Application Guidelines Appendix

Chapter 6: Target Technology Areas

For each technology area, this chapter provides an overview, a background on the expected R&D proposals, and bottleneck issues. Please note that these categories and bottleneck issues are only examples; we are looking for a wide range of innovative proposals without limiting ourselves to them. We welcome proposals in interdisciplinary fields that may not fit within the scope of each technology area, as well as proposals that span different fields across multiple technology areas.

Furthermore, even if a proposal does not fit into any of the technology areas, it will be considered for selection if it is an R&D proposal that will make a significant contribution to realizing carbon neutrality.

When applying, please select the most relevant technology area after interpreting each technology area as broadly as possible. If you do not think your proposal fits into any of the technology areas, please submit your proposal as "Other New Idea."

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6.1 "Energy Conversion and Energy Storage" Area

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Ⅰ. Overview of the Technology Area

In the Green Growth Strategy for Attaining Carbon Neutrality, it is considered essential to make renewable energy the main source of power and to innovate technologies for utilizing hydrogen energy. To expand the use of renewable energy, there is a need to reduce the cost of introducing solar power generation and other forms of energy and to improve energy conversion efficiency. In addition, hydrogen, which is expected to be utilized in a wide range of fields such as power generation, industry, and transportation, requires significant improvements in conversion efficiency in its generation, conversion to energy carriers, and technologies for utilizing it.

Energy storage technologies are also an essential element in supporting the transition to a sustainable energy system. Heat storage technologies, which are used to correct mismatches in time, place, and temperature when handling thermal energy, have made great strides in using of factory waste heat, but there is still room to better utilize unused waste heat and other resources at medium and low temperatures. Today, storage batteries and other electricity storage technologies have become indispensable for maintaining people's lifestyles and economic activities, and their importance is only increasing. There is a need for more versatile, economical, and environmentally friendly electricity storage methods for a wide range of applications, from the small electricity storage devices around us to the large-scale electricity storage devices for power grids that promote the use of renewable energy sources such as solar and wind power, whose output fluctuates widely.

This technology area therefore engages in ambitious research and development that is expected to develop into innovative energy conversion and energy storage technology seeds, with an emphasis on free thinking without being bound by precedents, while taking into account these social demands. We aim to contribute to the transformation of Japan's energy structure on the premise of carbon neutrality by developing technologies that lead to the stable procurement and large-scale use of next-generation energy, developing technologies related to hydrogen energy carriers, and making breakthroughs through the discovery of new materials and new processes and systems for heat and energy storage.

Furthermore, the selection of R&D proposals will be based on the premise that the proposed technology can contribute to the reduction of greenhouse gas emissions throughout the entire utilization process from the perspective of energy flow and material flow.

In addition, there is a common technological field between the "Energy Conversion and Energy Storage" area of this program and the "Storage Batteries" area for which JST plans to invite applications for team-based research under the "Green Technologies for Excellence (GteX)" program this fiscal year. Although the scale and research phase of this program are not such that team-based research is required for GteX, proposals for innovative elemental technologies such as electrolytes (liquid), active materials, and electrode materials that greatly surpass existing performance, as well as budding electricity storage technologies with potential for future development, are eligible for adoption.

Please also refer to "1.1.4 Key Points when Applying to ALCA-Next" in Chapter 1 of the ALCA-Next Application Guidelines for information on the relationship with GteX.

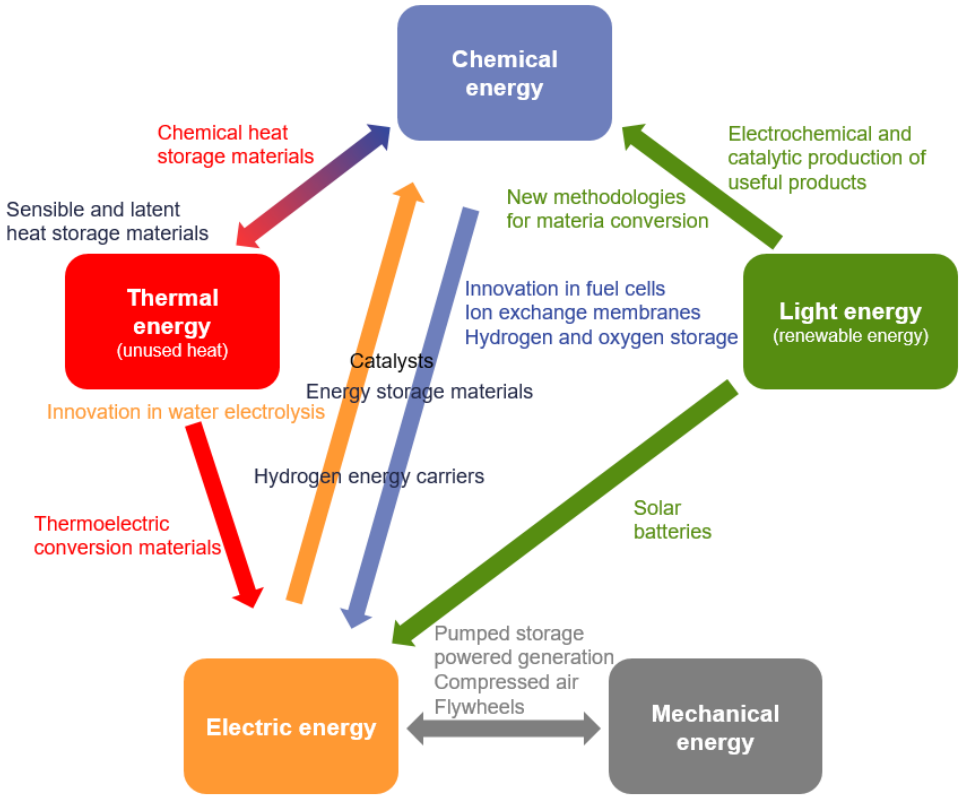

Figure 1: Target technologies in the "Energy Conversion and Energy Storage" area

Ⅱ. Technological Elements Expected to Be Proposed

In the area of "Energy Conversion and Energy Storage," we expect R&D proposals in the following

categories:

a. Low-cost, high-efficiency, high-convenience solar energy conversion technologies
b. Technologies for synthesizing and utilizing hydrogen energy carriers with minimal energy usage and cost
c. Technologies for storing unused thermal energy at medium and low temperatures
d. Safe, low-cost electrical energy storage technologies to facilitate the use of renewable energy
e. New ideas for energy conversion and storage technologies to achieve carbon neutrality

a. Low-cost, high-efficiency, high-convenience solar energy conversion technologies

