2024

Activity Report

HITACHI-AIST Circular Economy
Cooperative Research Laboratory

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Expand the circle into a society that generates harmony.

The “Circular Symphony” is HITACHI-AIST Circular Economy Cooperative Research Laboratory’s vision of the circular society, in which technology, rules and human values all harmonize to compose a sustainable future. Diverse stakeholders each play their own parts in the performance of a single symphony, embodying the aspiration that we can create a future of coexistence between the environment, the economy, and society.

Circular Symphony

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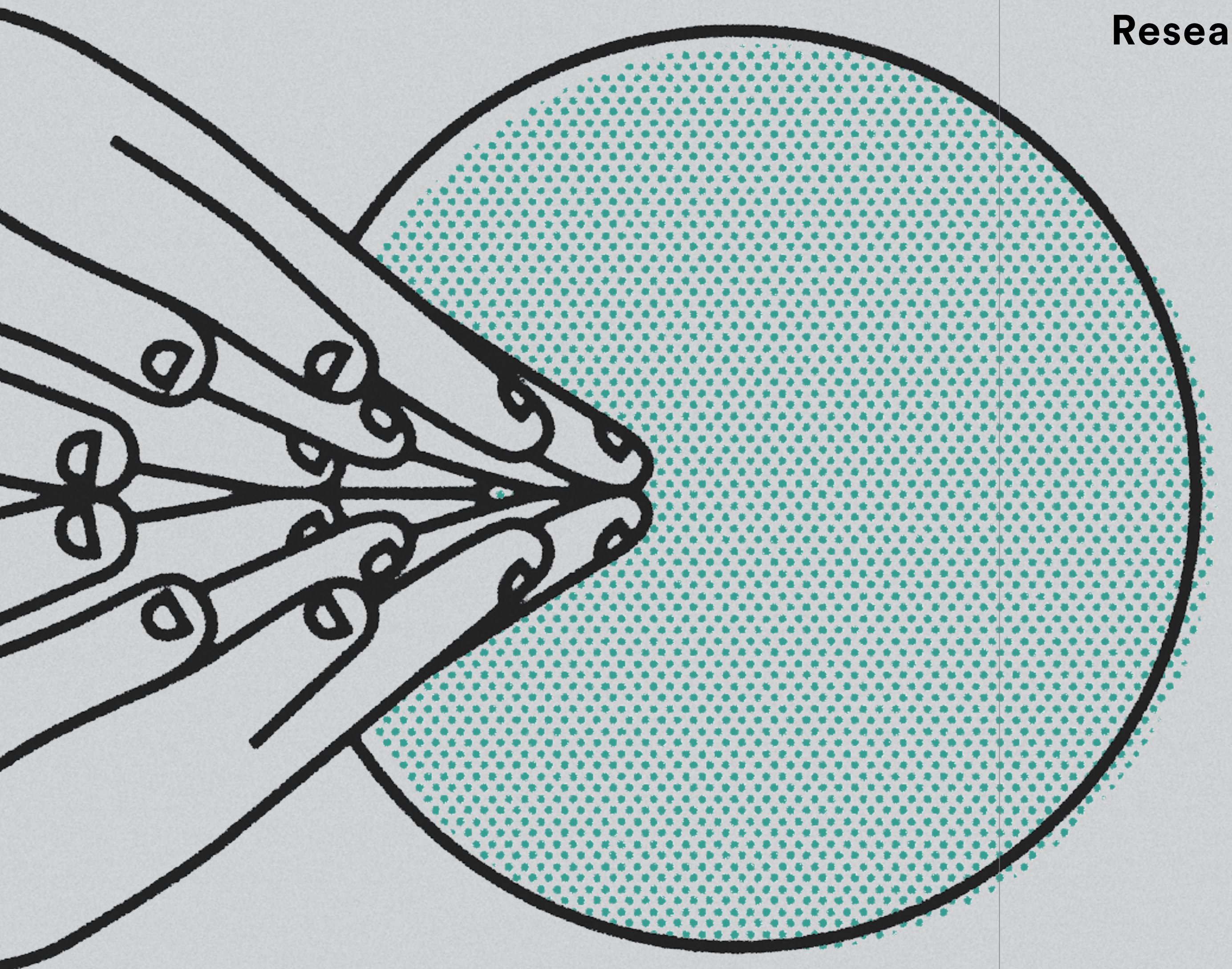
Introduction



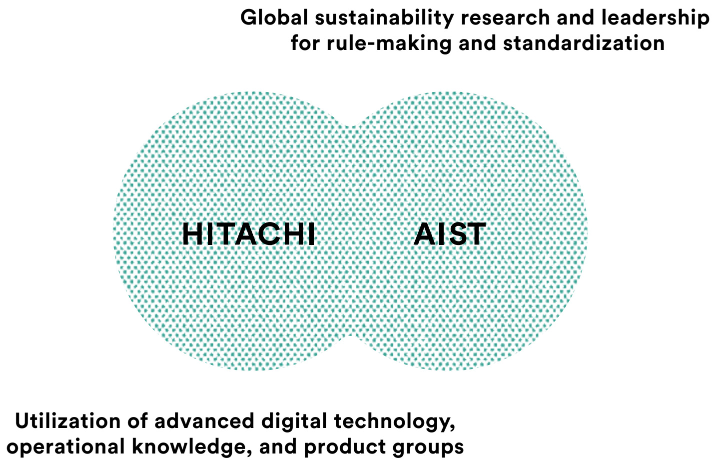
Introduction

About HITACHI-AIST Circular Economy Research Laboratory

As global environmental issues become ever more serious, a shift from the previous economic model of mass production and mass consumption to a circular economy is now required of international society as a whole, Japan included. HITACHI-AIST Circular Economy Research Laboratory was established as a center for conducting research on a Grand Design for using limited resources in a highly effective manner, as well as on the rules, problem-solving strategies, and other measures needed to achieve this circular economy, and sharing these worldwide.

Toward the Circular Economy

HITACHI-AIST Circular Economy Research Laboratory is a joint research center established in 2022 by Hitachi and the National Institute of Advanced Industrial Science and Technology (AIST). The goal is to combine Hitachi's information technology (IT), operational technology (OT), and product knowhow 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 collection, monozukuri (design and manufacturing) and service engineering from both organizations 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 Issues in Japan

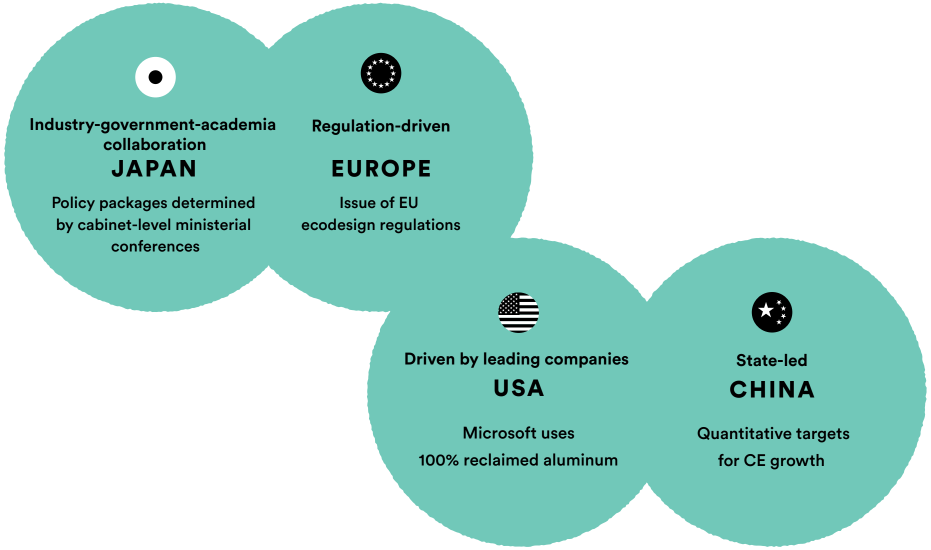
We consider that Japan currently faces the following three issues in the push to establish a circular economy.

1. In a global, diverse market environment, sharing a vision for society that delivers economic growth without resource circulation becoming a drag on the market
2. Collecting and using data across product life cycles 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

We believe that a genuine circular economy can be achieved by sharing these issues and collaborating with stakeholders in industry, academia, and government.

International Trends in Legislation and Policy

In the international community, movements to review and revise legal frameworks and policies with a view to achieving a circular economy are already underway worldwide. In light of international trends in 2024, we have attempted to classify the processes leading toward a circular economy by region.



Publication of the ISO 59000 Series on the Circular Economy

ISO59004	Standardization of the definition, vision, principles and other aspects of the circular economy
ISO59010	Provision of guidance on transitioning to circular economy business models and value networks
ISO59020	Standardization of indicators and assessment frameworks for evaluating circularity

→ Potential for development to circular economy management

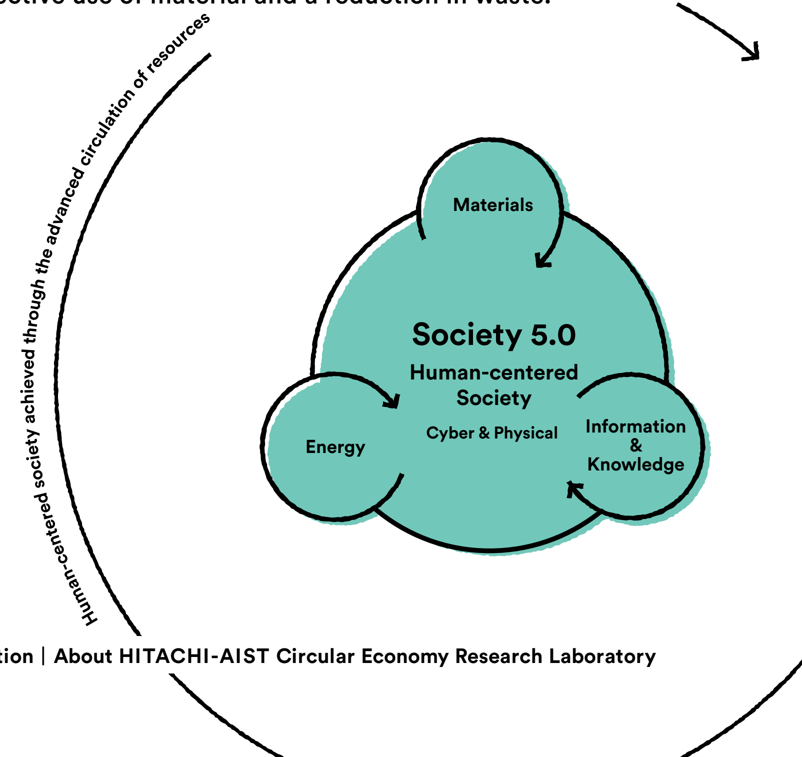
Looking at the recently published international standards on the circular economy, it can be seen that the importance of "value networks" that advantage the entire cycle through interactions between stakeholders is starting to be recognized.

We believe that these changes in the surrounding environment provide a good opportunity, and we must be prepared to respond to them flexibly. In our laboratory, we are engaged in R&D with a view to the Society 5.0 era for which Japanese society is aiming, while taking international trends into consideration.

Circulating Materials, Energy, Information, and Knowledge

Japanese society is now entering the new phase known as "Society 5.0." In this novel form of society, following on from the hunger-gatherer, agricultural, industrial, and information societies, advanced cyber-physical systems lead to both economic development and the solution of social problems.

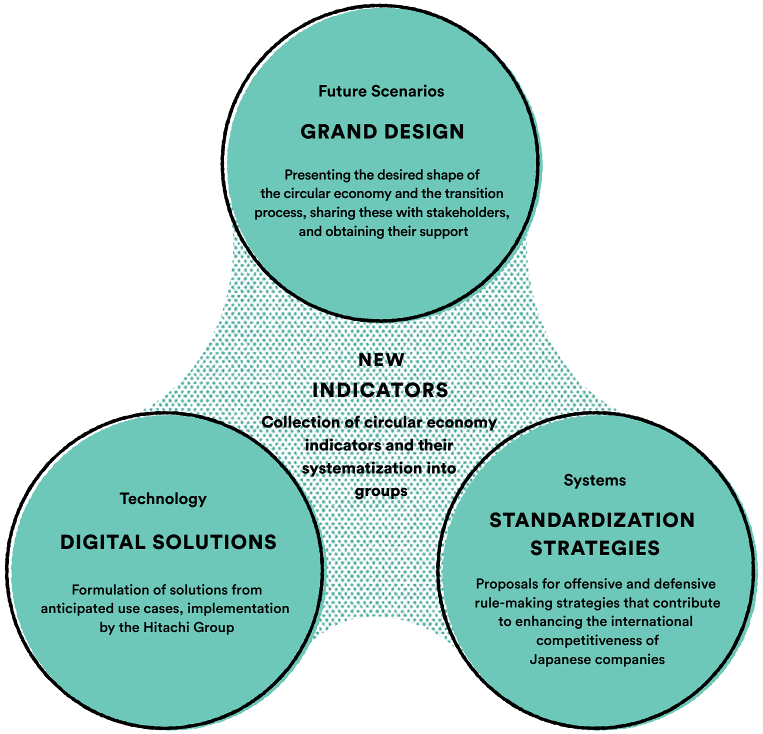
In the Society 5.0 era, we understand information and knowledge as constituting a new type of resource in addition to the conventional resources of materials and energy, and believe that this must also be circulated. Through the use of material and energy resources, pure data obtained from a physical space becomes information, knowledge, and finally wisdom. If we can use this information and knowledge to eliminate unnecessary calculations and limit energy consumption, extending the capacity of the computer to its utmost, this should lead to the effective use of material and a reduction in waste.



Research Toward Formulating a Roadmap

To create a roadmap for achieving a circular economy, the laboratory has designated three research themes from the three standpoints of "Future Scenarios," "Technology," and "Systems." These are "Formulation of Grand Design for Circular Economy & Society," "Development of Digital Solutions for a Circular Economy," and "Planning of Standardization Strategies/Proposal of Measures."

Under the Grand Design research theme, our aim is to present the desired shape of a future society and the transition process, share this with stakeholders, and obtain their support. Under the Digital Solutions research theme, we will identify issues from use



cases based on the premise of a circular economy-based society, propose solutions to resolve them, and move ahead with their implementation by the Hitachi Group. Under the Standardization Strategies research theme, we will propose measures including data collection and utilization methods, and work on offensive and defensive rule-making that contributes to the international competitiveness of Japanese companies.

In 2024 a new taskforce was set up to connect these three research themes through the "Systematization of Indicators for the Circular Economy," and work has now started on collecting such indicators and their systematization into groups.

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

2024 2 — **The First Open Forum:** Discussion of the shape of the ideal circular economy-based society of the future and issues on the way to its attainment.

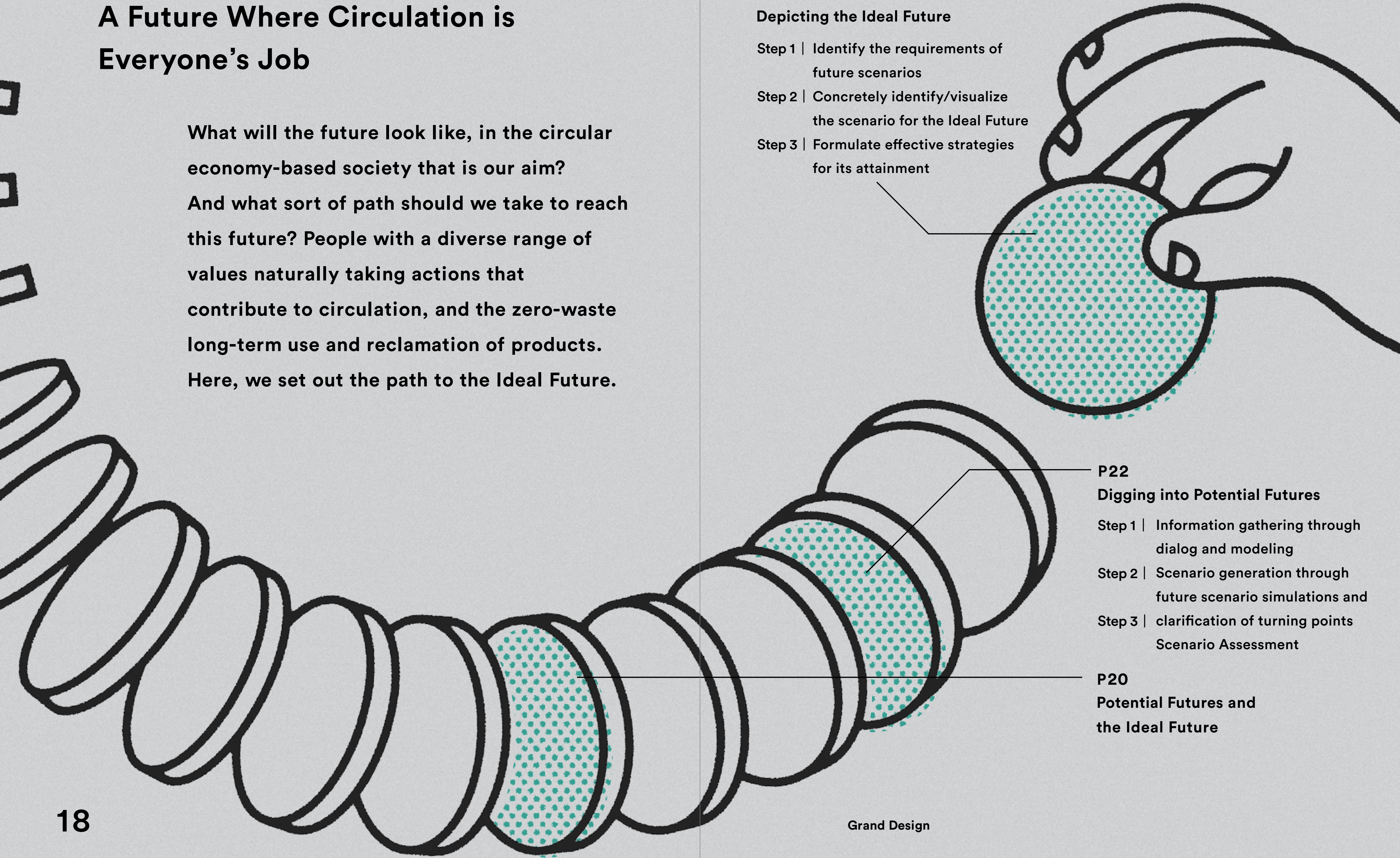
2024 4 — **Standardization Symposium:** Publicizing the results of the laboratory's activities and sharing efforts toward standardization in seven countries worldwide.

