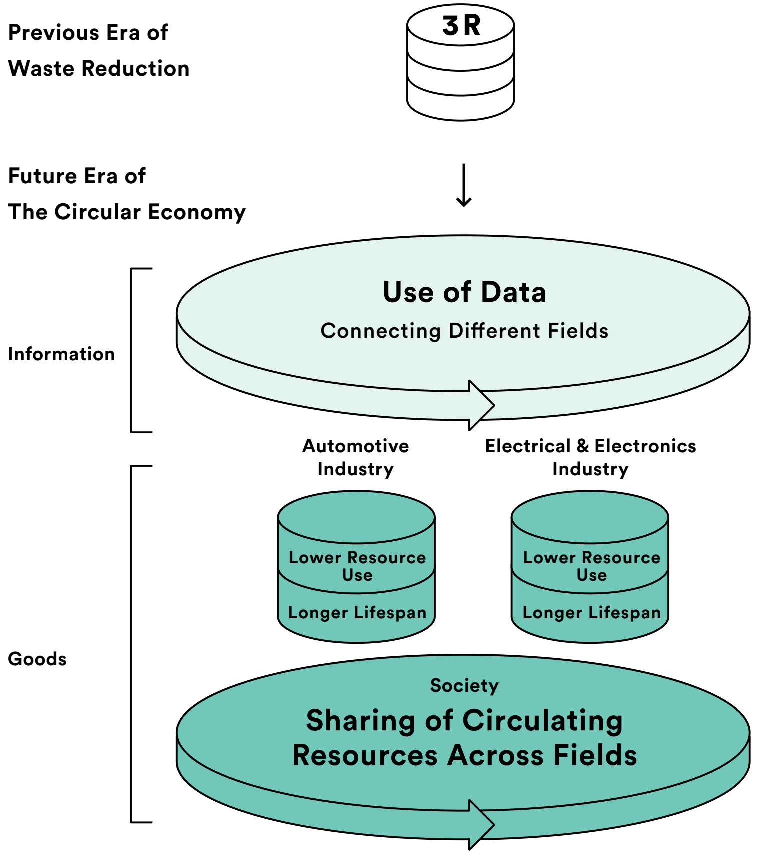
Giving Circulation Value

This study brought to light the importance of data utilization for the promotion of resource reuse. Grading, which makes the value of circulation apparent, offers particularly good prospects.

To envisage the future following on from the 3Rs in standardization, we focused on the following topics, taking the automotive industry as an example.

- Over 50% of the literature in the automotive field mentions materials that are used across multiple industries.
- An increasing number of reports describe the repurposing of batteries from electric vehicles (EVs) for domestic and other uses. The grading of used lithium ion batteries (LIBs) is carried out individually.
- Taking the automotive recycling industry as a case study, standardization/data usage of grade information on used products in an information network.
- In Europe, a regulation mandating the use of recycled plastic in new cars has been proposed.

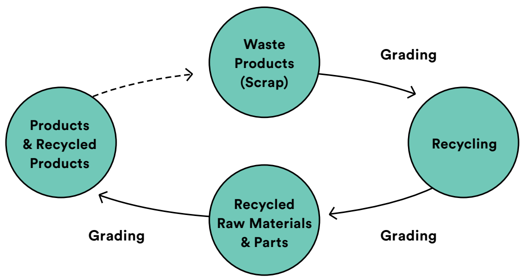
From the previous era of the "3 Rs," which had the goal of reducing waste, we will soon come to the era of the "circular economy," in which the efficient use of resources and longer product lifespans thanks to the utilization of data are valued both socially and economically. We can anticipate that resources that had formerly been circulated only within a single industry will be circulated within society at large, across industry boundaries, thanks to the use of standardized data.



Making Value Visible and Encouraging Circulation

As an example, scrap aluminum has conventionally been reused as casting material, but the amount of scrap produced is forecast to exceed the demand for casting material in the near future, breaking down the balance of supply and demand.

This means that there will be a need for the development of a new resource circulation system to recycle scrap not as casting material but as high-grade expanded materials (materials formed by processes such as flattening, molding, drawing, and extrusion). If it could be graded on the quality of the waste product before it enters the recycling process, this would make it easier to recycle as high-grade material. And if the recycling processes for raw materials and parts made from recycled resources could also be certified and graded, users could also use these products and recycled products with peace of mind.



Standardizing grades, making the value of waste products visible, and certifying the recycling process will not just make upgrading easier, but also enable people to feel comfortable about using recycled products. To standardize grading, we will specify requirements to be met by grading in ISO/TC323, which deals with the standardization of the circular economy, and then formulate online standards by field and material in a space called Standard as DataBase (SDB).