Crystalline silicon solar cells, which have become increasingly low-cost and high-efficiency, are being used mainly in large-scale facilities such as mega solar power plants, and recently their applications are expanding to consumer uses such as home roofs. However, in order to further increase the use of solar cells, it is essential to expand their installation to factory roofs, building walls, highway noise barriers and slopes, agricultural greenhouses, and other areas with low load-bearing capacity where crystalline silicon solar cells cannot be installed. To this end, there needs to be further research focused on dramatically increasing the efficiency and lifespan of new solar cells, such as organic thin-film solar cells and lead-free perovskite solar cells, which can be lightweight, flexible, and low-cost all at the same time. Another important issue is the development of fundamental technologies to harness sunlight and convert it into energy carriers with high energy density. This category calls for innovative proposals that fundamentally resolve these issues. For example, we expect R&D proposals to solve the following bottleneck issues, but are looking for innovative proposals not limited to those listed below.

- Low-cost, thin, lightweight, flexible solar cells that enable dramatic expansion of installation locations

  To further expand the use of solar cells, we invite R&D proposals for technologies such as organic thin-film solar cells and lead-free perovskite solar cells that will contribute to dramatically increasing the efficiency and lifespan of new solar cells.

- Novel solar cells that utilize nanostructures to achieve high energy conversion efficiency

  We invite ambitious R&D proposals that aim to realize solar cells with unprecedentedly high conversion efficiency by designing solar cells utilizing novel concepts such as quantum effects and photon management, and by developing the materials and cell structures to make this possible.

- Useful material production technologies that use solar energy and that achieve lower cost and higher efficiency than existing technologies

  We invite proposals for research and development of methods to use sunlight to activate stable small molecules such as water and carbon dioxide and convert them into useful substances such as hydrogen, methane, and methanol, as well as catalysts to facilitate this conversion process.

- Solar cells that make full use of interface design to enable highly efficient and energy-saving energy conversion

  We invite ambitious research and development proposals for solar cells with novel or existing structures that can achieve high conversion efficiency by improving junction interface characteristics and performance.

b. Technologies for synthesizing and utilizing hydrogen energy carriers with minimal energy usage and cost

In building a hydrogen energy society, one key technology will be energy carriers that enable efficient storage and transportation of hydrogen in liquid or hydrogen compound form, which is more efficient for storage and long-distance transportation than hydrogen in gaseous form. Ammonia, organic hydrides, and formic acid have been studied as energy carriers, but as yet, no energy carrier has been established that combines cost and convenience.

A common challenge for hydrogen energy carriers is the efficient synthesis of carrier molecules and hydrogen extraction. Ammonia is a promising hydrogen energy carrier, but conventional industrial synthesis methods require a lot of energy, so a completely new synthesis method is needed as a carbon-neutral energy carrier. There are also utilization-related challenges in the form of figuring out how to reduce costs and save energy in the process of "dehydrogenation" to extract hydrogen. Also important are technologies that directly utilize hydrogen energy carriers without dehydrogenation.

For the fuel cells that supply hydrogen fuel, power generation efficiency can be improved by using pure oxygen as an oxidant, but the technology for storing the pure oxygen used in fuel cells is also key.

This category calls for innovative proposals that fundamentally resolve these issues. For example, we expect R&D proposals to solve the following bottleneck issues, but are looking for innovative proposals not limited to those listed below.

- Technologies to synthesize ammonia with minimal energy usage

We invite R&D proposals for the development of high-performance catalysts capable of reacting at low temperatures and pressures, and for continuous synthesis methods under mild conditions.

- Synthesis and dehydrogenation technologies for novel hydrogen energy carriers by exploring high-performance, low-cost catalysts and processes

  We invite proposals for research and development on the synthesis and dehydrogenation of novel hydrogen energy carriers that outperform ammonia and organic hydrides, for which research has been ongoing, in terms of hydrogen storage density, conversion efficiency, and safety.

- Technologies for directly utilizing hydrogen energy carriers

  We invite proposals for research and development on direct utilization technologies that do not involve dehydrogenation, such as direct fuel cells that use hydrogen energy carriers as fuel to extract electrical energy.

- Development of oxygen storage materials to promote hydrogen utilization

  The use of pure oxygen is an effective way to improve the efficiency of fuel cell power generation. To this end, we are seeking R&D proposals for materials that can efficiently and densely store oxygen obtained through water electrolysis and other means, as well as oxygen in the atmosphere.

c. Technologies for storing unused thermal energy at medium and low temperatures

High power conversion efficiency can be achieved based on the Carnot cycle by things like turbines and engines operating at high temperatures, but in the mid- to low-temperature range, which accounts for most of the energy consumed, the technologies for utilizing thermal energy are not yet mature enough given the manufacturing and maintenance costs, and much heat is wasted without being utilized. Therefore, there is a strong need to develop heat management technologies such as heat storage, heat reclamation, and heat recovery technologies that contribute to the reduction of greenhouse gas emissions in the mid- to low-temperature range. In this category, we invite proposals for the exploration of heat storage materials, process development, and high-efficiency thermoelectric conversion materials and systems to better utilize unused waste heat at medium and low temperatures. In addition to conventional sensible and latent heat storage, which store thermal energy, we will also focus on chemical heat storage, which uses chemical phenomena, especially reversible chemical reactions, to store heat as chemical energy. Chemical heat storage has a higher heat storage density

than sensible and latent heat storage, and is expected to be used in more technologies for practical application. For example, we expect R&D proposals to solve the following bottleneck issues, but are looking for innovative proposals not limited to those listed below.

- Exploration of chemical heat storage materials and development of processes that can be used under mild conditions with high heat storage capacity

  We invite R&D proposals for the exploration of new heat storage materials to better utilize unused waste heat at medium and low temperatures. Since chemical heat storage requires equipment that can withstand the reactions, we are also looking for innovative process proposals that solve this problem.