In addition to those events, we have also publicized our efforts at scientific, technological, and economic conferences and events, including CEATEC, the Society of Automotive Engineers of Japan, and the Circular Partnership EXPO, and have taken these opportunities to exchange opinions with a large number of people.

Grand Design

A Future Where Circulation is Everyone's Job

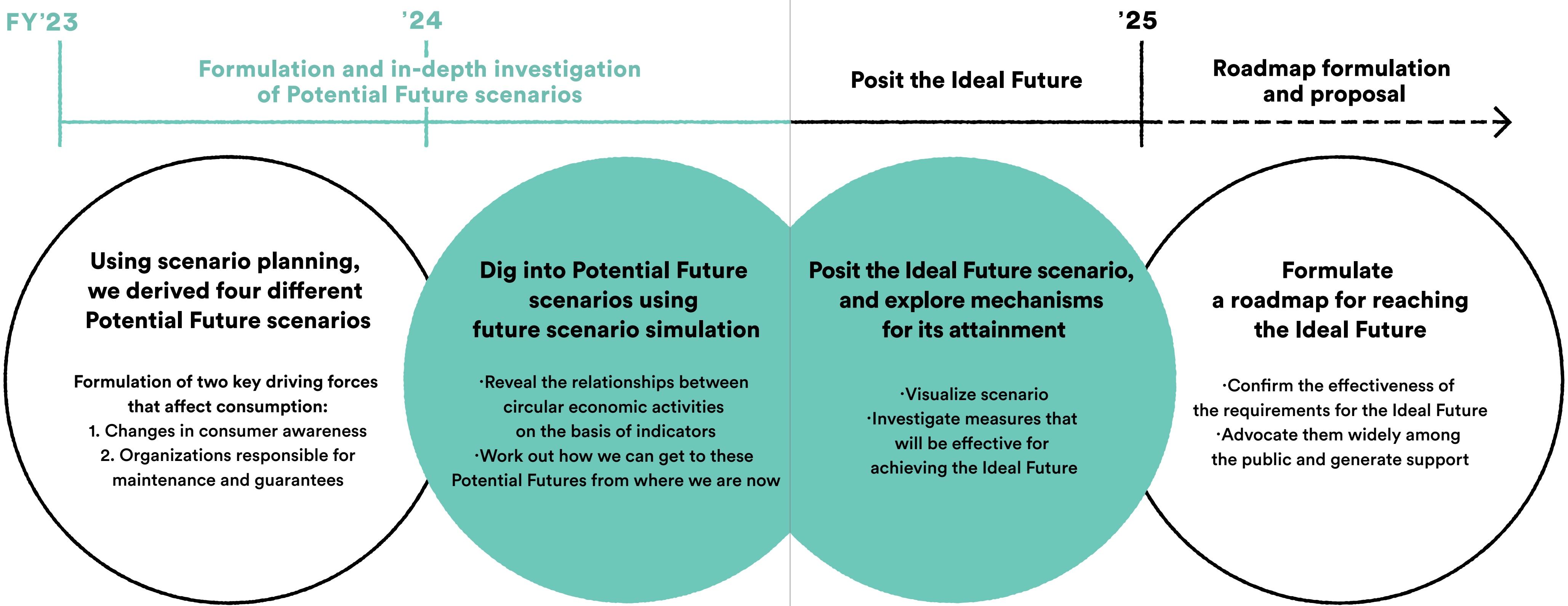
What will the future look like, in the circular economy-based society that is our aim? And what sort of path should we take to reach this future? People with a diverse range of values naturally taking actions that contribute to circulation, and the zero-waste long-term use and reclamation of products. Here, we set out the path to the Ideal Future.



Potential Futures and the Ideal Future

Under the Grand Design research theme, we have been working on formulating Potential Futures and the Ideal Future with respect to the circular economy. By exploring visions for society under a number of Potential Futures that could possibly happen, our goal is to define the future toward which we intentionally want to work and the path to reaching it.

In 2023, we used the scenario planning method to depict four Potential Futures, and arrived at four visions of the future. In 2024, we used future scenario simulation to go into these Potential Futures in greater depth, identified the Ideal Future from among them, and investigated effective measures required for its attainment.



Digging into Potential Futures

How would we reach the Potential Futures depicted so far? What sort of events would occur on the way, and when might they happen?

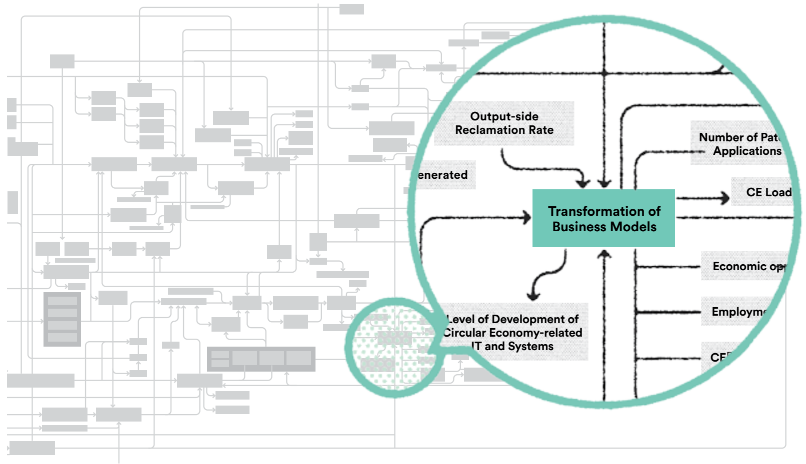
In 2024, we used future scenario simulation in the attempt to find clues to the answers to the above questions, by investigating the causal relationships between events relating to the circular economy and identifying important turning points, while conducting quantitative assessments of social, economic, and environmental key performance indicators (KPIs).

Scenario validation and assessment proceeded according to the following three steps.

1. Information gathering through dialog and modeling
2. Scenario generation by future scenario simulation and identification of turning points
3. Scenario assessment

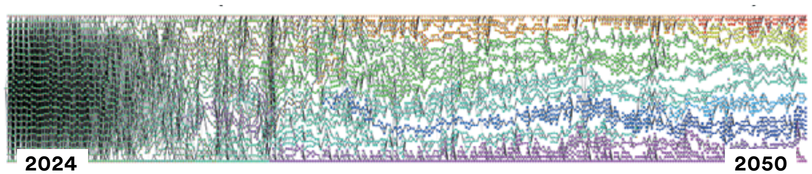
Step 1 | Information gathering through dialog and modeling

First, 391 elements and the causal relationships between these elements were formulated in workshops involving 13 members of the laboratory.



Step 2 | Scenario generation by future scenario simulation and identification of turning points

A total of 20,000 scenarios generated by Monte Carlo simulation were classified into nine groups, and the turning points and divergent factors were reviewed.



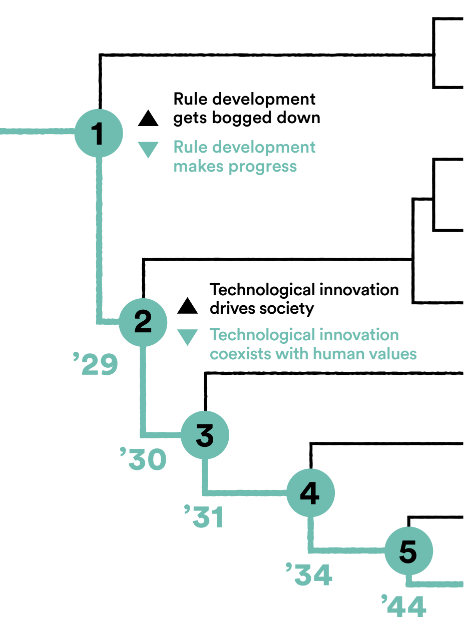
Step 3 | Scenario Assessment

The nine groups of scenarios were assessed on a three-point scale as very good (★★★), good (★★), or poor (★) according to a number of indicators covering resource circulation and environmental, economic, and social aspects, and Scenarios E and I were assumed to depict desirable worlds. The next task is then to ascertain the changes that happen at the turning points in each time period, their timing, and the effects of these changes, in order to achieve the scenarios we are trying to reach.

Scenario E is a future that can be reached if resource reclamation and a number of other technologies, including carbon capture and utilization (CCU) and direct air capture (DAC), can come into operation by around 2030, but whether this is actually technically feasible does perhaps merit further consideration. Scenario I, however, is a future that is reachable by other than technological means, in which circulation is achieved by means including raising consumers' awareness of resource circulation and utilizing repair and other techniques for extending product lifetime.

The scenario we are trying to reach is thus Scenario I, which balances the promotion of circulation well between rules, technology, and individuals, and in which people's efforts toward the circular economy are consistent with their returns.

Change Due to Divergence



Scenario	Assessment	Direction of Potential Future Scenario
A	★	Too late because no progress made on rules
B	★★	Development is delayed, KPI improvement from 2050
C	★★	Progress made in relieving environmental burden but people impoverished
D	★★	Just follow technological support even if this is undesirable
E	★★★	Technology drives the attainment of the environment people want
F	★	Unilateral rules are not followed by anyone else
G	★	People's understanding of the circular economy does not keep up
H	★★	People understand, but don't know how to be involved
I	★★★	**Framework established in which actions and the environment are consistent with each other**

Scenario Summary

- Rule development is delayed, and other KPIs do not catch up
- KPI are good, but technological feasibility may be over-optimistic
- Continued dependence on fossil fuels
- **Major change in consumer awareness**

Requirements for reaching Scenario I

1. Systems and regulations must be developed by around 2030.
2. Repair, remanufacturing, maintenance, and other technologies and services for extending product lifetime are introduced
3. In the 2030s, we must continue to move away from the use of fossil energy and resources as planned
4. Consumers' awareness of resource circulation must be better than at present
5. In the 2040s, frameworks promoting resource circulation (such as "Eco Points") are widespread throughout society

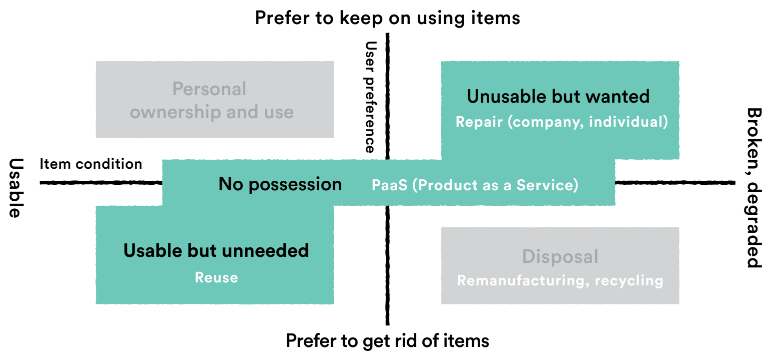
Depicting the Ideal Future

Next came the exploration of the Ideal Future, with the circular economy-based society that is our aim. Here, too, we went through three steps to visualize the Ideal Future and ascertain the requirements for its attainment.

1 Identify the requirements of the future scenario
2 Substantiate & visualize the scenario for the Ideal Future
3 Formulate effective strategies for its attainment

Step 1 | Identify the requirements of the future scenario

We derived the necessary requirements from discussions with seven experts from a range of standpoints, including rules, technology, and human values, regarding the regulations and extended lifetimes required to achieve Scenario I. The results showed the importance of societal mechanisms whereby items need not be lightly thrown away, depending on their condition and the user's intentions, while catering to the preferences of a diverse range of users.



Items rescued by extended-lifespan mechanisms

Step 2 | Substantiate & visualize the scenario for the Ideal Future

A society that promotes circulation by extending lifetime, in which social frameworks take account of the diversity of people's values

Having identified the requirements in Step 1, we posited the Ideal Future toward which were are intentionally heading, as described above. To provide a substantive idea of this future, as a case study we visualized the circulation of small batteries carried by two consumers living in the Ideal Future.

Please watch the movie "A Day in a Circular Economy," which depicts how a day is spent, in a circular economy-based society.

Environmentally conscious
Rina

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

Convenience-focused
Kenji

Happy to use environmentally friendly services that incorporate the natural world in his busy everyday life.

Environmentally conscious Rina has support for regenerating things her way

Mechanism
1

Components made to a standard ecologically friendly design reduce the environmental burden and cost for the entire industry. Environmentally conscious individuals are given options.

“I’ll take my beloved bike to the community center to be customized, and try changing the tires for the recycled ones I chose after talking to an expert!”

Mechanism
2

Used batteries are repurposed in a different sector, depending on the user’s preferences.

“I can’t use this battery for my bike any longer, but it can go to the watering system in the community vegetable garden. With support from the company, the community members and I successfully installed it together!”

Convenience-focused Kenji is induced to recycle without even realizing

Mechanism
3

Digital support for operations that increase economic and environmental value.

“I use a shared electric bike for my commute. If I use my own battery I get points, and when I pedal myself it charges the battery and it’s good exercise for me, so that’s a win”

Mechanism
4

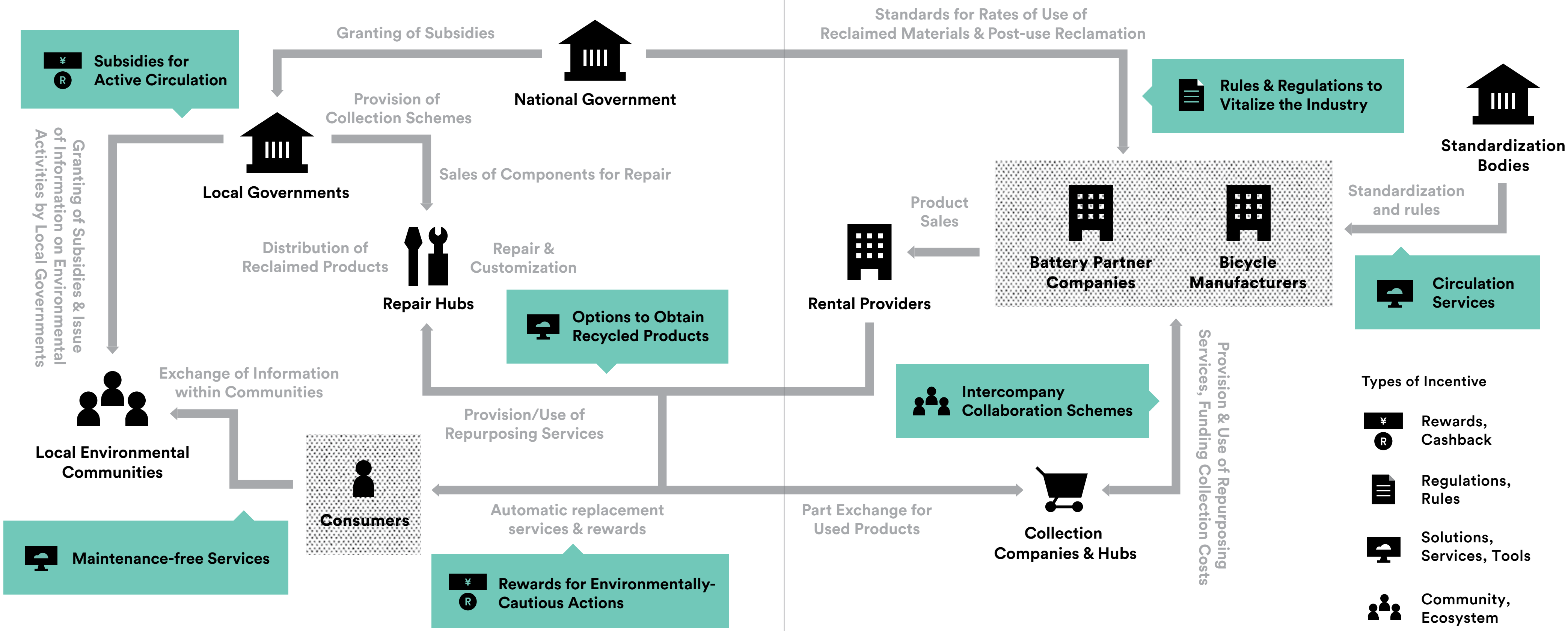
Use status monitoring enables collection while items still have some value.

“It’s great that I can help the environment just by taking out the new battery that’s been delivered to my door and putting the old one back in the box.”

Step 3 | Formulate effective strategies for its attainment

We consider that an effective means of achieving the Ideal Future is to design incentives that can act as driving forces for the origination, actions, and indicators that will be key to arranging circulation. “Incentives” here are not only financial, but are understood in a broad sense to include regulations and rules, services, communities, and other factors that support the acceleration of the circular economy. To make policy proposals that accord with widely varying values, when and at what stage should incentives be brought in, and for which stakeholders? We have brought to light and validated the relationships between people, things, money, and information within the value networks between stakeholders.

A future task is to verify the best points of origin to enable their more effective introduction. Going forward, we will construct a roadmap to the Ideal Future, based on these value networks, and identify specific requirements for the transition.



’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 Potential Futures scenarios.