Issues in Economic Indicators

Circular economy indicators that look at reductions in physical linear substances being used is certainly important. In addition, economic indicators that appropriately evaluate the effects of a wide range of measures contributing to CE, including extending the lifespan of equipment or products by repairs and similar means, which is considered a key driving force in the future scenarios of the Grand Design, will be equally important or the smooth transition to CE, but our surveys have shown that these are lacking. For example, one economic indicator that is already the subject of discussion, Circular Material Productivity (RMP) has the following issues.

$$R_{MP} = \frac{\text{Revenue}}{\text{Total Mass of Linear Inflow}}$$

Circular Material Productivity, R_{MP} (WBCSD Circular Transition Indicator 4.0)

ISSUES This indicator changes rapidly in years when there is linear* inflow in the form of facilities investment, and fails to properly evaluate efforts to extend the lifespan of equipment each year. (This is a particular problem in industries liable for large facilities investment.)

*Linear: The antonym of circular, meaning resources that are not circulated.

STRATEGY FOR RESOLUTION Level out the portion corresponding to facilities investment each year, and properly evaluate efforts to extend the lifespan of equipment each year.

FACTS

1. Repair is one of the key driving forces toward the circular economy (in the Grand Design created by our laboratory).
2. Existing standardized economic indicators do not evaluate the effects of extending the lifespan of equipment by means such as remanufacturing, reuse, and repair.

Proposal for a New Circular Transition Indicator

This shows the ratio calculated by dividing the compensation for the products and services supplied that year as the numerator by an amount corresponding to the nonrecyclable virgin natural resources used for this purpose as the denominator. This denominator formerly only took account of the "fully used amount" (the amount corresponding to the variable cost), but if the "partially used amount" (the amount corresponding to wear on physical fixed assets over the year) is also included, performance could be improved by using fixed assets for longer.

$$\text{Proposed Resource Circularity Indicator} = \frac{\text{Compensation for Products \& Services Provided in the Year (Revenue)}}{\text{Amount Corresponding to the Non-Recyclable Virgin Natural Resources Used in These Products \& Services (Mass × Unit Price)}}$$

Fully Used Amount
Variable Cost of Raw Materials, etc.
+
Partially Used Amount
Wear of Equipment & Other Fixed Assets

Anticipated Effect

Evaluating each year's efforts to extend the lifespan of equipment as contributing to the circular transition may enable companies to make a soft landing in the circular economy though providing a variety of measures available for transition to CE.

Collaboration with Relevant Organizations

Based around ISO/TC323, which is central to the circular economy, we are also collaborating with other TCs, including IEC SC3D, which is moving ahead with data linkage.

ISO/TC323

- Two representatives of Hitachi (R&D) are currently in the process of registering as members of the Japanese Committee.
- One representative of Hitachi (Business Division) is already registered with the International Committee.
- One representative of AIST is already registered with the International Committee, and took part in the 2023 Annual Meeting.
- WG 2[*1]: Convenor, Professor Ichikawa of Tama University. WG3[*2]: Continuing exchange of information with the General Manager of the Japanese Committee, Professor Murakami of the University of Tokyo.