- Development of safe, inexpensive, and high-performance latent and sensible heat storage materials

  We invite proposals for the research and development of low-cost, environmentally friendly materials such as plant-derived and reused materials.

- Development of thermoelectric conversion materials with high efficiency at medium and low temperatures

  We invite proposals for research and development of material systems that use environmentally friendly materials and can operate at less than 200°C.

- Development of low-cost medium- and low-temperature waste thermal energy recovery and utilization systems for social implementation

  We are looking for R&D proposals that will contribute to the social implementation of thermoelectric conversion systems, leading to a significant reduction in costs and higher efficiency in manufacturing, operation, and maintenance.

- Development of highly efficient thermal energy storage systems using interface control technologies

  We invite proposals for the research and development of thermal energy storage systems that apply novel ideas to the control of interfaces in contact with heat transfer mediums.

d. Safe, low-cost electrical energy storage technologies to facilitate the use of renewable energy

For the large-scale introduction of renewable energies such as solar and wind power needed to realize a carbon-neutral society, it is essential to advance electric energy storage technologies suitable for power systems, including storage batteries and capacitors, which regulate renewable energies.

Among these, redox flow batteries are attracting attention as grid storage batteries because of their low life cycle cost and high safety achieved through their use of flame-retardant materials, but they have issues such as having a low volumetric energy density and requiring a large installation area. This category calls for innovative proposals that fundamentally resolve these issues. The program also invites R&D proposals on elemental technology research on low-cost and safe electrical energy storage technologies that include flame-retardant ionic liquids, aqueous electrolytes, and innovative methods of creating storage batteries. For example, we expect R&D proposals to solve the following bottleneck issues, but are looking for innovative proposals not limited to those listed below.

- Development of electricity storage materials that contribute to smoothing output fluctuations

  We invite proposals for the research and development of electricity storage materials suitable for power management, including storage batteries and capacitors, which regulate the supply-demand balance of renewable energy and output fluctuations caused by weather and other factors.

- Technologies to significantly increase the volumetric energy density of redox flow batteries

  We invite R&D proposals for electrolyte and other solutions that contribute to improving volumetric energy density in order to realize large-scale electricity storage devices for power grids.

- Large-scale electrical energy storage technologies using ionic liquids and aqueous, non-flammable electrolytes

  We are seeking R&D proposals for ionic liquids and aqueous electrolytes, which are being considered for future application in next-generation electrical energy storage technologies, to improve ion transport properties and enable higher voltages in electricity storage devices.

- Electric energy storage technologies that enable low-costs and high-performance using interface control technologies

  We invite R&D proposals that aim to reduce the cost and improve the performance of storage batteries through innovations in electrolyte and electrode interface structures and their creation methods.

e. New ideas for energy conversion and storage technologies to achieve carbon neutrality

We invite R&D proposals based on new ideas for energy conversion and energy storage technologies that do not fall into the above categories and that will make a significant contribution to realizing carbon neutrality.

6.2 “Resource Circulation” Area

Program Officer
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Ⅰ. Overview of the Technology Area

In this technology area, we carry out research and development for technologies, materials, and chemical processes that enable efficient recycling of resources with low environmental impact and contribute significantly to reducing greenhouse gas emissions. The recovery and recycling of carbon and other resources is taking on increased importance worldwide as means to achieve carbon neutrality. For example, the recovery and recycling of greenhouse gases from industrial exhaust, which is a large-scale source of greenhouse gas emissions, is expected to contribute significantly to carbon neutrality. Consequently, there is a need for research into technologies for energy-saving and highly efficient separation and recovery of greenhouse gases, including carbon dioxide, and for the establishment of new processes for synthesizing high-performance and highly functional chemicals and fuels from greenhouse gases directly or from biomass that has absorbed and immobilized greenhouse gases. In addition, the production and distribution of storage batteries, fuel cells, and solar cells are expected to increase in the future in order to reduce greenhouse gas emissions. However, the supply of metal resources as raw materials and the countries that produce them are limited, making it important to recycle existing resources in order to ensure a stable supply of raw materials. We therefore aim to develop technologies, materials, and chemical processes that will enable the recycling of organic and inorganic resources and contribute significantly to the reduction of greenhouse gas emissions.

In the selection of R&D proposals, emphasis will be placed on the premise that the proposed technology can contribute to the reduction of greenhouse gas emissions with low environmental impact throughout the entire process of using the proposed technology from the perspective of energy flow and material flow.

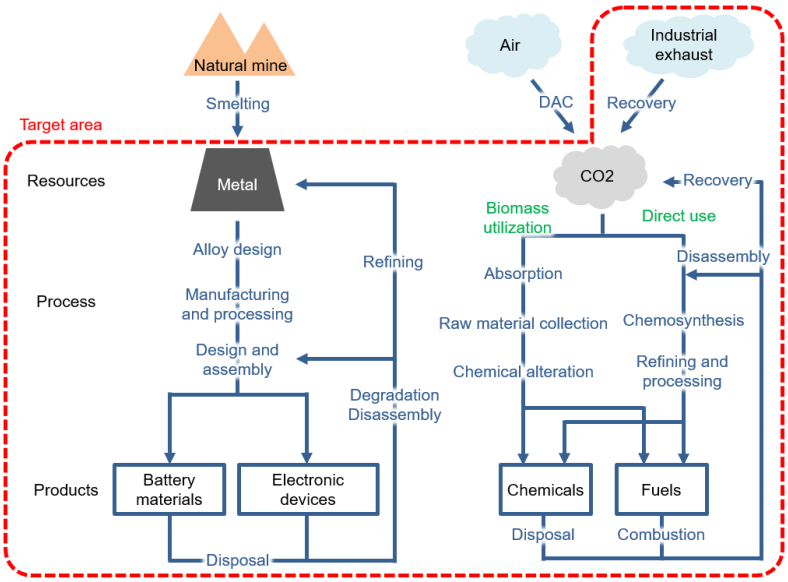

Figure 2: Target Technologies in “Resource Circulation” area

Ⅱ. Technological elements for which proposals are expected

In the “Resource Circulation” area, we expect R&D proposals in the following categories:

a. Highly efficient and energy-saving greenhouse gas separation, recovery, and utilization technologies
b. New synthesis technologies to produce high performance and highly functional materials from biomass with low environmental impact and high efficiency
c. Recycling process technologies using degradable and easily disassembled materials that contribute to the reduction of greenhouse gas emissions
d. New ideas for resource recycling to achieve carbon neutrality

a. Highly efficient and energy-efficient greenhouse gas separation, recovery, and utilization technologies