1 Environmental identity
2 Expanded role for third parties
3 Manufacturer branding
4 Manufacturer-driven decoupling

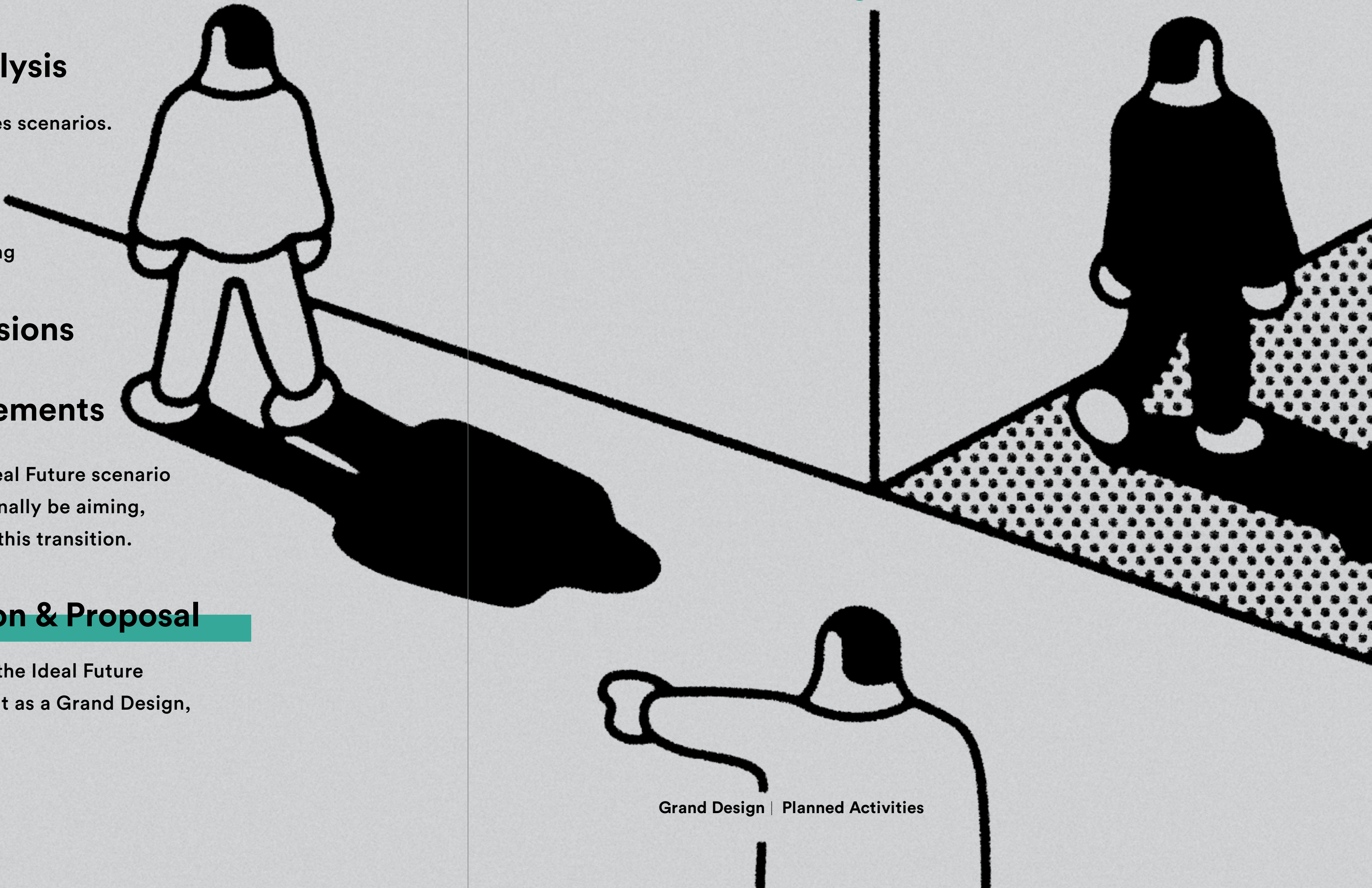
’24 Substantiation of Visions of the Future and Definition of Requirements

Bring to light the dynamic the Ideal Future scenario toward which we should intentionally be aiming, and the conditions for achieving this transition.

’25 Roadmap Formulation & Proposal

Propose a roadmap for reaching the Ideal Future and indicators for its achievement as a Grand Design, and generate support.

By linking the roadmap for the Ideal Future to digital solutions and standardization strategies, we will publicize our Grand Design widely through conversations with a diverse range of stakeholders.



The Circular Economy-Based Society of the Future as Imagined by Today’s Teenagers

Thinking together with the Future Workforce of 2040

What will the world look like once the circular economy has permeated the whole of society?
We asked today's teenagers who will make up the working population in 2040 to answer this question, which has countlessly been bounced back and forth between ourselves.

Co-sponsors	HITACHI-AIST CE Laboratory Hakuhodo UNIVERSITY of CREATIVITY
Collaborators	Amita Corporation, Hitachi Ltd., Seigakuin Junior & Senior High School, Joshi Seigakuin Junior & Senior High School

Together with Hakuhodo University of Creativity we co-hosted a Future Visualization Workshop for current junior and senior high school students, who will be of working age in 2040, with the aims of understanding key factors in the transition to the circular economy and clarifying the motivations for changing values and behavioral transformation on the part of future consumers.

In the workshop, using SF prototyping, we asked 18 junior and senior high school students to imagine gadgets, systems, and occupations that might emerge against the backdrop of the circular economy-based society of the future revealed in our Grand Design.

They also invented stories about how various social issues that might occur in this future could be overcome, such as resource supply sources, sudden power cuts, and newly imposed taxes on waste materials, and depicted four vibrant versions of life in the future.

The freewheeling, unique ideas sparked by the depiction of the Ideal Future by our laboratory may offer suggestions for flexible thinking to encourage the consumers of the future to get involved in the circular economy.

Potential Future Social Issue

If a tax on garbage is imposed, hamburger shops may find it difficult to stay in business. How might the amount of trash be minimized?

The Future as Imagined by Teenagers

1 Reduce trash by introducing a system of discounts for customers bringing their own lunchboxes.
2 Provide edible wrappings made out of rice for customers who don't have their own containers.
3 Give people who don't eat all their food a 300-yen discount coupon if they dig their leftovers into a vegetable plot behind the shop.
4 Use the vegetables grown in the plot fertilized with leftovers as hamburger ingredients in the shop.

Potential Future Social Issue

My family's public bathhouse is struggling to stay afloat! Can the current fashion for the circular economy help put them back in business?

The Future as Imagined by Teenagers

1 The setting is in Yamanashi Prefecture. Reuse the heat from the public baths to generate electricity and supply it to the local community.

2 Provide the leftover hot water from the baths to local orchards for agricultural use. Sell the fruit grown with the bathwater at the public bathhouse to create publicity.

3 Ask customers to pedal bicycles and convert this energy into electricity, too, so the bathhouse also gives them healthy exercise before they clean off in the baths.

4 As a token of thanks for their cooperation, give them discount coupons that can be used in local establishments, helping revitalize the community as a whole.

Potential Future Social Issue

People living on the island of Circleland have a power cut every Monday for emergency maintenance on undersea power cables. How can they secure enough power for 3000 households?

The Future as Imagined by Teenagers

1. The generators and power storage equipment owned by hotels on the island are sufficient to support 1,200 households.
2. A luxury liner moored nearby generates electricity by wind power, which provides enough for 1,300 households.
3. The remaining 500 households draw energy from the solar cars on the island.
4. The islanders use these hotels, passenger vessels, and solar cars every Monday to support their livelihoods.

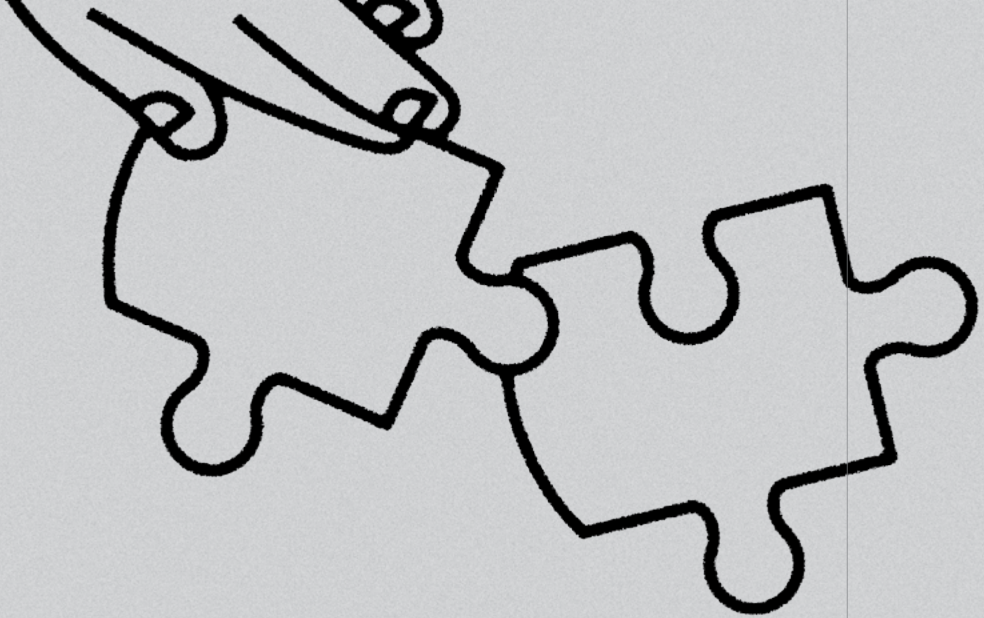
Potential Future Social Issue

The supply of cloth has drastically decreased due to the overseas situation. You want to open a theater, but can’t make the costumes. What happens when you talk to your favorite soba restaurant about the problem?

The Future as Imagined by Teenagers

1 Make fibers for use in clothing using soba as the raw material instead of cotton.
2 Use misshapen vegetables and fruit discarded by farmers as dyes. There are as many dyes as there are types of food, so you can make whatever sort of clothing you want.

Indicators



Individual Efforts Toward a Single Future

Companies and people use different indicators as targets for their individual efforts.

For example, if someone works hard to increase A, this naturally increases B, so that someone else can work harder in turn. However, there is also the risk that if B increases too much, C will decrease. By finding out about these interactions, it should be possible to work together toward a single future despite having different goals.

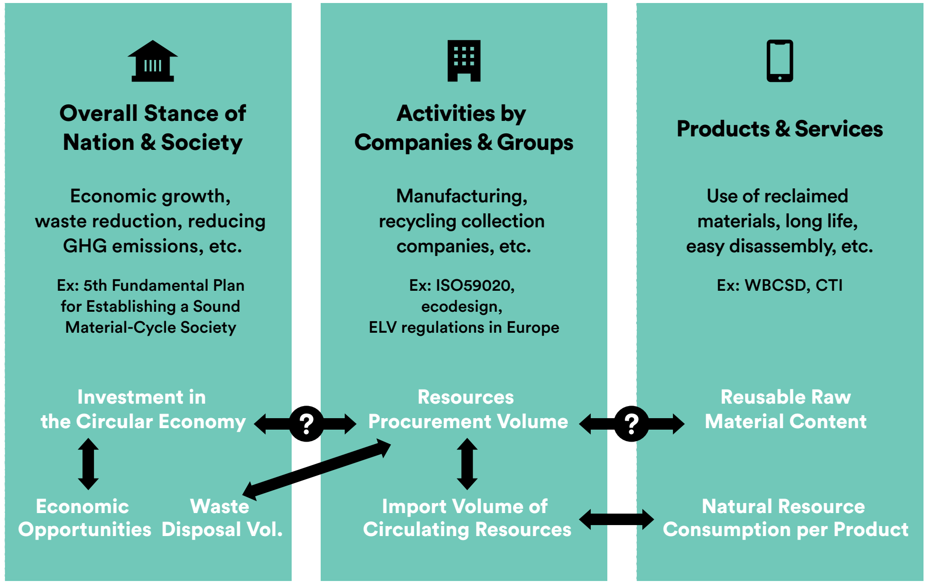
P50
Indicators in the Circular Economy

- Current Situation and Issues with Indicators
- Compilation and Extraction of Indicators
- Classification of Extracted Indicators

P56
Revealing the Relationships Between Indicators

- Review and concrete identification
- Revealing the structural relationships between indicators
- Interactions between indicators and points to note

Indicators in the Circular Economy

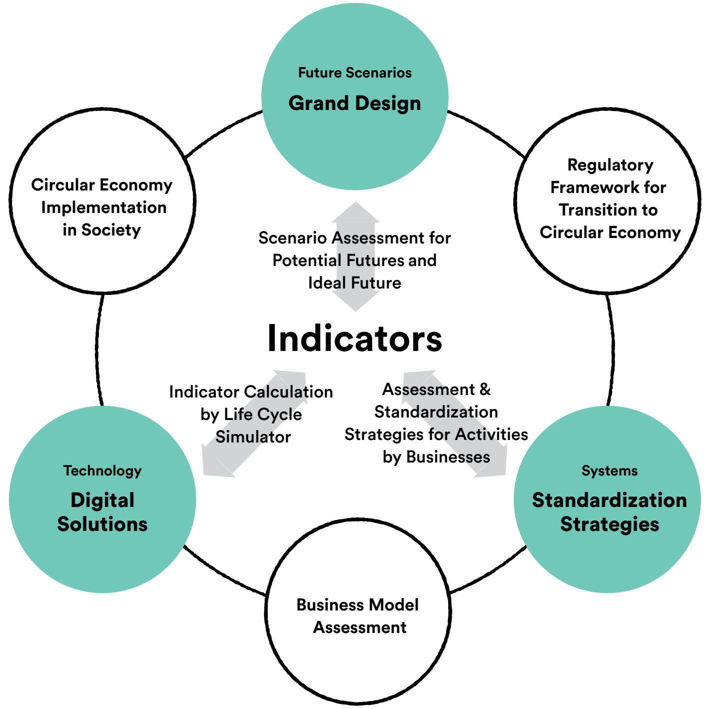


The Current Situation and Issues with Indicators

The circular economy is structurally multifaceted, consisting of a wide variety of initiatives by stakeholders, including not just the national government and society as a whole but also industrial sectors such as the manufacturing and service industries as well as consumers. Under these circumstances, individual countries are pressing ahead with enacting regulations and creating specific indicators with a view to the circular economy.

Choosing suitable indicators is important in order to respond to the various initiatives by different stakeholders. Currently, however, the fact that activities are based on a range of diffe-rent indicators makes it difficult to understand how they can all lead to the Ideal Future as a whole.

We therefore believe that awareness of the relationships between indicators is crucial for the choice of index, and recruited volunteers from among the laboratory members working on each research theme to establish an "Indicator Taskforce."Our aim was not just to conduct research on indicators, but to encourage lively debate within the teams working on each theme by sharing and exchanging opinions. We started this process by compiling an exhaustive list of indicators. These were then classified and review-ed, fundamental indicators that could constitute key indicators for building a circular economy were identified, and their relationships were analyzed. The final goal was to suggest points to note when choosing circular economy indicators.



Compilation and Extraction of Indicators

Information on the circular economy was gathered from sources including the International Organization for Standardization (ISO) and other international organizations, corporate activities such as environmental, social, and government (ESG) reports, national and local government policy materials and action plans, and academic papers, and approximately 1,400 indicators were identified from a total of 34 (types of) resource materials.

Reports on Indicators Proposed by International Organizations

- ISO/CD 59040 Circular Economy PCDS
- UNEP Resource Efficiency
- The OECD Inventory of Circular Economy indicator

Policy Materials & Action Plans by National & Local Government

- Proposed EU ecodesign regulations
- Growth-Oriented, Resource-Autonomous Circular Economy Strategy (METI)
- Resource Circulation Strategy for Plastics

Academic Papers

- A circular economy business model innovation process for the electrical electronic equipment sector
- A taxonomy of circular economy indicators

Corporate & Business Group Activities

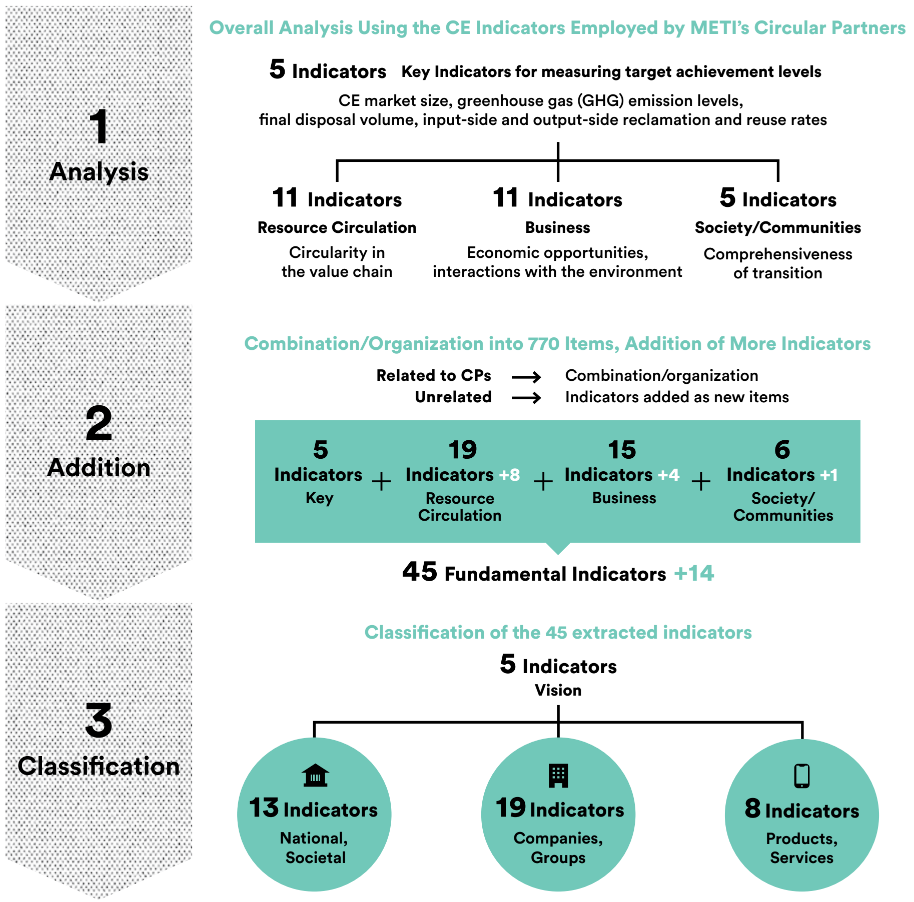
- Company ESG reports, relevant key performance indicators (KPIs) in integrated reports
- Circular Economy Indicators Coalition (CEIC) Circular Indicators Library
- Battery Passport proposals by different organizations

Approximately 1,400 indicators were extracted from 34 types of material, including those shown above

Indicators with similar meanings combined into a single indicator, giving approximately 770 indicators for investigation

This list was then organized into approximately 770 indicators by combining similar items. To investigate the relationships between them, we used the indicators utilized by Circular Partners (CPs), a partnership led by the Ministry of Economy, Trade and Industry (METI) to identify groups for analysis. Those items related to CPs were grouped and a further 14 unrelated items were added, yielding a final total of 45 indicators.

※CPs indicators: Indicators structured on the premise of the forms of the Ideal Future and the the Ideal Future in 2050, based on expert discussion.



Classification of Extracted Indicators

The 45 extracted indicators were classified according to whether they concerned vision, nation/society, companies/groups, or products/services. Five were designated as key indicators capable of directly measuring the status of the Ideal Future: circular economy market size, greenhouse gas emissions in the value chain, input-side reclaimed materials use rate, output-side reclamation rate, and final disposal volume. Many of the added items were classified as concerning companies/groups or products/services, and these have the potential for extension as indicators for assessing a more diverse range of initiatives in industrial fields.