IEC SC 3D Common Data Dictionary

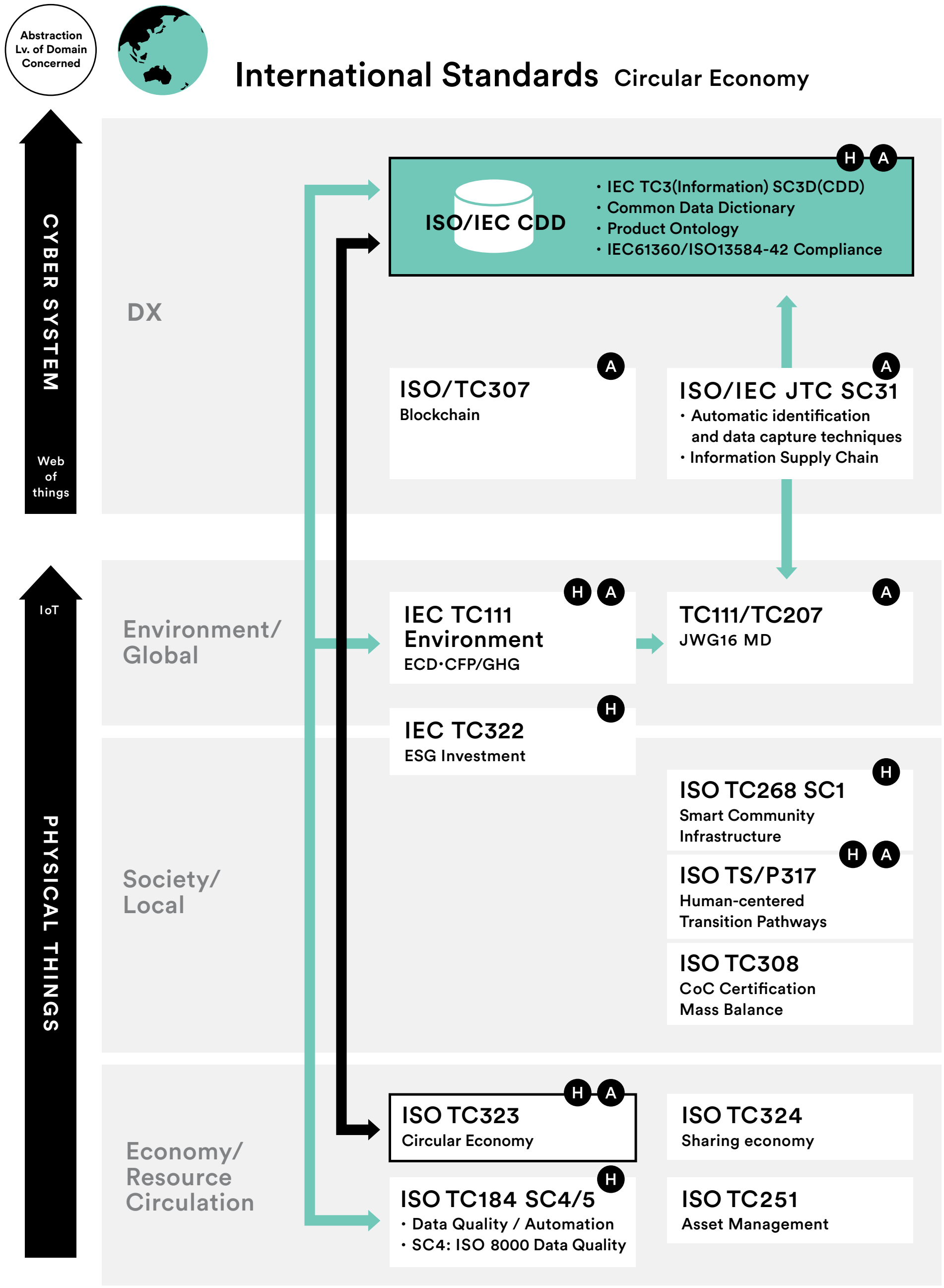
Building links with key persons in CircThread[*3], which handles disassembly indicators (to be proposed as part of the DPP).

Overseas Influencers in the CE Field & Standardization Experts

A list of candidate partners from organizations such as WBCSD, WRI, and NIST and academic institutions has been narrowed down to around 10 people. We will further deepen this relationship in future through long interviews.

※1 Practical Approaches to Develop and Implement Circular Economy ※2 Measuring and Assessing Circularity ※3 An EU project with the aim of creating digital threads for the management of products, resources, and services in the circular economy.

International Standards Circular Economy



’22 Status Assessment & Strategy Development

Assess current status and analyze the internal environment by gathering publicly available information and conducting joint studies. Clarification of approaches with a view to drawing up issues with and strategies for standardization and proposals for measures to be taken.

’23 Drawing Up of Standardization Strategies

Gather information from interviews with standardization experts. Identify issues and needs on the basis of the information gathered in each study, and draw up offensive standardization strategies.