The amount of greenhouse gas emissions generated by the use of fossil resources is enormous, and in order to reduce these emissions, efforts are being made to develop energy-saving technologies and shift to carbon dioxide-free renewable energy. However, achieving carbon neutrality requires the separation and recovery of greenhouse gases from large-scale sources and the conversion of the recovered greenhouse gases into resources, making it a pressing issue. Although technologies for the separation and recovery of greenhouse gases are already being studied for practical application, there is still a need to develop technologies that outperform conventional methods for both separation and recovery in order to significantly improve performance and reduce costs for a wider range of

applications. There is also a need to establish new synthetic processes for compounds that are in high industrial demand and to convert greenhouse gases, especially carbon dioxide, into resources.

Therefore, in this category, we invite R&D proposals for the development of innovative adsorption materials and separation membranes for greenhouse gases, as well as for the construction of new synthesis technologies for high-value-added compounds using carbon dioxide as a raw material. R&D proposals will be highly evaluated if they clarify the expected operating conditions and scale, and if they can contribute to the reduction of greenhouse gas emissions throughout the entire separation, recovery, and utilization process. For example, we expect R&D proposals to solve the following bottleneck issues, but we are looking for innovative proposals that are not limited to those listed below.

- Development of novel materials and processes capable of separating, capturing, and converting greenhouse gases with high efficiency and energy savings

  We invite proposals for research and development of materials and processes for low-cost, high-efficiency separation, recovery, and conversion of methane, which has a high global warming potential, and carbon dioxide, which is emitted in large quantities from factories and other sources.

- Synthesis technology for new high-value-added compounds using carbon dioxide as a raw material

  We invite R&D proposals for new and groundbreaking technologies to convert carbon dioxide into chemical products that are in demand by industry, viewing carbon dioxide as a resource.

b. New synthesis technologies to produce high-performance and highly functional materials from biomass with low environmental impact and high efficiency

The importance of utilizing biomass (woody and herbaceous materials) to absorb, fix, and recycle carbon dioxide is recognized worldwide, and research on the utilization of biomass has been conducted in a wide range of fields. Although Japan has abundant forest and marine resources, the country lags behind other countries in research on biomass utilization. In particular, there is a need to develop technologies that take into account Japan's unique weather, environmental, and geographical conditions. In this category, we seek to develop groundbreaking new chemical synthesis methods that efficiently convert inedible biomass into high-performance or highly functional chemical products and polymeric materials, as well as technologies that enable low-cost production of general-purpose chemical products and fuels such as organic acids and alcohols. For example, we expect R&D proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Chemical synthesis technologies that utilize the skeletal structure of biomass-derived raw materials and convert them into high-performance or highly functional chemical products and polymeric materials.

  We invite proposals for research and development related to new chemical synthesis technologies that utilize the skeletal structures of cellulose, sugar chains, lignin, terpenes, polyphenols, and other biologically derived substances, such as six-membered rings, to transform them into high-performance or highly functional chemical products or polymeric materials.

- Synthesis technologies that utilize biomass-derived raw materials to efficiently produce general-purpose chemical products and polymeric materials at low cost.

  We invite proposals for research and development that can produce socially in-demand chemical products and polymeric materials efficiently and at low cost via the use of cellulose, sugars, lignin, terpenes, and polyphenols, etc.

The biological use of biomass is covered under the "Green Biotechnology" area. For details, refer to Chapter 6: "Green Biotechnology" Area of the Application Guidelines.

c. Recycling process technologies that contribute to greenhouse gas reductions by utilizing degradable and easily disassembled materials

In order to achieve carbon neutrality, energy-saving and efficient use of limited resources is considered important from a sustainability perspective. There are particularly high expectations for the realization of "carbon recycling," which treats greenhouse gases as a resource, and for the cyclical use of storage batteries, fuel cells, and solar cells, which are seeing increasing demand in order to achieve carbon neutrality. In order to utilize resource circulation, it is important to develop energy-saving and efficient methods for degrading and dismantling materials. In this category, we are seeking to develop chemical synthesis methods for degradable materials that can significantly contribute to reducing greenhouse gas emissions; to develop easily disassembled materials that contribute to energy-saving and efficiency in resource circulation; and for the development of material usage processes that will enable the recycling and utilization of greenhouse gases as a resource. For example, we expect R&D proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Development of recyclable polymeric materials that can be degraded and recycled in the

environment

We invite proposals for novel and unprecedented research and development related to synthesis methods for recyclable polymeric materials that are highly versatile and that can significantly reduce greenhouse gas emissions through the reuse of raw materials.

- Development of efficient synthesis methods and utilization processes for easily degradable materials and of control interfaces that contribute to the cyclical utilization of bonded dissimilar materials and composite materials

  We invite proposals for novel research and development that contribute to 1) the development of synthesis methods and utilization processes for easily degradable materials that will contribute to the cyclical utilization of the dissimilar and composite materials that make up battery materials, etc., and 2) the energy-saving and efficient degradation and disassembly of dissimilar and composite materials via their control interfaces.

d. New ideas related to resource circulation to achieve carbon neutrality

We are also looking for research and development proposals that do not fall into the above categories but that are based on new ideas for circular use of organic and inorganic resources and that will make significant contributions to realizing carbon neutrality.

6.3 "Green Biotechnology" Area

Program Officer
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Ⅰ. Overview of the Technology Area

The food, agriculture, forestry, and fisheries industries have been listed as priority areas in the "Green Growth Strategy" to contribute to realizing carbon neutrality, and attention is being paid to bio-manufacturing and the development of technologies that utilize biotechnology. In particular, the solidification and recycling of carbon dioxide in forests, timber, agricultural land, and oceans by plants and microorganisms has been attracting attention, and is expected to make a significant contribution to the reduction of greenhouse gas emissions. In this technology area, we aim to develop game-changing innovative technology seeds that contribute to reducing greenhouse gas emissions by making maximum use of the functions of microorganisms and plants.