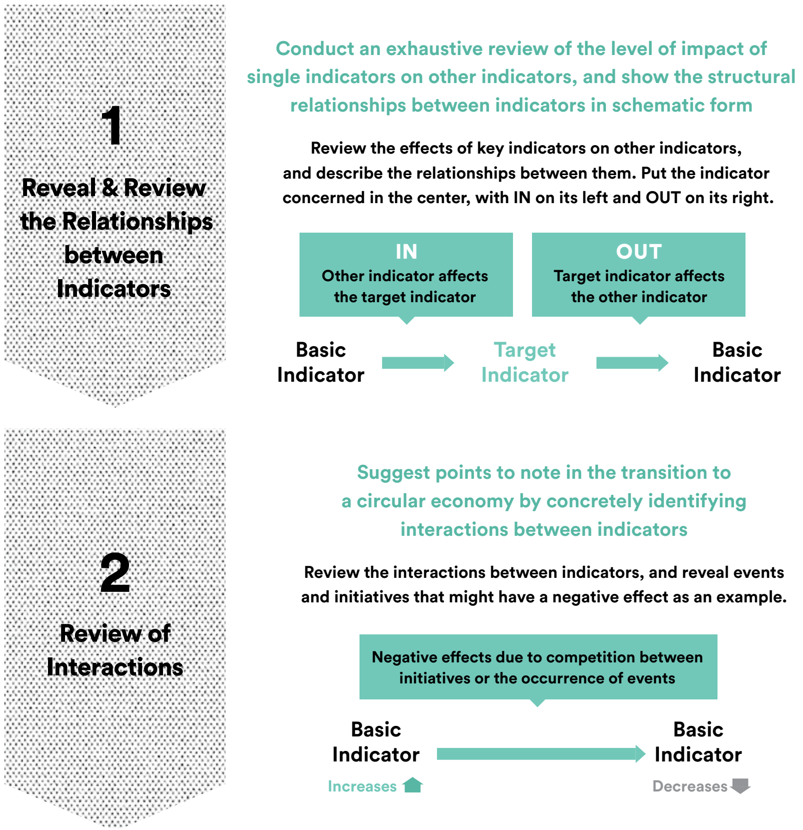
※CE: Circular Economy

Key Indicators	**The Ideal Future (Vision)** #1 CE market size #2 GHG emissions reductions in the value chain	#3 Input-side reclaimed materials use rate #4 Output-side reclamation rate	#5 Final disposal volume
	National, Social	**Companies, Groups**	**Products, Services**
Indicators used by CP's	#15 Waste disposal volume #16 Economic opportunities #17 Market formation and expansion #18 Investment in CE #24 Interactions with the environment #25 Impact on biodiversity #26 Ecological footprint #27 Comprehensiveness of transition #28 Citizens' awareness & behavior #29 Proportion of ethically conscious consumers #30 Employment trends #31 Number of CE-related jobs created	#6 Circularity in the value chain #7 Resource procurement vol. #8 Internal procurement rate of reclaimed materials #9 Product production vol. #10 Resource productivity #11 Input vol. of reclaimed material #19 Number of CE-related patent applications #20 Economic impact of trade #21 Import vol. of circulating resources #22 Export vol. of circulating resources #23 Import vol. of products utilizing circulating resources	#12 Product consumption activity #13 Natural resource consumption per product #14 Waste generated per product
Additional Indicators	#42 Degree of response to local characteristics	#37 Actual resource circulation rate #38 Circular value-added productivity #39 Renewable energy consumption #40 Water circulation rate #41 No. of CE corporations/personnel trained #43 Strategy formulation/initiatives #44 Number of traceability disclosures	#45 Lv. of development of circular economy-related IT & systems #32 Ecodesign adoption rate #33 Critical materials rate #34 Non-virgin raw material content #35 Reusable raw material content #36 Resource recycling feasibility rate

Revealing the Relationships Between Indicators

Organization and Concrete Identification

Our next task was to reveal the relationships between the extracted indicators. The relational framework between indicators was arranged by positioning indicators that affect the provisions of a given indicator A on its IN side, and those affected by A on its OUT side. In some cases, however, this caused problems due to the interactions between indicators. One example, described below, is that pursuing one particular initiative may have a negative impact on other indicators.



The relationships between the five key indicators and the other 40 indicators were reviewed, and listed according to whether they were placed on their IN or OUT sides. This process demonstrated that almost all these 40 indicators were related to the five key indicators in some way.

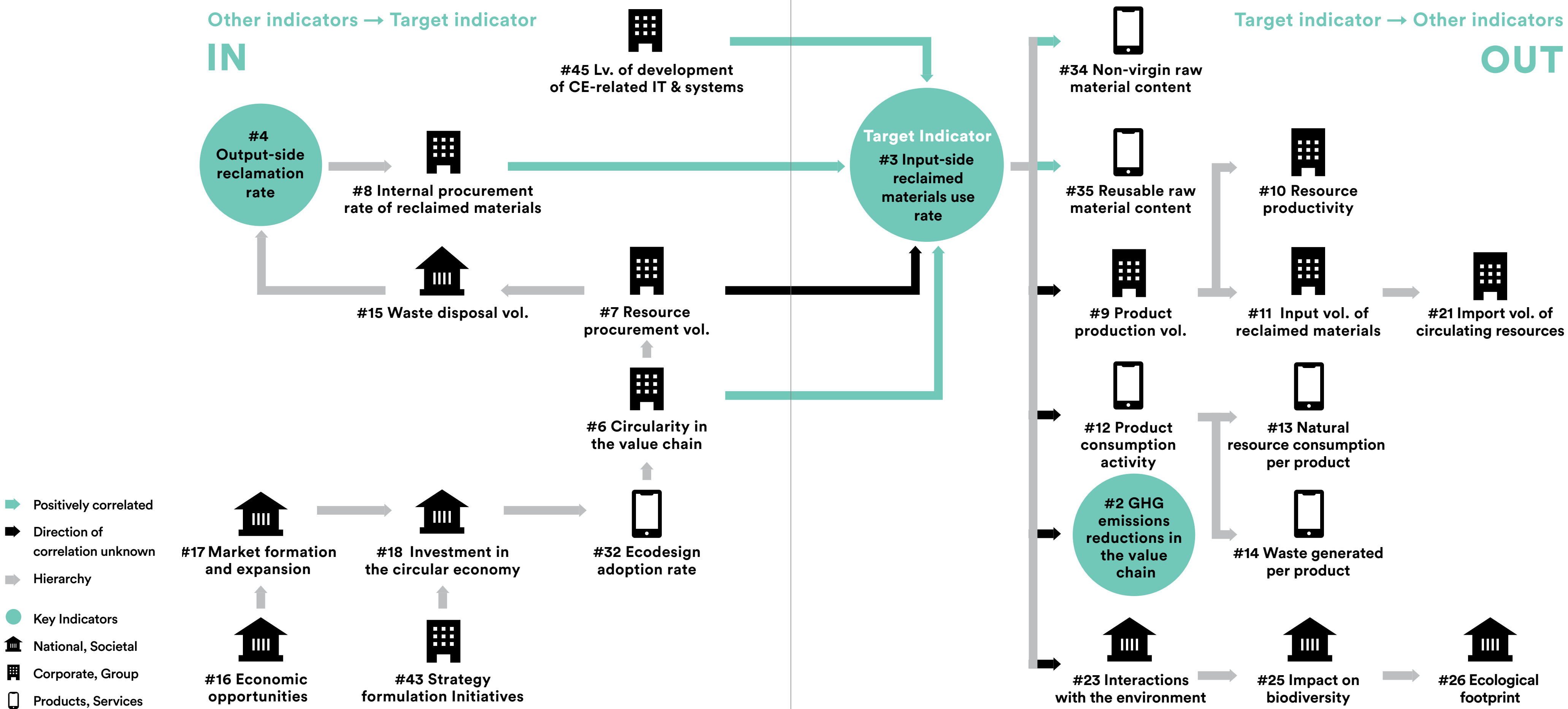
	#1	#2	#3	#4	#5		#1	#2	#3	#4	#5
#6	-	I	I	I	-	#26	O	O	O	O	O
#7	O	I	I	-	-	#27	I	-	-	-	-
#8	O	I	I	O	I	#28	I	-	-	-	-
#9	O	I	O	O	-	#29	I	-	-	-	-
#10	O	I	O	O	-	#30	I	-	-	-	-
#11	-	I	O	O	-	#31	I	-	-	-	-
#12	O	I	O	O	-	#32	I	I	I	I	O
#13	O	I	O	-	-	#33	O	I	-	-	-
#14	O	I	O	O	-	#34	-	I	O	O	-
#15	O	I	I	I	I	#35	-	I	O	O	-
#16	I	O	I	I	O	#36	O	I	-	O	I
#17	I	O	I	I	O	#37	O	I	-	O	I
#18	I	O	I	I	O	#38	I	-	-	-	-
#19	I	-	-	-	-	#39	O	I	-	-	-
#20	O	-	-	-	-	#40	O	-	-	-	-
#21	O	I	O	O		#41	I	-	-	-	-
#22	O	I	-	O	I	#42	O	-	-	O	-
#23	O	-	-	-	-	#43	I	O	I	I	O
#24	O	O	O	O	O	#44	-	-	-	-	-
#25	O	O	O	O	O	#45	I	-	I	I	-

■ Key Indicator ■ National, Societal ■ Companies, Groups ■ Products, Services

I (→IN) Key indicators #1–5 change due to variations in the other indicator
O (→OUT) Other indicator changes due to variations in key indicators #1–5

Revealing the Structural Relationships Between Indicators

As an example, this diagram and table illustrate the interrelations between other basic indicators when key indicator #3, the input-side reclaimed materials use rate, is placed in the center. Currently, however, these relationships are not necessarily quantitative, with qualitative relationships also included. Also, the table only shows the connections between individual initiatives, and interactions with other initiatives should also be investigated in future.



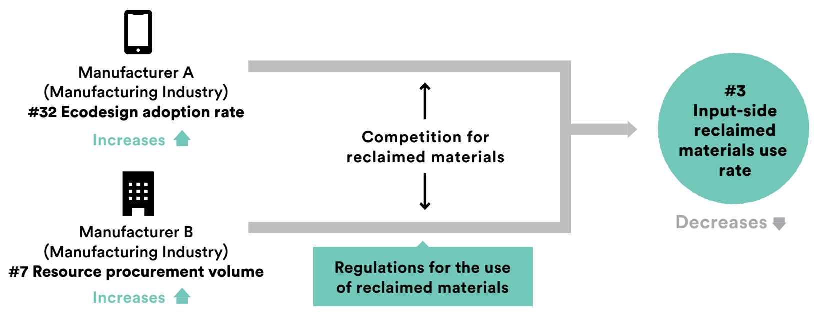
Interactions Between Indicators and Points to Note

As described above, an over-emphasis on certain indicators may in some cases have a negative effect on other indicators.

One example of such a negative effect is the relationship between indicators #32, the ecodesign adoption rate, and #3, the input-side reclaimed materials use rate. For example, if manufacturer A increases the ecodesign adoption rate of its refrigerators, this improves their durability and scalability, so that the manufactured refrigerators have a longer lifetime. At the same time, manufacturer B is increasing the amount of reclaimed materials it uses in refrigerator production. Because it takes longer for the longer-lasting refrigerators to come to be recycled, the supply of reclaimed materials is insufficient, putting A and B into competition with each other, and as a result the input-side reclaimed materials use rate decreases. This interaction demonstrates the importance of considering resource flow in the value chain as a whole, including other initiatives, rather than blindly attempting to increase the ecodesign adoption rate in isolation.

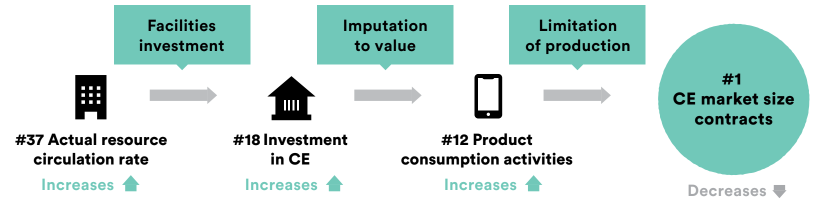
A second example is what happens when #18, investment in the circular economy, is increased with the goal of increasing #37, the actual resource circulation rate, in order to improve #3, the input-side reclaimed materials use rate. Even if new products and services with greater circularity are created, unless the market accepts that they have added value, their consumption will decrease, potentially resulting in decreased production and a smaller market. To resolve this it will be vital to make their value visible and to appeal to users, as well as making business decisions based on quantitative assessments of their cost-benefit ratio and added value.

CASE 1 Extended lifespans due to ecodesign and competition for materials under regulations for the use of reclaimed materials causes a drop in the input-side reclaimed materials use rate



Solution Coordinate with other companies and the value chain as a whole toward the achievement of individual key KPIs

CASE 2 The market does not accept the added value of new circular economy goods and services, so their consumption stagnates and the size of the circular economy market contracts



Solution To transition to the circular economy-based society while maintaining economic performance, use multiple indices to point out the return on investment and added value

Because efforts to improve a particular indicator may thus have negative effects on other indicators, it is therefore important to use other indicators when establishing its impact. This requires being aware of the relationships between groups of indicators and their interactions, and checking multiple indicators. An effective way of achieving a circular economy for society as a whole will be to review not just the effects and scope of individual initiatives, but also the relationships between them via value networks, including the use of simulations.

’24 Extraction and Systematization of Indicators

- Collection and extraction of circular economy indicators
- Reveal the structural relationships between these various indicators

’25 Look into methods of incorporating indicators into the research themes

- **Grand Design:** Look into methods of linking indicators assessing value networks to the design of incentives
- **Digital Solutions:** Incorporate circular economy indicators into life cycle simulators and conduct assessments
- **Standardization Strategies:** Conduct studies with a view to the social implementation of Circular value-added productivity

Reflect the various indicators concerning the circular economy and their structure in the evaluation axes for initiatives in the Grand Design and Solutions, and carry out studies with a view to their implementation in society.

Digital Solutions

Digitization and Quantitative Evaluation of Circulation

For example, what might the best method of circulation be for this product?

We are developing new solutions to encourage voluntary action on the part of corporations and users, by digitizing the life cycle of items and quantitatively evaluating their economic performance and environmental load.

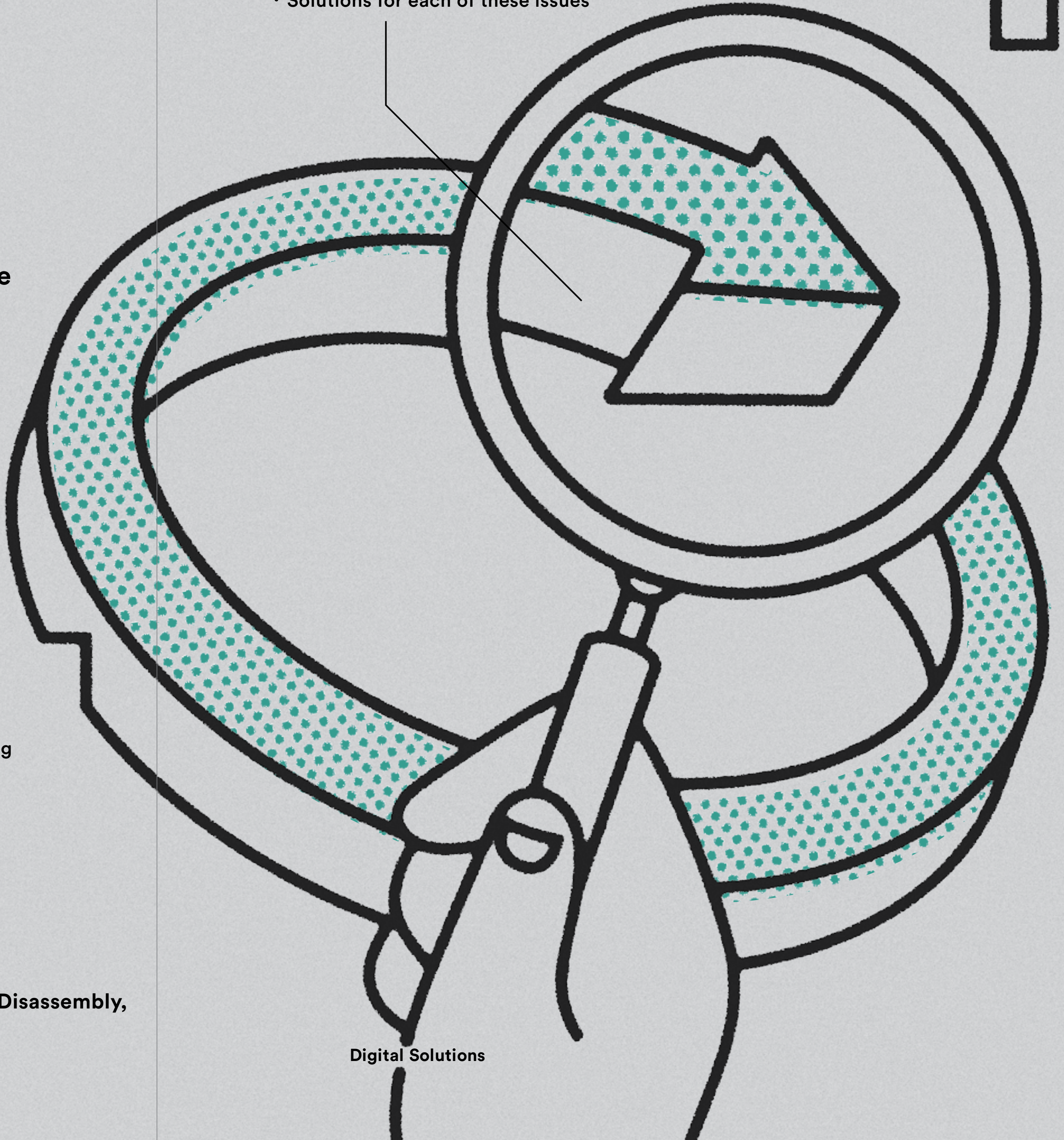
P74
Life Cycle Transparency and Assessment