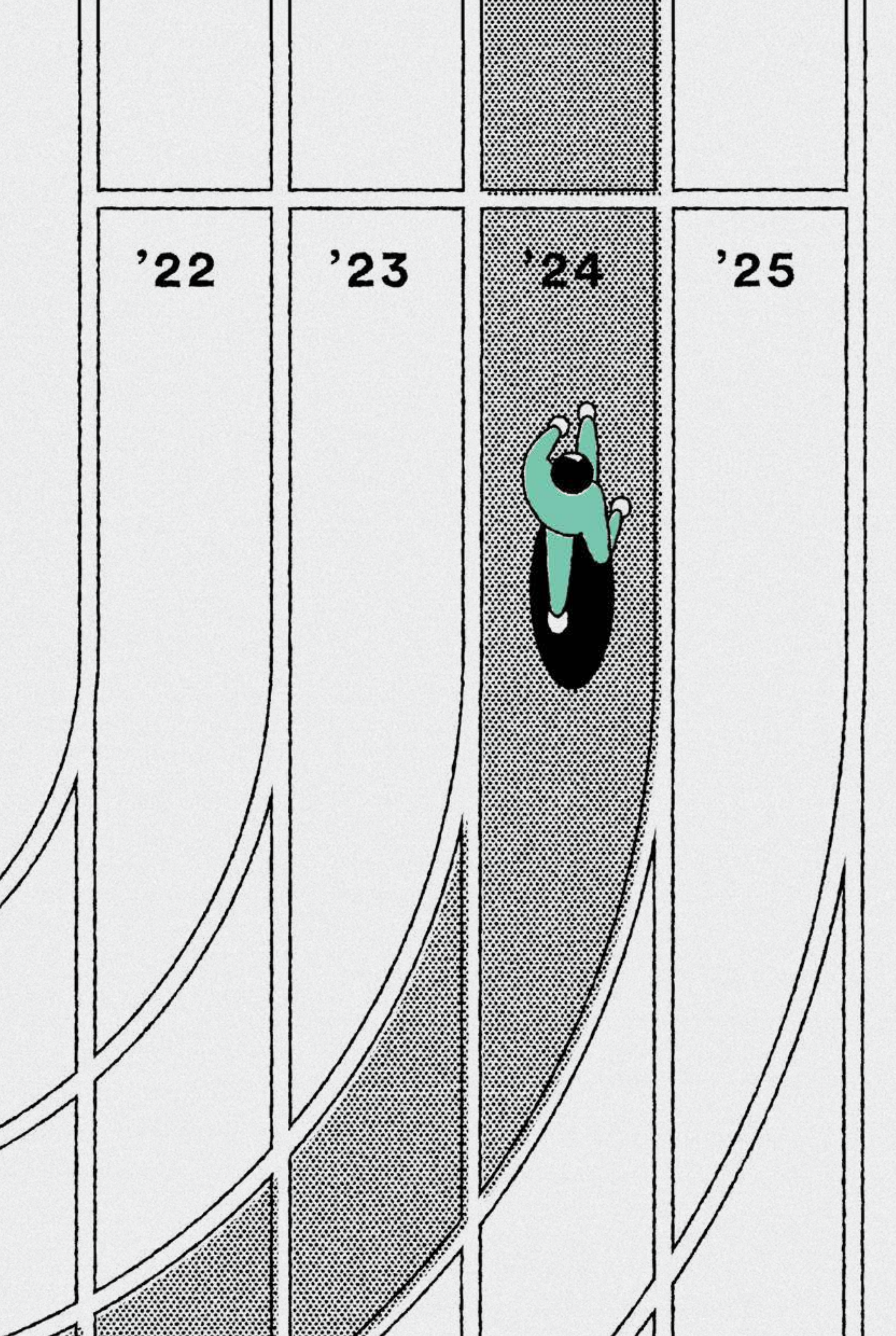
’24 Optimization with a View to Implementation

Optimization of the resulting strategies on the basis of opinions from other relevant organizations and testing. Proposals for rules contributing to business models and initiatives toward standardization. Start work on Working Draft (WD) preparation.

’25 Prepare for Implementation

Once the WD has gone through internal review, proceed to the preparation and submission of a Committee Draft (CD). Go on to the DIS and FDIS stages from 2025.

We will draw up rule-making strategies that contribute to the international competitiveness of Japanese corporations, and make them happen.



Afterword

At the Hitachi-AIST Circular Economy Cooperative Research Laboratory First Open Forum: Embarking on Circular Economy Journey and Methodologies Involved, held on February 5, 2024, representatives of the laboratory presented the activities to date of the Hitachi-AIST Circular Economy Cooperative Research Laboratory, which had been founded in October 2022. This booklet is a summary of the presentations at that forum as well as an interim report of our activities.

In our laboratory, we understand the resources that should be circulated in the Society 5.0 era as comprising materials, energy, and information and knowledge, and are deepening the discussion on the three themes of “Grand Design,” “Digital Solutions,” and “Standardization Strategies” described in this booklet. These three types of resource have previously been considered to be independent of each other, but we believe that the Society 5.0 era is the era that will see the start of intense clashes between them. We will therefore envision a Grand Design whereby Society 5.0 will be achieved through the effective utilization and high level circulation of these three resources. From the technical standpoint, we will also come up with specific digital solutions and draw up offensive and defensive rule-making strategies that will contribute to enhancing the international competitiveness of Japanese companies.

Of course, the circular economy is not something that can be achieved by a single organization alone. I welcome any level of interest in and attention to our laboratory’s activities, discussions with us from a range of different perspectives, and hope to build expectations for what this approach can do. I look forward to the continued support of the organizations that are joining with us to make the circular economy a reality, and hope to accelerate our combined efforts as we move forward.

Director, Hitachi-AIST Circular Economy Cooperative Research Laboratory
Katsumasa Miyazaki

Laboratory Members

As of March 2024

Please join us in making the circular economy a reality.

https://unit.aist.go.jp/hitachi-cecrl/en/index.html

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