While there have been many studies to elucidate and improve the functions of microorganisms and plants, recent years have also seen a growing interest in research targeting the symbiotic relationship between microbiota and plants, and even the symbiotic relationship with surrounding organisms. It has become clear that communication takes place through secretion and metabolism of minute amounts of signal transducers and other substances in complex biological systems in which diverse organisms interact with each other, and it is expected that the mechanisms of interaction in complex biological systems will be elucidated, controlled, and utilized to maximize biological functions.

In this technology area, we will conduct innovative and ambitious research into areas with many unknowns, such as the elucidation and utilization of the mechanisms of interactions in complex biological systems in the natural environment, and develop new technologies that contribute to realizing carbon neutrality through the use of biotechnology, mainly in academia. In research and development, we have high expectations for contributing to the reduction of greenhouse gas emissions and the fixation and recycling of carbon dioxide.

We also expect R&D proposals in interdisciplinary fields, including new R&D through collaboration and the melding of biological research with research in other fields such as physics, chemistry, and information science.

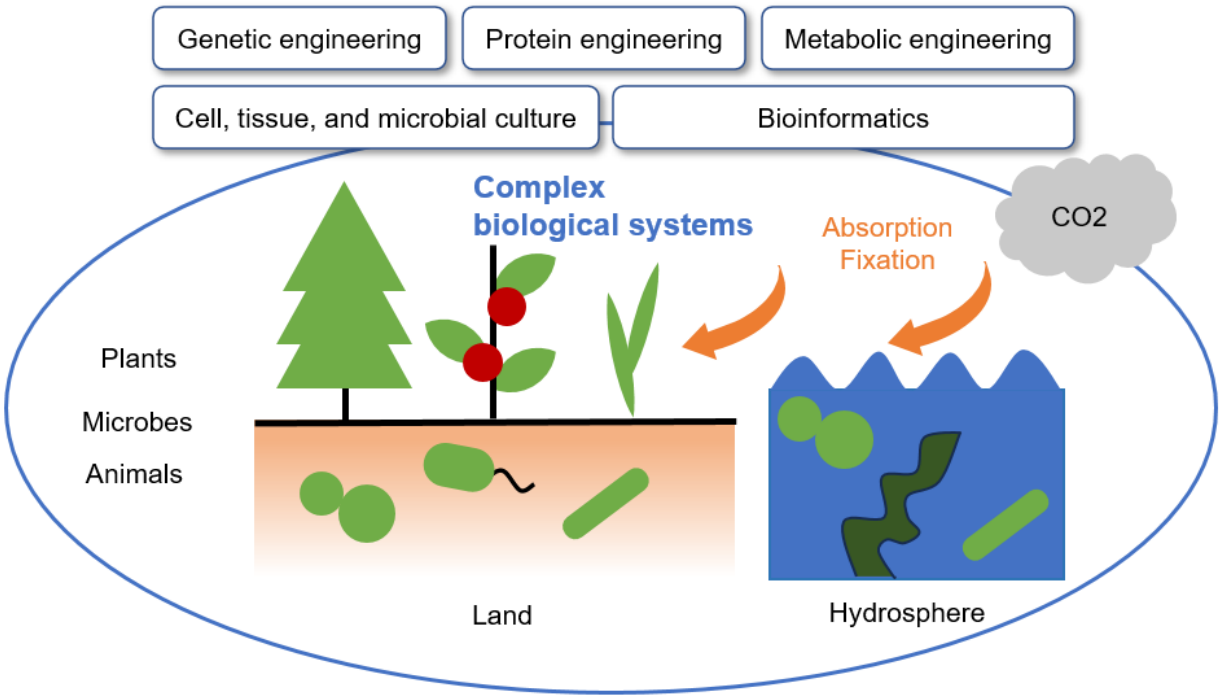

Figure 3: Target technologies in the "Green Biotechnology" area

Ⅱ. Technological Elements Expected to Be Proposed

In the "Green Biotechnology" area, we expect R&D proposals in the following categories.

a. Innovative analysis, design, and control technologies for the structure and function of complex microbial systems
b. Methods to control complex biological systems to maximize plant functions such as tolerance to environmental changes and enhancement of carbon dioxide fixation capacity
c. Next-generation breeding technology for diverse plants to realize high-yield and low-environmental-impact biomass production
d. Development and utilization of novel microorganisms and plants that can both reduce greenhouse gas emissions and produce food
e. New ideas for using biotechnology to achieve carbon neutrality

a. Innovative analysis, design, and control technologies for the structure and function of complex microbial systems

Microorganisms play a major role in the carbon and nitrogen cycles on the planet; and controlling

the functions of microorganisms in the environment is considered important for reducing greenhouse gas emissions. In the natural environment, a large number of microorganisms not only form a microbiota, but also exist in complex biological systems with other organisms such as plants. It has been reported that microorganisms and plants are involved in this complex biological system through various interactive factors (signal transducers), but there are many unknowns that include variation in interactions under diverse climatic and geographical conditions. Although progress has been made in metagenomic analysis of microbiota, systematic analysis and characterization of the structure and function of complex microbial systems in the environment remains difficult because there are many difficult-to-culture bacteria in the environment, and conventional techniques are insufficient to analyze these bacteria.

Therefore, this category calls for innovative high-throughput analytical techniques for information on complex microbial systems in order to elucidate the structure and function of complex microbial systems, about which there are many "black boxes," and to obtain new knowledge that will contribute to the maintenance of global material cycles. For example, we expect R&D proposals to solve the following bottleneck issues but are looking for innovative proposals not limited to those listed below.

- Innovative high-throughput analytical techniques for environmental changes in microbiota to conserve soil and maintain carbon and nitrogen cycles

  We invite proposals for research and development that will involve the elucidation of various interactive factors (signal transducers) in microorganisms, plants, and other organisms.

- Microbiota design and control technologies for reducing greenhouse gas emissions by controlling biofilm activity in the aquatic environment

  We invite proposals for research and development that will elucidate the structure and function of complex microbial systems in the aquatic environment.

- Analysis of interactions among microorganisms in dynamically changing microbiota in diverse environments, elucidation of their mechanisms of action, and control technologies

  We invite proposals for research and development that will elucidate and control the unknown interactions that occur with dynamic changes in the microbiota of diverse environments.