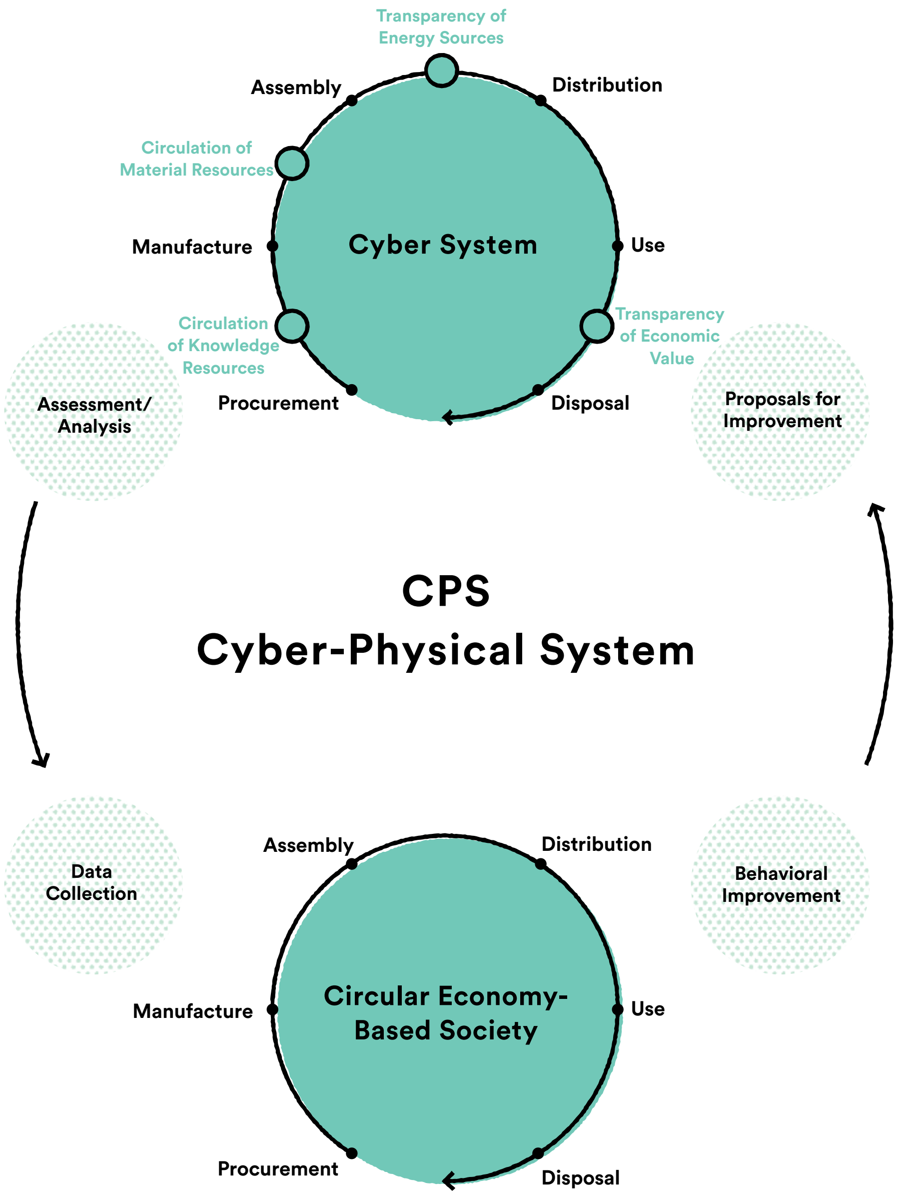
- Case 1: Air conditioner compressor magnet recycling
- Case 2: ATM component reuse

P82
Digitization of the Collection, Disassembly, and Reclamation Process

P68
Cyber-Physical Systems for Optimizing Circulation

- Two basic issues to resolve
- Solutions for each of these issues





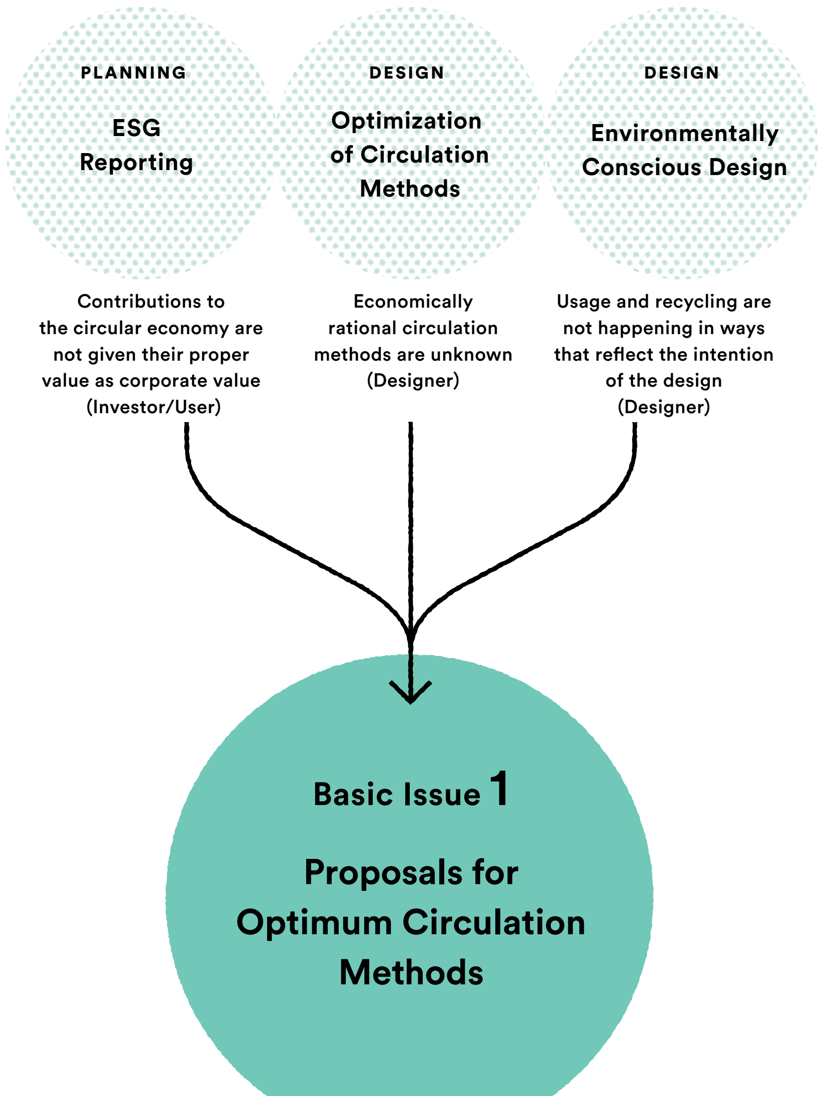
Cyber-Physical Systems for Optimizing Circulation

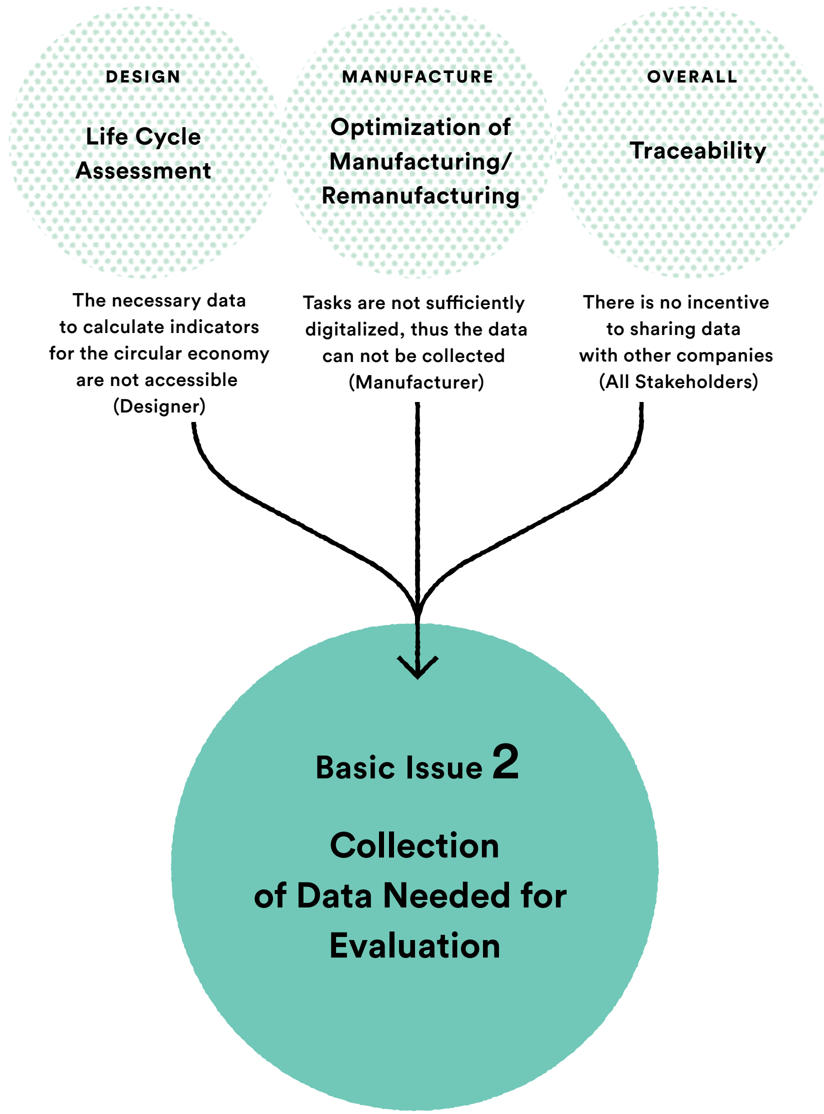
The circular economy cannot be achieved by individual companies alone. Collaborative efforts involving manufacturers, recyclers, consumers, and other stakeholders will be key. Such cooperation between stakeholders requires the construction of value networks that are intertwined rather than unidirectional.

One of the goals of our laboratory is to use digital solutions to construct value networks that encourage voluntary action toward the circular economy, not just by ensuring that the flow of products is transparent but also by properly assessing stakeholders’ actions and providing appropriate feedback. This requires the development of cyber-physical systems to enable a circular economy.

Two Basic Issues to Resolve

We started by holding workshops and other events to put together six use cases for cyber-physical systems, based on the stakeholder behavior required to achieve our aim of a circular economy.





We then conducted interviews and other surveys within Hitachi to identify and explore the issues faced by stakeholders in making these use cases realistic, which led us to the following two basic issues to be resolved.

Solutions For Each of These Issues

ISSUE 1

Solution 1

Life Cycle Simulator

Modeling the flow of products and tasks, and assessing circular economy indicators and economic value

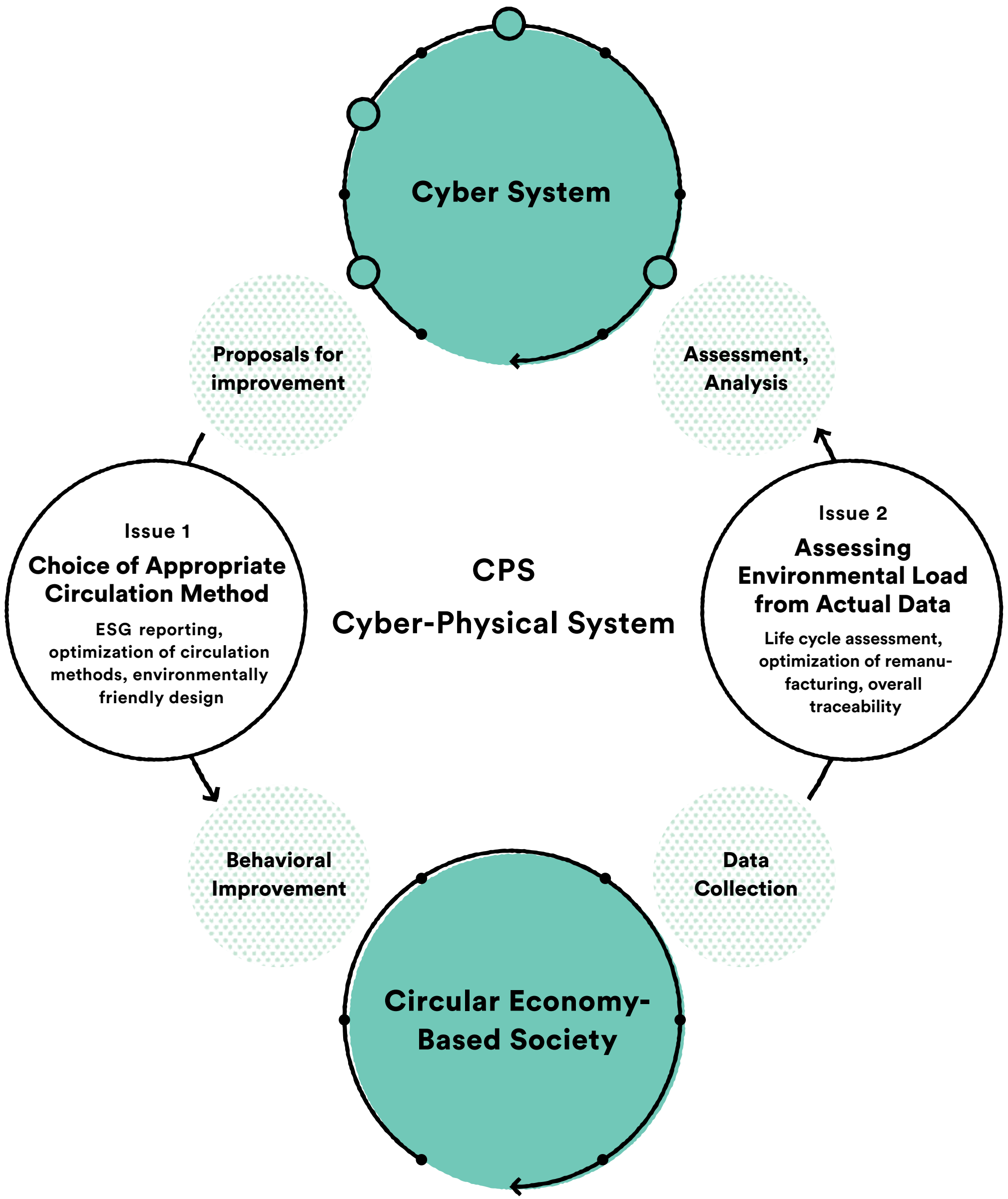
ISSUE 2

Solution 2

Downstream Digitization

Digitizing collection, disassembly, and reclamation, which are crucial to the circulation of products

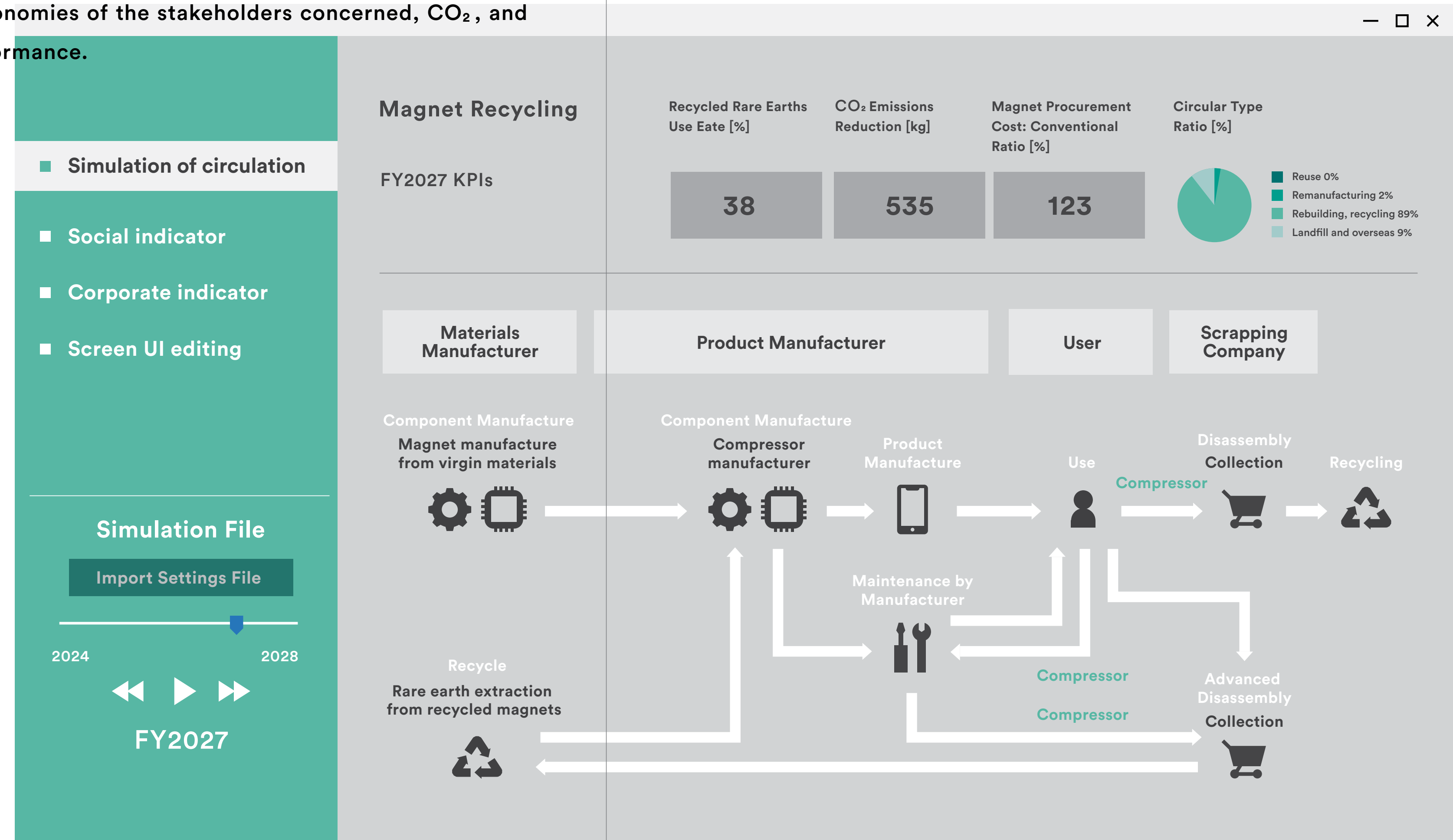
We are now developing solutions that will resolve these two issues, which we will use to construct cyber-physical systems that will drive the development of value networks to enable a circular economy.



Solution 1 | Life Cycle Simulator

Life Cycle Transparency and Assessment

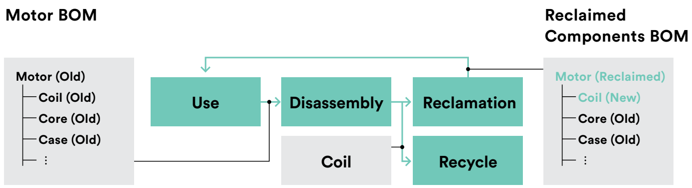
This simulator models product life cycles, analyzing the material flows involved and their associated inflows and outflows of CO_2 and money. The aim is to optimize life cycles and processes by conducting quantitative analyses of the life cycle as a whole, the circular economies of the stakeholders concerned, CO_2, and economic performance.



One of the features of this simulator is that it because uses data in bill of materials (BOM, a list of components and structural elements in a product) format, it can analyze circulation at the product and component levels simultaneously in a single model. Another is that the unified indicator calculation method using material flow and primary units means that indicators can be flexibly interchanged. We are also creating libraries based on actual case studies, to simplify and speed up the settings for models and parameters that pose issues for its actual use. Our initial aim is to accumulate knowledge,

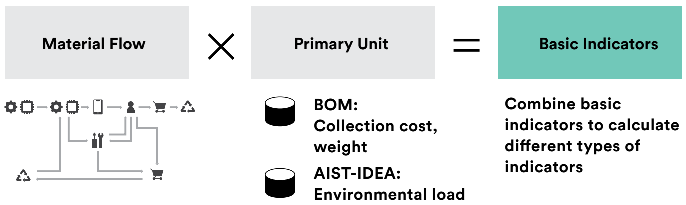
Feature 1

Simultaneous analysis of circulation at the product and component levels using BOM-format data



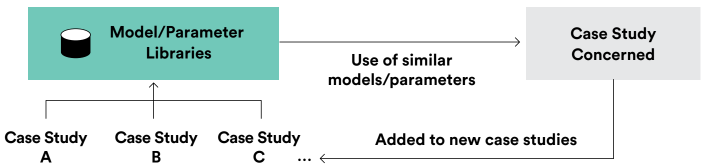
Feature 2

Unified indicator calculation method using material flow and primary units means that indicators can be flexibly interchanged

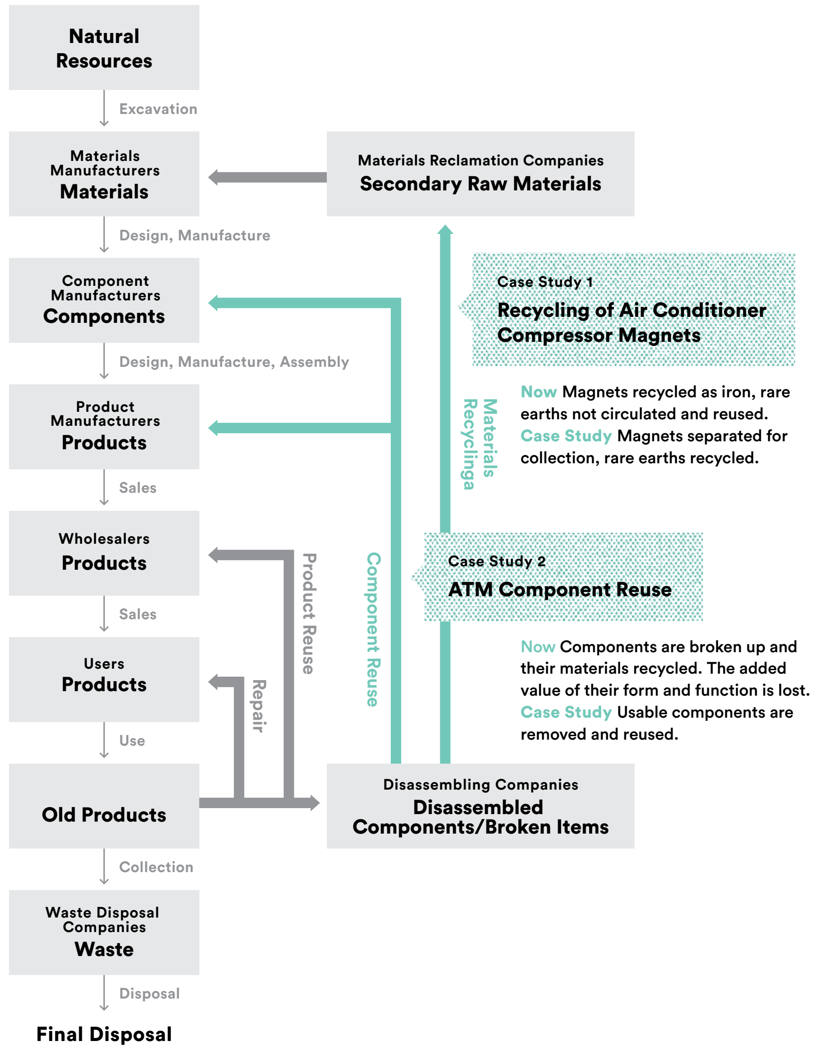


Feature 3

Creating libraries of models and parameters to simplify and speed up analysis



with a focus on case studies from Hitachi, in order to develop a more realistic simulator. Using this simulator means we will be able to assess actions for improvement in quantitative terms, enabling us to suggest highly effective solutions. Here, we describe two case studies for which this simulator was actually used.



Solution 1

Case 1 | Recycling of Air Conditioner Compressor Magnets

We analyzed and compared two patterns of initiatives for circulating the rare earths contained in air conditioner compressors.

Now The magnets in used air conditioner compressors are recycled as iron, and the rare earths they contain are not circulated and reused.

Initiatives In magnet recycling initiatives, materials manufacturers, product manufacturers, and disassembling companies collaborate to build a value network and achieve the circulation of rare earths.

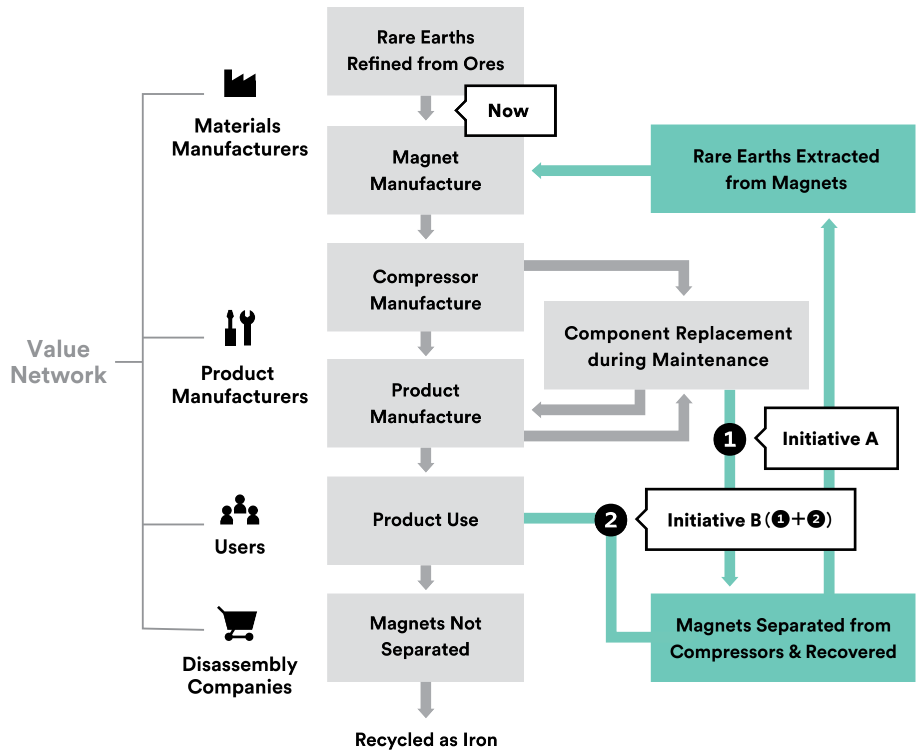
A Magnets are separated and recovered from compressors collected for maintenance, and their rare earths are extracted and reused in magnet manufacture.

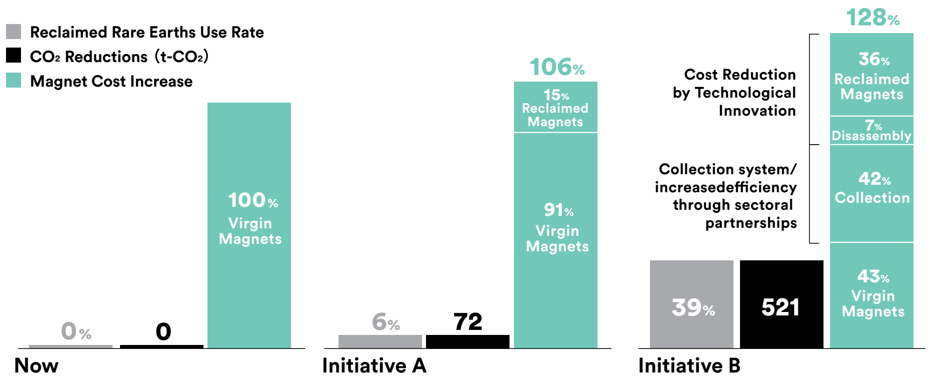
B In addition to Initiative A, magnets are also collected from used products, with the aim of increasing the amounts of rare earths in circulation.

Results The reclaimed rare earth use rate and CO_2 reductions are increased by rare earth circulation, this effect is greater in Initiative B due to the larger amount of materials involved, and the environmental values of both resource circulation and energy reduction increase. From the economic standpoint, however, rare earth circulation leads to increased costs. This is because the cost of recycled magnets is higher than that of virgin magnets. An analysis of the cost structure of the recycled magnets in Initiative B showed that reclamation/disassembly and collection account for around half each.

※This result is our own estimate using parameters drawn from business studies by the Hitachi Group.

Proposal In addition to reducing the costs of reclamation and disassembly through technical innovation by manufacturers and recyclers, it will also be necessary to make collection more efficient, and this will require efforts including collection systems and sectoral partnerships.





Solution 1

Case 2 | ATM Component Reuse

We used simulations to evaluate an initiative to reuse components from the ATMs installed in banks and convenience stores.

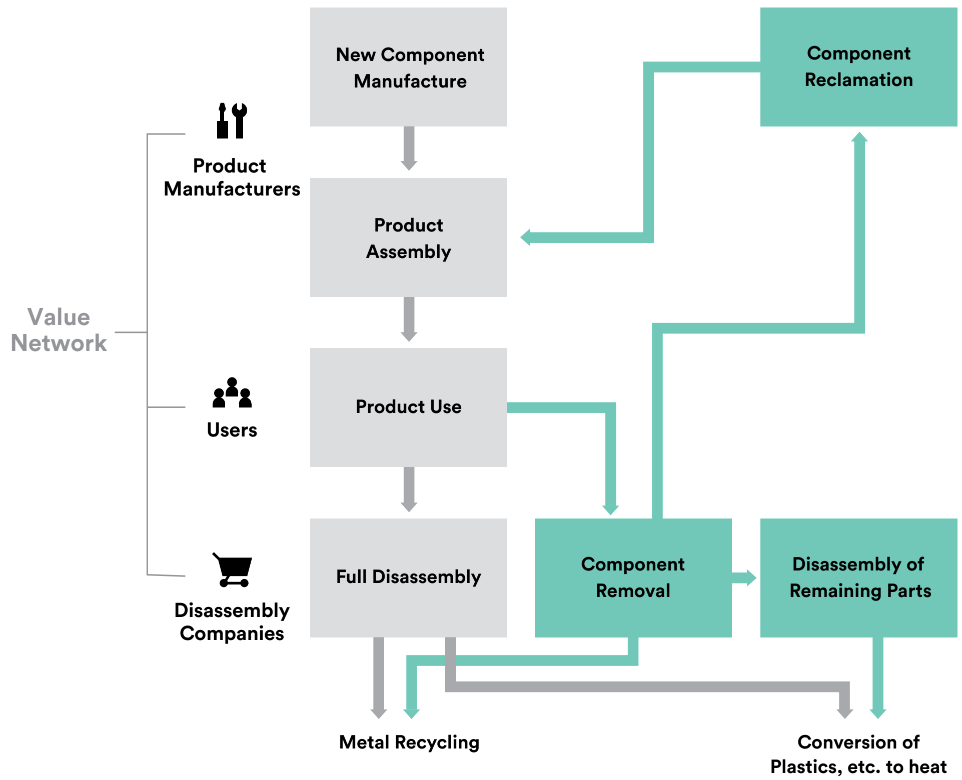
Now Recovered ATMs are dismantled by disassembly companies, their metals are recycled, and their plastics and other components are used as fuel for heat collection.

Initiatives Components are removed by disassembly companies working in partnership with manufacturers, and these are reclaimed by the manufacturers and their quality assured for use as components of new ATMs.

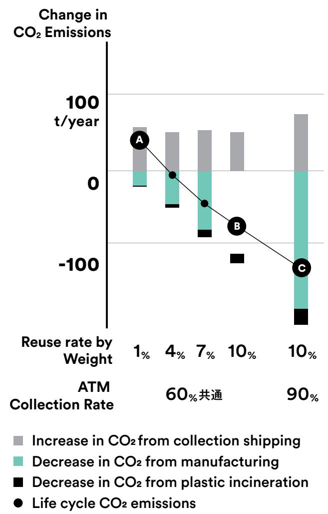
Results Reusing components means that fewer new components need to be manufactured, reducing new resource input. However, the current reuse rate of 1% by weight actually increases CO_2 emissions. This is because the increased CO_2 generated by shipping in the collection process outweighs the effect of reducing new component manufacture.

※This result is our own estimate using parameters drawn from business studies by the Hitachi Group.

Proposal Increasing the types of components that can be reused could tilt the balance of energy input and output toward reduction. Increasing the collection rate would also have a major effect in improving environmental and economic effectiveness.



	Economic Effectiveness of Value Network (Ratio of Increase)	New Resource Input (t/year)	Life Cycle CO_2 Emissions (t/year)
Now Reuse rate by weight 1% ATM collection rate 0%	1	↓ -4	↑ +40 Ⓐ
Proposal 1 Reuse rate by weight 10% ATM collection rate 60%	↑ ×2.2	↓ -41	↓ -79 Ⓑ
Proposal 2 Reuse rate by weight 10% ATM collection rate 90%	↑ ×3.6	↓ -61	↓ -126 Ⓒ



Solution 2 | Downstream Digitization

Digitizing the Process of Collection, Disassembly, and Reclamation

Expressing the entire life cycle in digital form requires base units for downstream processes (the post-use side, sometimes known as "venous processes"). Distinguishing between product models and modeling base units at the process level, in order to be able to handle multiple product models and processes, is achieved via three steps.

1. Acquisition of data linked to type, and database construction
2. Creation of base units for downstream processes by combining process-level base units from the database
3. Use these base units in life cycle simulations and propose appropriate circulation methods for products

Step 1
Acquisition of Data Linked to Product Models

Used Product → Disassembly → Reclamation

Database

Feature 1 of Downstream Processes: Multiple Product Models

Automated Distinguishing Between Product Models

Feature 2 of Downstream Processes: Multiple processes

Process-Level Data Measurement

Creation of a database for data (electricity consumption, etc.) linked to each product model and process

Step 2
Conversion to Base Units

Use combinations to create a series of base units for downstream processes

Example: Compressor disassembly process

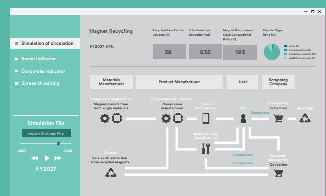
Shipping → Cutting Up → Component Collection → Demagnetization → Component Collection

Model base units for each process using the database from Step 1

	Shipping	Removal	Component Collection	Drying		
		Cleaning	Cutting Up	Electrical Discharge	Demagnetization	
		Sorting				

Step 3
Utilization
(Improved Simulation Accuracy)

- Quantitative evaluations of economic and environmental indicators, using the base units for upstream/downstream processes
- Proposals for appropriate circulation methods for the products concerned based on quantitative data



Based on Step 1, we are currently proceeding with development and validation, working on studies of actual cases to achieve Step 2.

To create sophisticated base units for each type of product and process, an automated system must be developed that automatically distinguishes between product models based on their external appearance, and automatically measures the electricity consumption from equipment operation in each process. We are developing technology that automatically distinguishes the product model based on shape features taken from images of used products and their labels and using remote sensors to measure the electricity consumption by the equipment used in each process, in order to assess the environmental load per process.

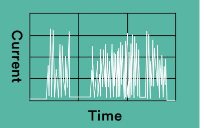
Using technology developed by NEDO-PJ

Automatically Distinguish Product Models

Use shape features and labels/identifiers to distinguish product models

Build a system using AIST's own technology

Automatically Measure Electricity Consumption



Attach a current clamp to the outside of the distribution panel, and make automatic measurements remotely via wireless sensors

Measurement Results

Daily electricity consumption (kWh/day) for each process in disassembly

Case Cutting	Rotor Removal	Demagnetization	Coil Removal
2.8	1.0	8.8	6.5

’22 Definition of Issues

Identification of use cases through workshops, and definition of issues to be resolved with a view to implementation.

’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, and laying the foundation for data collection through the “downstream digitization.”

’24 Development and Validation of Core Technology for Solutions

- **Life Cycle Simulator:** Conduct validation of two case studies. Confirm the potential for evaluating and selecting strategies to improve economic and environmental performance on the basis of the results of quantitative analysis.
- **Downstream Digitization:** Promote digitization with the aim of creating base units for downstream (post-use) processes, in order to assess the actual status of the environmental load throughout the value chain.

’25 Validation of Values in Real-World Examples and Extension of Functions

- Construction of a cyber-physical system integrating the life cycle simulator and downstream digitization
- Quantitative demonstration of the validity of the Grand Design and Standardization
- Collection of case studies and circulate knowledge via partnership formation

Form partnerships and expand the functions of solutions, while validating the value of actual case studies of a wide variety of types of circular economy.

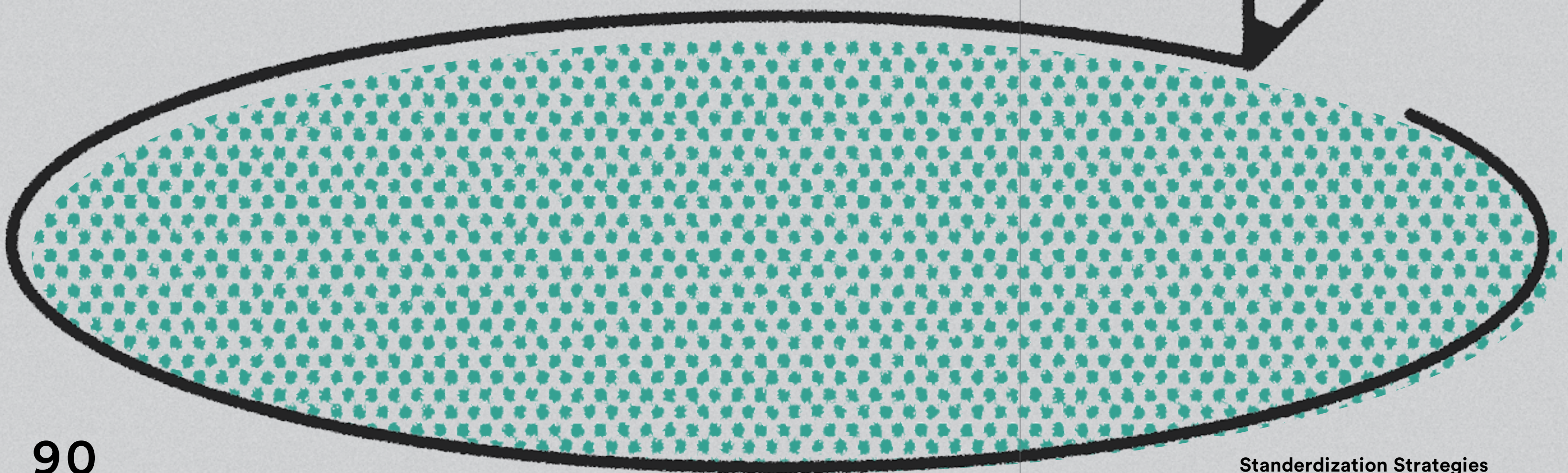
Standardization Strategies

Making Value Visible in the Right Way

Movements are already underway in global rule-making for the circular economy. However, rules should never be decided once and for all, but must be updated and improved to make society even better. We are proposing ways of making value in the circular economy visible in the right way and assessing it properly.