- Technologies for exploring genetic resources for new microorganisms and microbiota that contribute to low-carbon development, and applications for these technologies

  We invite proposals for the exploration and application of the vast untapped biological resources of the unknown biosphere.

- Analysis, design, and control technologies for complex biological systems in soil, including soil

animals, to reduce greenhouse gas emissions

We invite R&D proposals for exploration and analysis of complex biological systems extending from microorganisms and plants to animals.

b. Methods to control complex biological systems to maximize plant functions such as tolerance to environmental changes and enhancement of carbon dioxide fixation capacity

Plants are thought to exhibit adaptability to diverse environments through symbiotic relationships with various organisms. In the field of plant-microbiota interactions, for example, efforts are underway to identify microorganisms that contribute to plant growth and to study interactive factors (signal transducers). However, there is also a need to identify receptors and factors possessed by plants themselves and analyze their dynamic changes in order to establish more efficient and effective interactions.

In addition, there is potential for the effects of complex biological systems on plants to be utilized in developing plants that are tolerant to various environments, resistant to pests and diseases, and can maintain production and growth in a variety of environments. However, it remains difficult to elucidate the mechanisms of interactions in complex biological systems involving diverse elements.

Therefore, in this category, we seek to analyze plant genes that contribute to interactions with complex biological systems, elucidate interaction factors produced by plants, and develop novel plant gene improvement, breeding, and cultivation methods based on these mechanisms of action in order to cultivate plants that exhibit excellent growth potential, carbon dioxide fixation capacity, and tolerance to environmental changes by utilizing the action of complex biological systems. For example, we expect R&D proposals to solve the following bottleneck issues but are looking for innovative proposals not limited to those listed below.

- Analysis of plant genes affected by symbiotic microbiota and plants, and development of new plants using these genes

  We invite proposals on new research and development based on the identification of receptors and factors possessed by plants themselves, and the analysis of their dynamic changes.

- New plant cultivation technologies that enable the design and control of complex biological systems to accelerate growth, improve tolerance to environmental changes, and enhance disease and pest resistance

  We seek proposals for research and development involving genetic improvement and breeding methods based on analysis and elucidation of interactive factors and contributing

plant genes.

- Elucidation of mechanisms and control methods for microbe-plant interactions that contribute to reducing the carbon footprint in a variety of specific environments, including extreme environments

  We invite research and development proposals for the elucidation of the function and control of biological resources and biological information interacting in unknown biospheres such as the deep subsurface and the deep sea.

c. Next-generation breeding technology for diverse plants to realize high-yield and low-environmental-impact biomass production

The fixation of carbon dioxide by plant photosynthesis has potential to contribute to achieving carbon neutrality through negative emissions. To this end, it is particularly important to expand growing areas, improve productivity, and accelerate associated utilization cycles in order to increase plant biomass production, which can greatly help to reduce greenhouse gas emissions. For example, herbaceous biomass has the potential to power technologies for enabling more efficient crop breeding that will result in food production with a low environmental impact. For woody biomass, efforts must be made to expand the use of wood through the production of elite trees (elite trees are selected from the next generation of trees obtained through artificial crossbreeding among elite trees that have good growth, material quality, and other traits) and to secure and enhance medium- to long-term forest absorption of greenhouse gases through appropriate forest management. Achieving this will require the efficient development of elite trees through accelerated forest tree breeding and other measures, as well as expanded production of their seedlings.

Therefore, in this category, we call for the development of next-generation fundamental technologies that will increase the efficiency and speed of the breeding of diverse plants, including trees. For example, we expect R&D proposals to solve the following bottleneck issues but are looking for innovative proposals not limited to those listed below.

- Plant genome information analysis, gene selection, and genome editing technologies based on new opportunities for increasing biomass production with high yield and low environmental impact

  We invite R&D proposals for efficient crop breeding for increased biomass production, efficient development of elite trees, etc.

- Development of new breeding techniques to reduce fertilizer and resource inputs while

maintaining yields

We invite proposals for research and development in areas such as plant improvement by using new technologies to achieve low-environmental-impact food production.

- Plant breeding technologies that contribute to increased plant biomass production by improving the growth rate and carbon dioxide absorption capacity of trees through symbiotic relationships between microorganisms and plants

  We seek proposals for research and development in plant breeding by utilizing approaches such as identifying microbial groups that contribute to plant growth rates and isolating interactive factors.

- Technologies to elucidate the photosynthetic mechanism of plants and genetically improve their performance

  We invite proposals for research and development on elucidating the mechanism of photosynthesis, which is the basis of biomass production, and for innovative utilization technologies.

- Technologies related to the development of novel biomass with high carbon dioxide fixation capacity (microalgae, large algae, trees, etc.)

  We seek proposals for research and development in areas such as novel biomass development in a wide range of biospheres that include coastal and underwater biospheres, as well as terrestrial biospheres.

- Technologies aimed at reducing greenhouse gases other than carbon dioxide (methane, nitrous oxide, etc.) from plants

  We invite proposals for research and development of technologies that contribute to reducing greenhouse gases that have a greater impact than carbon dioxide.

d. Development and utilization of novel microorganisms and plants that can both reduce greenhouse gas emissions and produce food

Microorganisms and plants are expected to play a major role in addressing the pressing protein and energy crises that are strongly expected to be solved in the future, and many efforts have been made to develop food production technologies that utilize the functions of microorganisms and plants. To help realize carbon neutrality, it is considered important to simultaneously improve the efficiency of food production and more effectively reduce greenhouse gas emissions. For example, to reduce greenhouse gas emissions in agriculture, there is potential for technologies that improve soil and

increase fertilization efficiency by using microbial resources, that reduce energy input in livestock production, or that produce alternative proteins and fatty acids by way of precision fermentation.

In this category, we invite proposals for technologies that make maximum use of the functions of microorganisms and plants to enable energy- and resource-saving food production, as well as for the development of novel microorganisms and plants that contribute to food production. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Technologies to utilize microorganisms for the production of food and feed with low energy input
  We invite proposals for research and development related to the development of technologies for things such as soil improvement and fertilizer application efficiency utilizing soil microorganisms.
- New food production technologies utilizing novel microorganisms and plants
  We invite proposals for the development of microorganisms (groups) that efficiently produce fats and oils from agricultural and food residues, or for the development of microorganisms, plants, and complex systems that produce novel proteins that contribute to food production.

e. New Ideas for Using Biotechnology to Achieve Carbon Neutrality

We expect R&D proposals based on new ideas for contributing to achieving carbon neutrality that do not fall into the above categories.