P92
Strategies for Rule-Making

- Japanese issues from the viewpoint of international standardization
- “Offensive” and “defensive” strategies
- Global map of standardization trends



P96
Making the Value of Circulation Visible

- Making value visible 1: Circular value-added productivity
- Making value visible 2: Standardization of grading
- Coordination with relevant institutions

Strategies for Rule-Making

Japanese Issues from the Viewpoint of International Standardization

Japan is a world leader in the circular economy through its environmental activities in terms of the three Rs (reduce, reuse, recycle). However, with Europe now taking the initiative in the international standardization of the circular economy, there are concerns that rules may be imposed that are disadvantageous for the Japanese economy. If Japan is to achieve sustainable economic development, it is essential that it take a proactive stance in rule-making.

Issues

There are concerns that if Japan is unable to keep up with the European-led transition to the international circular economy, rules may be made that are to its disadvantage.

- Japan has led in environmental activities in terms of the 3Rs, underpinned by a high level of public awareness
- Europe is now taking the initiative in standardization, causing concerns about the domestic effects of this in Japan, and a proactive response to this trend is required

Measures

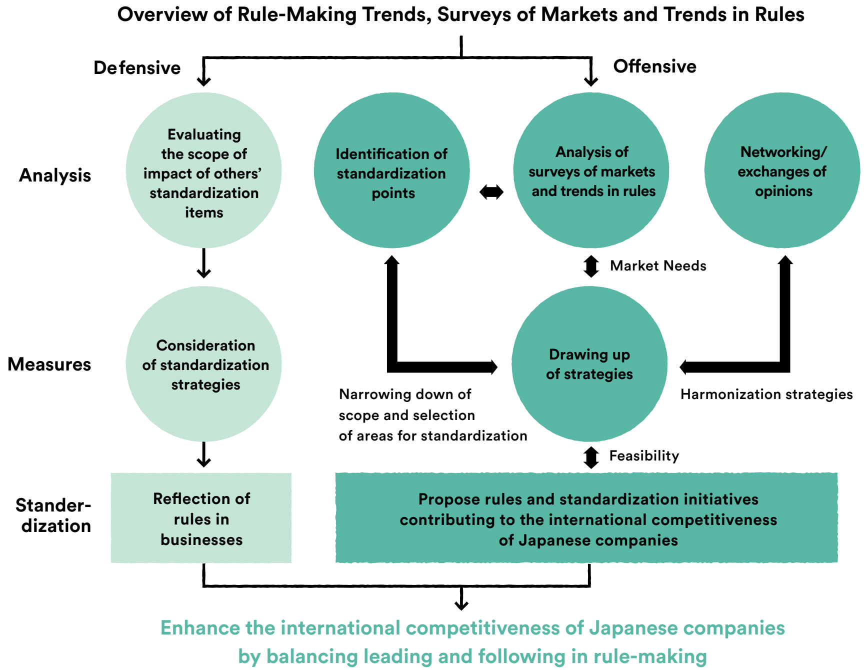
Japan must do its best to take effective action toward international standardization, in order to achieve global sustainable growth in the circular economy

For Japan to drive forward its intentions, we need to understand the full picture of European-led policies and standardization, analyze individual activities, and choose genuinely effective actions that contribute to the international competitiveness of Japanese companies

"Offensive" and "Defensive" Strategies

We are therefore drawing up"offensive" and "defensive" rule-making strategies for the circular economy that will contribute to the international competitiveness of Japanese companies. We are considering measures based on the results of analysis of the current situation, and will link these to standardization activities.

"Offensive" Standardization Strategies: Taking the initiative through Japanese-initiated rules and standards, with the aim of standardization that disadvantages neither Japan nor other countries.
"Defensive" Standardization Strategies: Incorporate European trends related to the circular economy into Japanese businesses as early as possible.



Global Map of Standerdization Trends

To assess the current situation, we produced a block diagram summarizing overall global rule-making trends relating to the circular economy and are updating it as required. This block diagram has been organized so that the characteristics of each region are highlighted from both the cyber and the physical viewpoints.

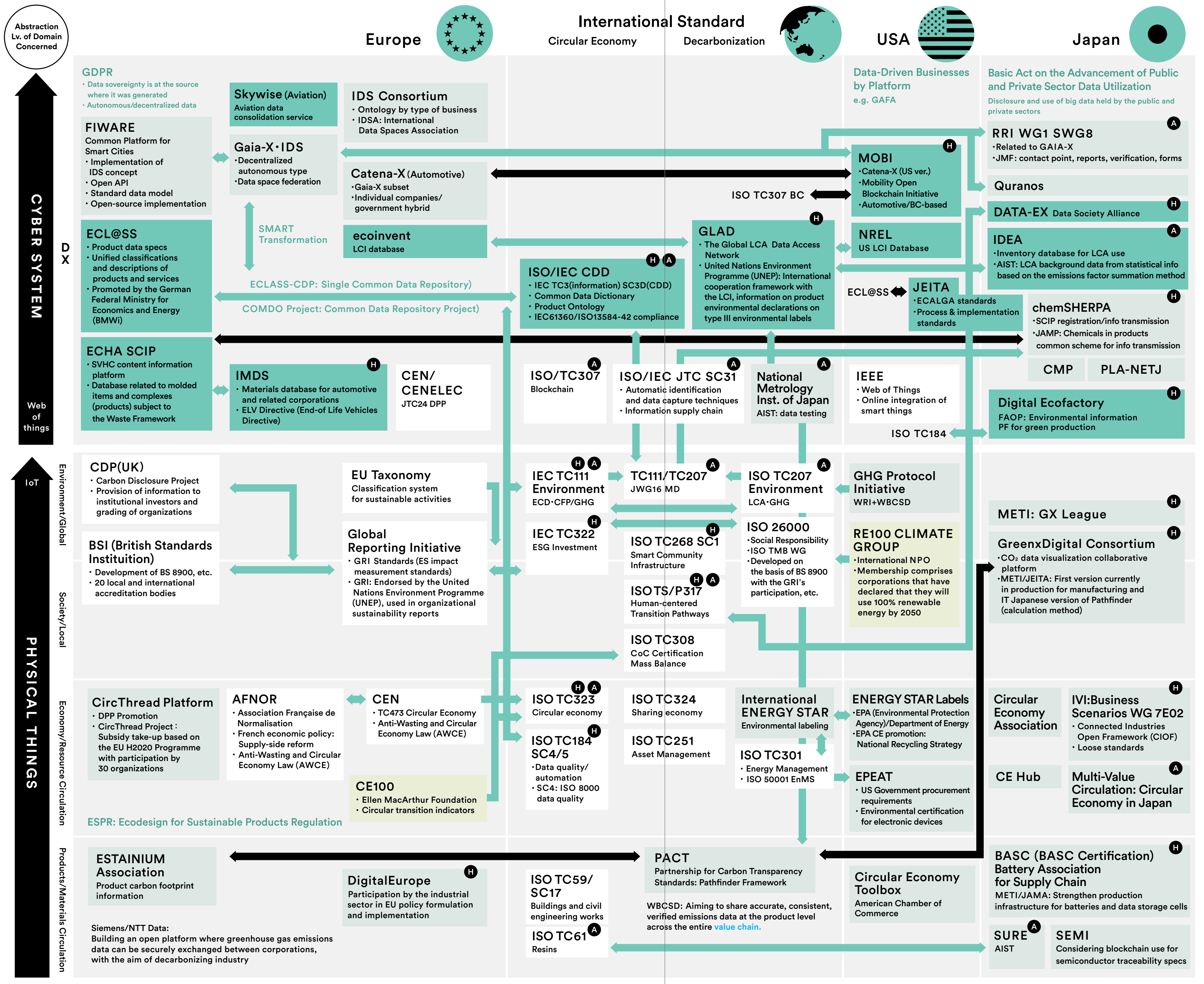
The objective of this overview assessment of worldwide trends is its use in the formulation of strategies and tactics with a view to the social implementation of business models and digital solutions.

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

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

Legends

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



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

Concerns

- Europe is ahead in terms of data space preparation, and is taking the initiative in rule-making concerning data sovereignty, access rights, and Digital Product Passports (DPPs).
- Data federation with Europe may be disadvantageous to Japan.

Findings

Efforts to connect the cyber and physical worlds are lacking.

Opportunities

- The international standardization of the online Common Data Dictionary (CDD) may be a chance for Japan to seize the initiative.
- The debate on the use of DPPs is also gaining traction in Japan.

Measures

- In the International Organization for Standardization (ISO)/TC323, a technical committee (TC) discussing the circular economy, it may be possible to take the approach that the connections between the cyber and physical worlds are still weak, and there is a need to be visualized.
- With ISO/TC323 as the main pillar, strengthen networking channels through standardization in collaboration with other TCs.

Making the Value of Circulation Visible

As a result of our analysis of the current situation, we are now prioritizing efforts to “make value visible” in our laboratory. Having taken a hard look at the value networks linking manufacture, use, collection, crushing and sorting, and conversion to basic materials, and the investors and other stakeholders that stand outside them, we decided to focus on the following two forms of value.

The first is the value generated by companies contributing to the circular economy. The indicator for standardization is circular value-added productivity. Presenting this value to investors and others outside the value network will improve the lack of incentives for companies and encourage “smart” contributions to the circular economy. The second is the residual value of materials needed by the demand side, also termed “grading.” This should enable the proper appreciation of usable components and products that have until now been thrown away, encouraging their reuse. Making visible the quality of reclaimed materials for which there was a mismatch between supply and demand will promote the supply of suitable raw materials according to their uses.

Making Value Visible: 1
Circular Value-Added Productivity Indicator

Issue Conventional indicators do not address the cost-effectiveness of circulation, and do not illuminate the significance of efforts for downstream-side companies after “Use”

Solution Encourage “smart” contributions to the circular economy by using an indicator that brings to light the increased efficiency of circular investment

Making Value Visible: 2
Grading

Products, Components

Issue The residual value of materials is not properly appreciated, and they are permanently disposed of or thrown away

Solution Increase supply in line with residual value by bringing to light residual functions/lifespan

Materials

Issue Concern that the mandatory use of reclaimed materials would cause a mismatch between supply and demand

Solution Make visible the quality (purity/homogeneity, hazardous material content, etc.) of reclaimed raw materials, enabling coordination of the supply of raw materials in accordance with their use

Circular Value-Added Productivity

We started by considering standardization policies for the “Circular value-added productivity” indicator. Taken together with existing economic indicators, this new indicator could constitute a rule for promoting the circular economy.

For example, the existing economic indicator of circular material productivity is calculated by dividing revenue by the amount of linear resource inflow. Because this indicator can be improved either by decreasing linear resources or by increasing the amount of reclaimed resources, it helps promote the use of reclaimed materials, but has problems of its own.

The use of reclaimed materials entails additional costs and facilities investment, but this index takes no account of this point, and because the numerator is “revenue” rather than “profit” there are concerns that it may lead to narrower profit margins by encouraging the use of reclaimed materials even this means a decline in profit. This may place manufacturers, and Japanese industries that are heavily dependent on these manufacturers, at a disadvantage.

We have devised an alternative indicator in our laboratory, which we term “Circular value-added productivity,” by combining existing economic indicators. This indicator is calculated by dividing the value added to business by the expenditure on circulation, and thus shows the amount of added value created with respect to cost, assessing the cost-performance of circular economy projects. This will encourage concentrated investment in highly efficient social systems and facilities, increasing value-added productivity throughout the value network. Because GDP is the total added value of the nation as a whole, it should also contribute to GDP growth. Because this formula is not resource-based, it enables the evaluation of a wide range of circular economy schemes, including those that do not involve the use of reclaimed materials, such as extending the lifetime of equipment and materials collection.

Existing Economic Indicator Circular Material Productivity

Indicator that increases with greater use of reclaimed materials, but takes no account of profit

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

Numerator	Lack of sensitivity to costs means that narrower profit margins may be needed to improve this indicator
Denominator	The main measure for companies mainly engaged in product manufacture is the use of reclaimed materials. In this case, costs cannot be passed through to purchase values and product prices, this risks decreasing profits and suppressing growth

R_{CMP} | Circular Material Productivity
One of the economic circular economy indicators from WBCSD CTI4.0, ISO59020

+

New Proposed Indicator Circular Value-Added Productivity

Promotes investment in social systems and facilities that generate major added value in a highly efficient waybut takes no account of profit

$$R_{CMP} = \frac{\text{Value-added* from Circular Economy Activities}}{\text{Expenditure for Circular Economy Activities}}$$

Effects
- Assesses the amount of added value generated with respect to cost, and the cost-performance of circular economy business
- Encourages concentrated investment in highly efficient social systems and facilities, increasing value-added productivity throughout the value network and leading to GDP growth
- Also assesses contributions to the circular economy other than reclaimed materials use (e.g., extending lifespan and collection)

R_{AP} | Circular Value-Added Productivity, *Value-Added = revenue - costs paid to other companies (intermediate input)

New Proposed Indicator Circular Value-Added Productivity

$$R_{CVP} = \frac{\text{(a) Value-added}^{※1}\text{ from Circular Economy Activities}}{\text{Expenditure for Circular Economy Activities}}$$

(b) Portion Used Up Completely

Equivalent to variable costs of raw materials/collection of unused things

Portion equivalent to the variable costs out of the sales costs of products, etc.

+

(c) Portion of Reuse or Longer Use

Equivalent to losses on tangible fixed assets such as facilities

Amount of facilities investment in product production, etc. ÷ statutory service life ÷ actual lifetime indicator※2

※1 Value-added = Revenue – Costs Paid to Other Companies (Intermediate Costs) ※2 Actual Lifetime Indicator = Actual Lifetime of Product ÷ Mean Lifetime of Product (One of the WBCSD Circular Transition Indicators) ➡ Direction for Improving the Indicator

Increasing Residual Value

(a) **Increase added value through more advanced reclamation technology**
Increases residual value, increasing the numerator

(b) **Make the reuse, remanufacture, collection/separation, etc. of used products and components more efficient**
Reduces costs, decreasing the denominator

Ex. Remanufacturing company (manufacturer/maintenance company, etc.)

$$R_{CVP} \fallingdotseq \frac{\text{Added Value of Remanufacturing Business}}{\text{Cost of Remanufacturing Business}}$$

Preventing Decline in Residual value

(c) **Use extended-lifetime products/components, extend lifetime through proper maintenance**
Actual lifetime indicator increases, and denominator decreases

Ex. Service providers (electricity companies/ railway companies, etc.)

$$R_{CVP} \fallingdotseq \frac{\text{Added Value Obtained from Business Facilities}}{\text{Yearly Wear on Business Facilities}}$$

Our new proposed indicator enables the cost-effectiveness of every type of circular economy scheme to be assessed, including reuse, remanufacturing, collection, separation, and lifetime extension.

The left-hand part of the denominator, "(b) Portion used up," is the portion equivalent to the variable costs out of the sales costs of products, etc., and includes collection costs. The right-hand part of the denominator, "(c) of Reuse or Longer Use," is similar to depreciation charges on facilities, etc., but differs in that it divides facilities investment not by the statutory service life, but by the actual facilities lifetime. This means that extending the actual facilities lifetime reduces the portion of reuse or longer use, decreasing the denominator and increasing the size of the fraction as a whole, thus improving the indicator. Companies increasing residual value through circulation should be able to improve this indicator either by increasing the numerator through the use of technologies that raise residual value, or reducing the denominator by making the reuse, remanufacture, collection, and separation of used products and components more efficient. Conversely, companies focused on preventing a decline in residual value, such as electricity and railway companies, can improve this indicator by reducing the portion of reuse or longer use, uses through lifetime extension by means of proper maintenance.