We invite proposals for basic research and technological development that are based on new ideas not limited to the above categories and that span different fields such as biological research, physics, chemistry, and information science.

Examples: ・Research contributing to the development of novel biomass capable of high-density carbon storage and to the densification of carbon storage in existing biomass
・Research on the thorough utilization of waste and unutilized biomass by plants, microorganisms, etc. and the recovery of important substances (phosphorus, rare metals)
・Research contributing to the development of innovative production processes for bioproducts (e.g., synthetic reaction processes, improved separation and recovery, continuous processes, low energy use, etc.)
・Research involving the search for and development of enzymes that can efficiently degrade macromolecules into low molecular compounds with high temperature load

tolerance

The development of synthesis technologies for chemical products made from biomass will be covered in the "Resource Circulation" area. For details, please refer to "6.2. 'Resource Circulation' Area" in Chapter 6 of the Application Guidelines.

6.4 "Semiconductor" Area

Program Officer
KURODA Tadahiro
(Professor, School of Engineering, The University of Tokyo)

Ⅰ. Overview of the Technology Area

The power consumption of our information and communication infrastructure is increasing exponentially as we develop into a full-fledged advanced information society driven by technologies such as 5G/6G, IoT, automated driving, and robotics, as well as DX. Achieving carbon neutrality will require dramatic advancements in the power saving capabilities of semiconductor devices and circuit hardware, which are the foundation of information and communication infrastructure. Also crucial will be advancements in power transmission technologies, namely those involving energy conservation and large, complex, and highly reliable power grids running on renewable energy or hydrogen, as well as storage batteries.

In this technology area, we aim to radically reduce the power consumption of semiconductors for information and communication infrastructure. Specifically, we aim to develop semiconductor device and process technologies that enable ultra-low power logic memory, innovative transmission hardware technologies that reduce power consumption per communication bit by several orders of magnitude, and materials and implementation methods that enable highly efficient thermal management. We will also develop highly efficient and reliable power conversion and control circuits, inverter/converter stabilization technologies, etc., for energy conservation and higher reliability in large, complex power grids.

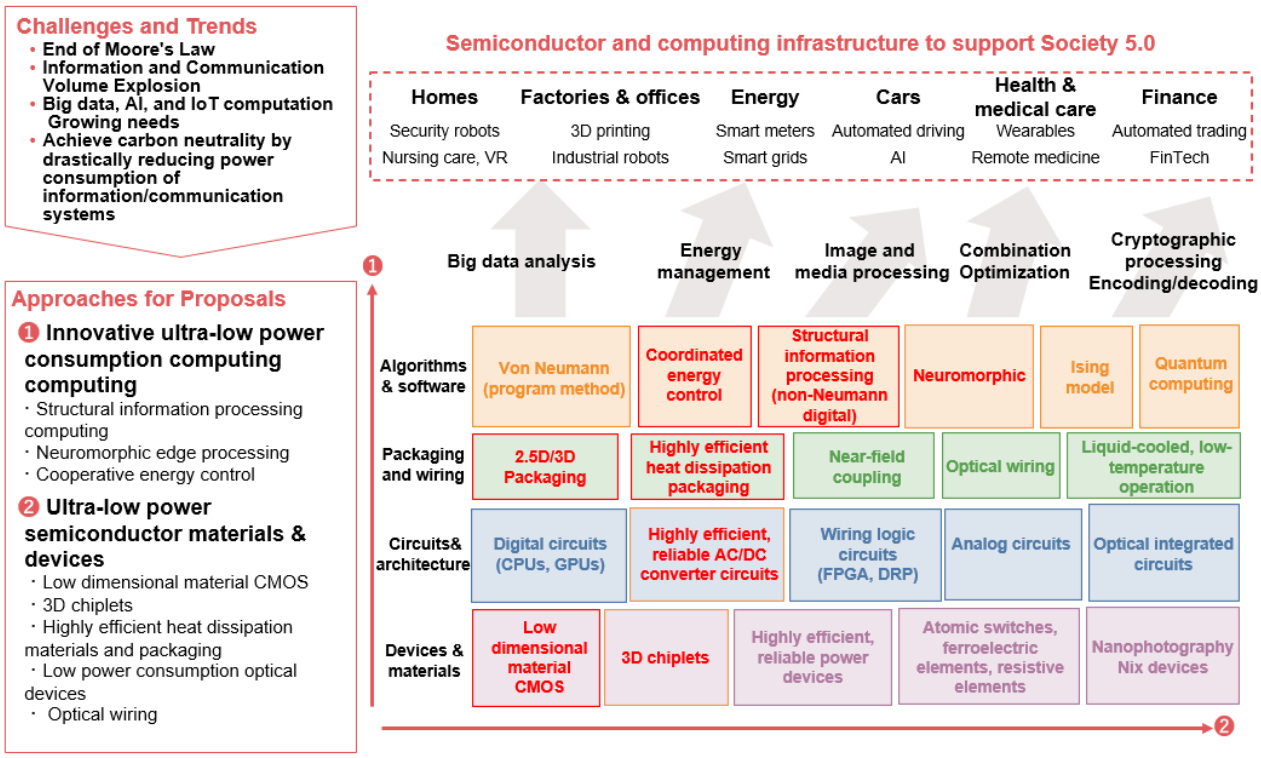

Figure 4: Target technologies in the "Semiconductors" area

(Modified from the JST-CRDS Strategic Proposal (CRDS-FY2017-SP-02))

Ⅱ. Technological Elements Expected to Be Proposed

In the "Semiconductor" area, we invite R&D proposals in the following categories:

a. Next-generation logic memory technologies enabling ultra-low power operation

b. Innovative transmission hardware technology that radically reduces power consumption per communication bit

c. Novel materials, devices, and thermal management technologies for highly efficient heat dissipation of chips and boards

d. Power conversion devices, circuits, and control technologies to achieve high efficiency and reliability in large and complex power grids

e. New ideas for semiconductors to achieve carbon neutrality

a. Next-generation logic memory technologies enabling ultra-low power operation

Information processing semiconductors using existing Si semiconductor materials are facing the limits of miniaturization and are approaching the end of Moore's Law. Furthermore, the explosive increase in AI parameters is requiring increasing CPU and GPU processing power and memory

capacity. Meanwhile, the large amount of data being transferred between processor, memory, and storage are a major bottleneck. One particularly large source of energy consumption is current main memory (DRAM) which, as volatile memory, requires frequent data transfers to and from storage and is one of the major sources of energy consumption. This situation is creating high expectations for various innovative next-generation electronic device technologies that can achieve even higher performance and lower power consumption to solve these issues.