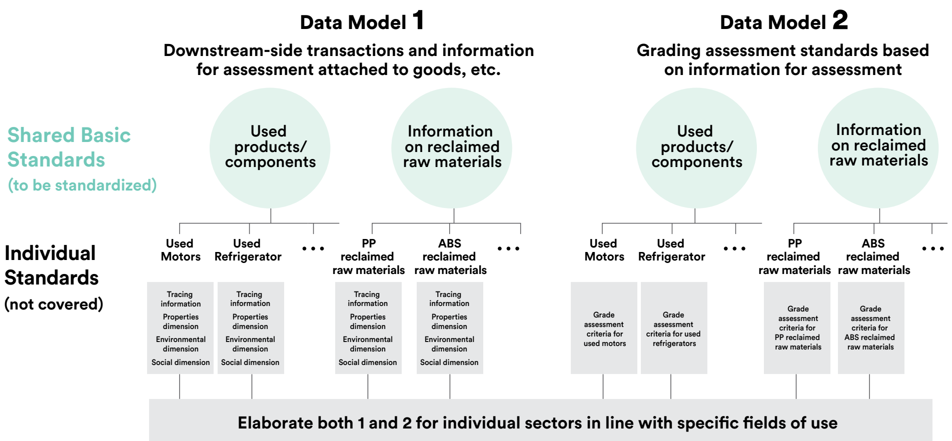
Case Study	Existing Indicator Circular Material Productivity	Proposed Indicator Circular Value-Added Productivity
More efficient collection and separation through social infrastructure systems	Not Covered	○
Extended lifespan through maintenance services	Not Covered	○
Reduction in virgin materials through promotion of use of reclaimed materials in new products	○	Not Covered

Making Value Visible: 2

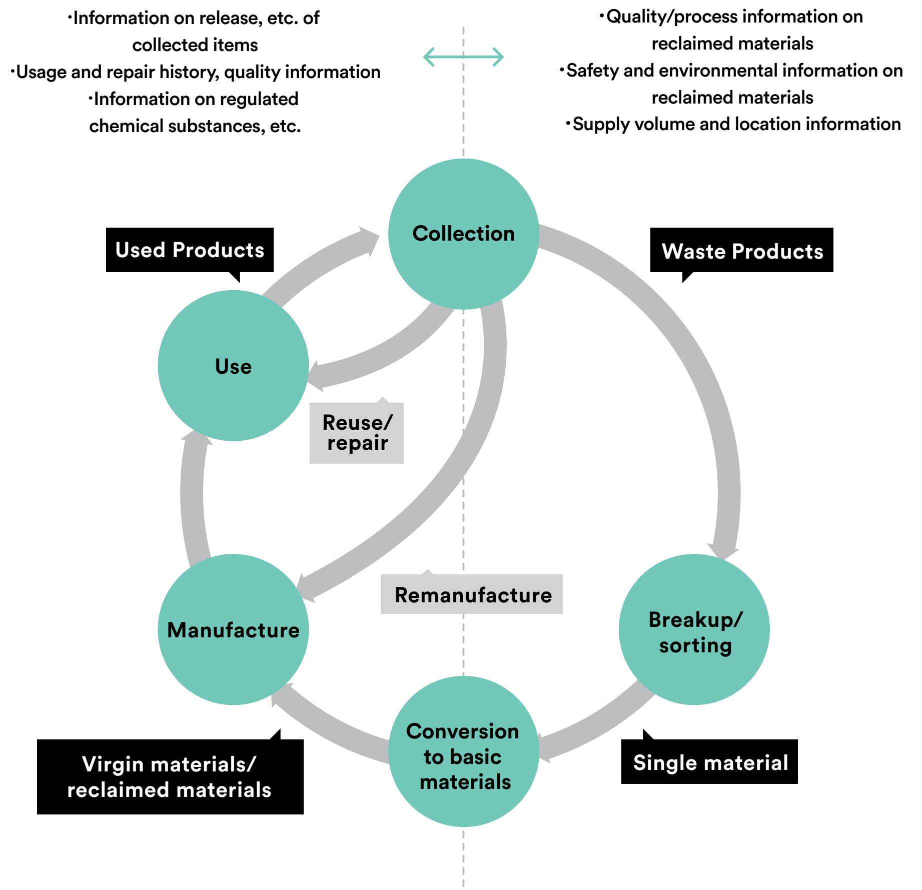
Standardization of Grading

We now turn to the visualization of "grading," meaning the residual value of materials needed by the demand side. International moves toward the standardization of grading are already in train, with previous initiatives including the International Electrotechnical Commission Technical Committee 111 (IEC/TC111, the technical committee formulating international standards on the measurement and assessment of environmentally friendly products) as well as Chemical and circular Management Platform (CMP) on the upstream side, and the ISO Technical Committee 323 (ISO/TC323) on the downstream side. One issue, however, is the fact that differences between standards on the upstream and downstream sides mean that data cannot readily be linked.

In our laboratory, we are in the process of standardizing data models for grading that will enable the linkage of upstream and downstream information, while making use of and integrating prior standards and other sources.



Standardization of Data Models for Grading



Previous Standards, etc.

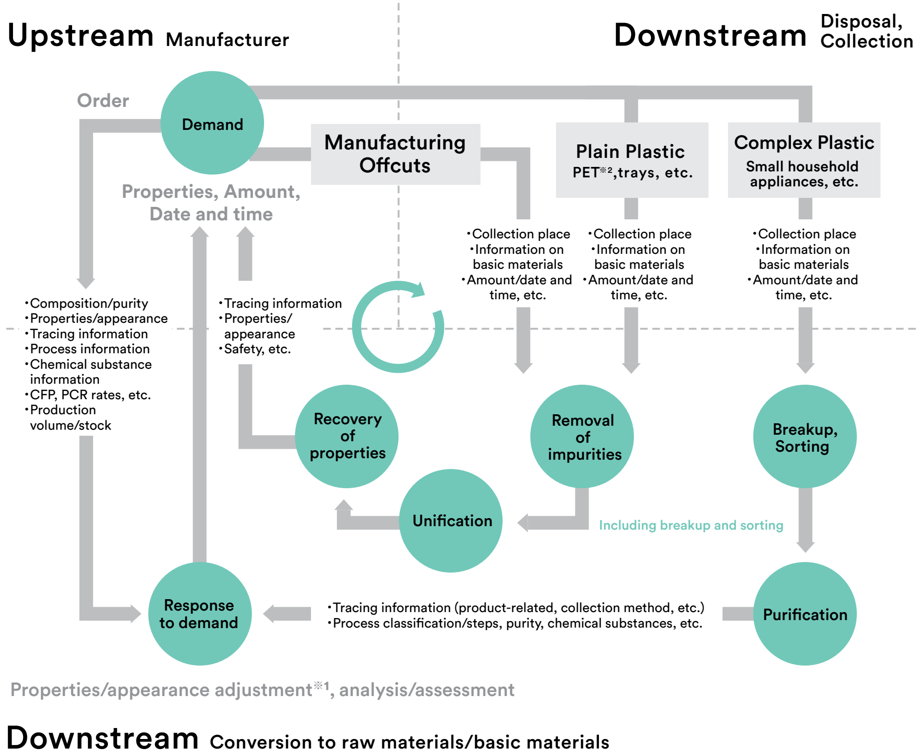
IEC/TC111 Leading on linking products, materials, and data **CMP**※1 Leading on developing a new system for linking information on chemicals and reclaimed materials, etc. **SIP**※2**(PLA-NETJ**※3**)** Leading on plastic circulation management and information-sharing, reclaimed material use	**ISO/TC323** Leading on terminology/ indicators/business models/ reclaimed materials use

※1 Chemical and Circular Management Platform ※2 Cross-ministerial Strategic Innovation Promotion Program
※3 Plastic Networking for Environmental Transformation Japan

The standardization of grading devised by our laboratory constitutes the standardization of data models that describe information for assessment and grade assessment criteria using a consistent structure and format. Information for assessment comprises downstream-side transactions and the information required for assessment, which is attached to products and components. Assessment criteria are the criteria necessary for grade assessment on the basis of the information for assessment.

Flows of Materials and Information in The Plastic Reclamation Process

Material Flow Material Black lettering: Information passed on

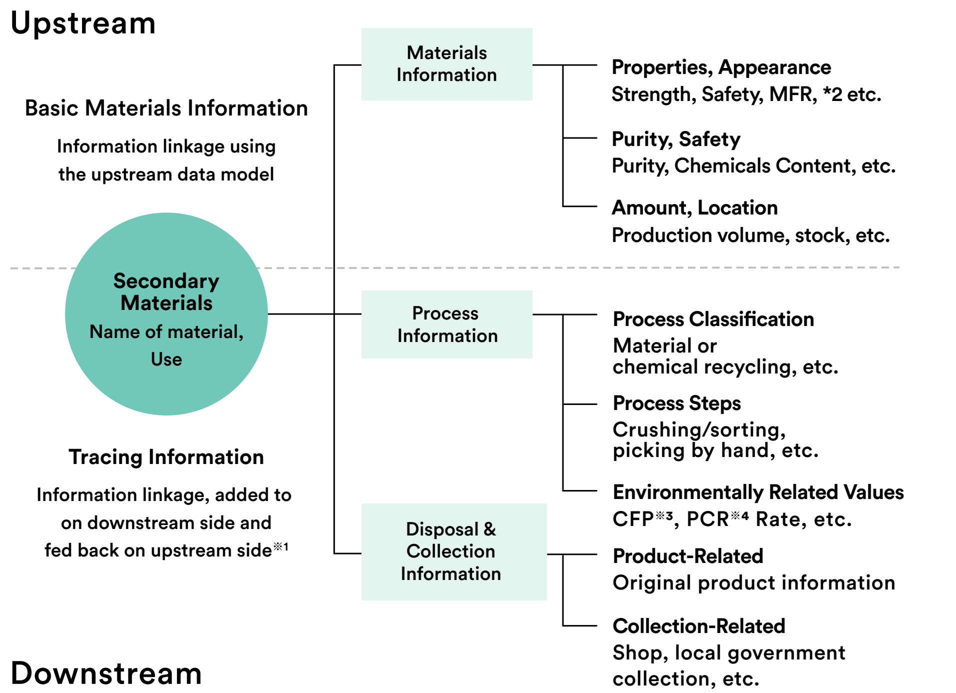


※1djustment of virgin materials and different types of additive
※2 Polyethylene Terephthalate

We are working on the extraction of "common basic standards," elements that are common across sectors. Ideally, the detailed standards required by individual sectors should be developed by the companies concerned on the basis of this common foundation. To extract these data models, we are investigating the assessment of reclaimed plastics as one use case. We are interviewing companies involved in this area, reviewing the flows of materials and required information, and identifying the information for assessment required for grade determination.

Information required for plastic grade determination

Information linkage, including items derived from both the upstream and downstream sides in the information for assessment



※1 Some added on upstream side ※2 Material Flow Rate
※3 Carbon Footprint ※4 Post Conusmer Recycle

Coordination with the Relevant Instituition

We are currently engaged in dialogues with a range of organizations involved in international standardization, promoting consensus formation and the fleshing out of standards.

In April 2024, we held a standardization symposium and a closed workshop on standardization.

The symposium featured presentations by the World Business Council for Sustainable Development (WBCSD) and the international chair of the European Committee for Standardization Technical Committee 473 (CEN/TC473) on international standardization in the circular economy, and a panel discussion by experts from diverse countries. This event was streamed live online to a global audience.

In the workshop, we held more in-depth discussions about the work on standardization going on in our laboratory, in which Japanese experts were also invited to join. These discussions included numerous expressions of support for the standardization work of our laboratory. In December 2024, we also gave a presentation at the Circular Partnership EXPO. We engaged in discussions with relevant departments of the Ministry of Economy, Trade and Industry and related groups, including the Circular Economy Association to promote the development of more concrete standards.

Standardization Symposium

'24 Apr 23
AIST Tokyo Waterfront

International Standardization Toward a Digital Circular Economy: Messaging, presentations from various countries, panel discussion

Participating Institutions:

US: NIST
Canada: ISO / IEC representative
Luxembourg: Ministry of the Economy
Brazil: Associação Brasileira de Normas Técnicas (ABNT)
Switzerland: WBCSD
Sweden: RISE and others
Japan: IEC/SC3D Chair
Seven countries in total
Number of participants

No. of Participants: Approx. 250 (50 in person, 200 online)

NIST: National Institute of Standards and Technology, WBCSD: World Business Council for Sustainable Development, RISE: Research Institutes od Sweden

Closed Workshop on Standardization

'24 Apr 24-25
AIST Tokyo Waterfront

Dialogue with experts from Japan and abroad

- Numerous expressions of support for our laboratory's standardization proposals
- Offers from overseas participants to help brush up our laboratory's proposed standards
- Discussions with around 20 circular economy experts from Japan and overseas

Circular Partnership EXPO

'24 Dec 4
Tokyo Big Sight

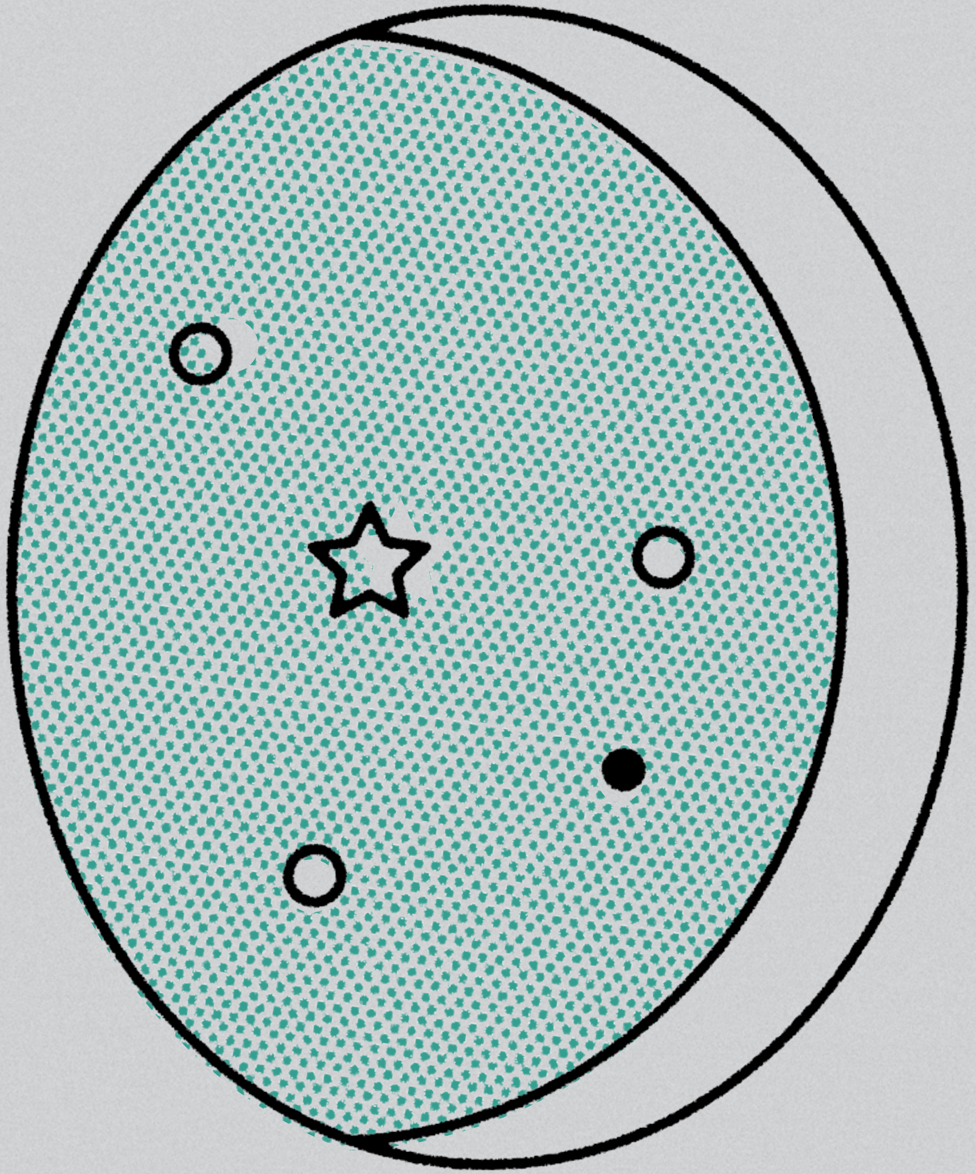
Introduction to international standardization initiatives to enable the transition to the circular economy

- Many expressions of interest in the new circular economy indicator and grading standardization
- Followed by widespread publicity for our activities.

No. of participants: Approx. 150

Dialogue & coordination with relevant institutions

We are engaged in discussions with relevant departments of the Ministry of Economy, Trade and Industry and related organizations as we continue to our efforts to flesh out standardization



Make the true value of the circular economy visible Spread the global message of Japanese-initiated rule-making, and make proposals

’22-23 Status Assessment and Drawing Up of Standardization Strategies

Conduct status assessments and analysis through information gathering and studies. Identify issues and needs, and draw up standardization strategies.

’24 Optimization with a View to Implementation

Draw up visualization strategies for the circular value-added productivity indicator and grading.

’25 Action with View to Implementation

Prepare committee drafts for two visualization strategies. In collaboration with relevant Japanese institutions, aim for submission to ISO/TC323.

Afterword

This year's report is another interim report, following on from last year's 2023 Activity Report by summarizing our activities in FY 2024. Its content is based on the presentations given at HITACHI-AIST Circular Economy Research Laboratory Second Open Forum on the Ideal Future of the Circular Economy and What is Needed to Get There? held on February 6, 2025.

In our laboratory, we regard materials, energy, and knowledge/wisdom as resources that should be circulated in the Society 5.0 era, and are engaged in research on the three themes of a Grand Design, Digital Solutions, and Standardization Strategies. In FY 2024 we also set up a new taskforce with the goal of reviewing indicators relating to the circular economy horizontally across these themes. This taskforce is engaged in compiling circular economy indicators and systematizing them into groups.

In April 2024 we held a symposium focused on standardization, at which standardization initiatives in seven countries around the world were shared. We also presented our efforts at events including the Japan Techno-Economics Society, CEATEC, the Society of Automotive Engineers of Japan, and the Circular Partnership EXPO, and engaged in dialogue with many people at all of these events.

In FY 2025, our laboratory comes to the end of the final year of our initial plan. As the culmination of the past three years, we will speed up research in order to achieve good results that will enable the circular economy to become a reality. I hope that you will look forward to these results, and consider it a great honor to be working toward the circular economy alongside all of you.

HITACHI-AIST Circular Economy
Cooperative Research Laboratory
Director Katsumasa Miyazaki

Laboratory Members

As of Mar 2025

Director	Katsumasa Miyazaki	HITACHI (Assigned to AIST)		
Dep. Director	Keijiro Masui	AIST		
Assistant Director	Shohei Terada	HITACHI (Assigned to AIST)		
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	Yasushi Umeda	The University of Tokyo		
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	Shinichi Taniguchi	HITACHI	Hirofumi Nagano	HITACHI

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	Yoshiyuki Furukawa	AIST	Yuki Murasato	HITACHI
	Ryo Nakabayashi	AIST	Yoshiyuki Ichihashi	HITACHI

Please join us in making the circular economy a reality.

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

WG1 | Formulation of Grand Design for Circular Economy & Society

Leader	Masahide Ban	HITACHI		
Dep. Leader	Keijiro Masui (concurrent position)	AIST		
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	Tetsuo Yasutaka	AIST	Yusuke Kaga	HITACHI
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WG2 | Development of Digital Solutions for Circular Economy

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	Hiroyuki Sawada	AIST	Takashi Misaka	AIST
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	Jonny Herwan	AIST	Naohito Hayashi	AIST
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	Koji Miyake	AIST	Takuro Mori	HITACHI
	Yutaka Genchi	AIST	Sanae Nakao	HITACHI
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	Shinichi Ikeda	AIST	Tadasuke Nakagawa	HITACHI
	Satoshi Kajino	AIST		

WG3 | Planning of Standardization Strategies/Proposal of Measures

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	Kenichi Miyamoto (concurrent position)	AIST Solutions	Yoshiyuki Ichihashi	HITACHI
	Hiroaki Sato	AIST	Takahiro Kihara	HITACHI
	Junji Mizukado	AIST	Yuki Murasato	HITACHI

HITACHI-AIST Circular Economy Cooperative Research Laboratory

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