In this category, we invite a wide range of R&D proposals, from basic to applied research, on next-generation electronic device technologies such as sub-nm generation of CMOS device technologies, 3D integrated device technologies, next-generation non-volatile memory, logic and memory integration, 3D chiplet integration technologies, and other next-generation logic and memory technologies, with the aim of significantly reducing power consumption. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Innovative channel materials and their device fabrication technologies for sub-nm generation of CMOS

  We invite proposals for research and development on innovative ultra-thin, high-mobility channel materials (2D layered materials, oxide semiconductors, SiGe, compound semiconductors, etc.), their deposition processes, gate stack formation processes, contacts, and other elemental technologies, process integration, and modeling for the practical application of sub-nm generation of CMOS.

- 3D structured devices and ultra-high density integration technologies

  We invite R&D proposals for CMOS transistor monolithic 3D integrated device technologies, hybrid junction 3D integrated device technologies, and heterogeneous 3D integrated device technologies with stacked heterogeneous material devices.

- Development of next-generation nonvolatile memory

  We invite proposals for research and development on the creation of new concepts for non-volatile memory, as well as on the development of existing non-volatile memory (FeRAM, MRAM, etc.) with larger scale, higher speed, lower operating voltage, and higher reliability.

- Device technologies for logic and memory integration

  We seek proposals for research and development on materials, processes, circuit configurations, high-density integration technologies, and device applications for 3D integrated devices that integrate memory and logic to radically shorten data travel distances, increase

speed, and reduce power consumption.

b. Innovative transmission hardware technologies that radically reduce power consumption per communication bit

The development of society into an advanced digital society (Society 5.0) will see the handling of vast amounts of data beyond conventional expectations, and global information volume is expected to reach more than 30 times that of 2018 by 2030 and 4,000 times by 2050. If development continues at the current pace, annual global power consumption for information alone is expected to reach 42 PWh in 2030 and 5,000 PWh in 2050, far exceeding the current consumption of around 24 PWh. In order to meet the ever-increasing demand for communications and realize a low-carbon society, there is an urgent need to develop innovative hardware technologies that reduce power consumption per communication bit by several orders of magnitude. It is particularly important to reduce communication energy usage by data centers where large amounts of data are processed. To achieve this, in addition to reducing the power consumption of high-speed router equipment, conventional electrical interconnects must be replaced with high-efficiency optical interconnects, and the repeated OEO conversions in the network must be removed and transformed into an optical switch network.

In this category, we invite R&D proposals for solving bottlenecks in information processing and communication paths using various technologies, including power-saving chip-to-chip and chiplet-to-chiplet communication, next-generation optical transceiver technologies for board-to-board (rack-to-rack) communication, high-speed optical switch technologies for optical networking, and power-saving high-speed router equipment. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Ultra-low power, high-density, broadband interconnect technologies for chip-to-chip and chiplet-to-chiplet interconnection

  We invite R&D proposals for new transmission methods, packaging technologies, optical wiring technologies, etc. that will enable a drastic reduction of communication energy on package substrates and boards.

- Next-generation optical transceiver technologies for high-capacity and power-saving data transmission among boards and racks

  We seek proposals for next-generation optical transceiver technologies such as Co-Packaged Optics (CPO) and Near-Package Optics (NPO), which enable significant reductions in the power consumption of chip I/O SerDes and optical transceiver optoelectronic interfaces, and

technologies to boost density and capacity, along with innovative active optical devices such as semiconductor lasers that can operate with low voltages, new ultra-high speed optical modulators, and ultra-low capacitance light receiving elements.

- Innovative optical switch device technologies that enable significant power savings by reducing OEO conversion

  Aiming to reduce OEO conversion in optical communication networks and data center networks and transform them into all-optical networks, we invite R&D proposals for optical switch technologies that can be applied to optical circuit switches (OCS), optical burst switches (OBO), and optical packet switches (OPS), and for means to give them multiple ports and greater speeds while miniaturizing them.

- Innovative memory and FPGA technologies for power saving in high-speed router equipment

  We invite research and development proposals for the development of non-volatile memory and circuit networks that will enable lower power usage by FPGA circuits that control the information processing of route-switching routers installed in many communication pathways.

c. Novel materials, devices, and thermal management technologies for highly efficient heat dissipation for chips and boards

As semiconductor integrated circuits continue to increase in capacity, heat dissipation from chips with integrated circuits has become a major bottleneck reducing the information processing speed and power consumption of chips. As semiconductor miniaturization slows down, there are high expectations for three-dimensional integrated circuits (3DICs), in which semiconductor chips are stacked vertically, as a means of increasing the degree of integration and reducing power consumption. However, there are concerns that the increased power density resulting from the three-dimensionality could cause reliability failures if the junction temperature of the devices increases. Innovative heat dissipation technologies need to be developed at various levels, including systems, device structures, materials, and physics, but there is still no academic system for going about this, creating a bottleneck.

In this category, we invite R&D proposals concerning the theoretical investigation of heat dissipation models, the exploration and development of materials and material processing, and the investigation and proposal of systems and device structures. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Building and validation of heat conduction models at the nanoscale and at interfaces, and

incorporation into simulations

We invite proposals for research and development related to the establishment of a scientific theory of thermal conduction models for interfaces and nanoscale ultrathin films that exist in many integrated circuits, and the development of high-precision simulation technology based on such models.

- Proposal and demonstration of advanced heat dissipation technologies using phonon engineering, etc.

  We invite R&D proposals for the development of innovative heat dissipation technologies based on the elucidation of the behavior of phonons, which are the primary heat conductors in semiconductors and insulators.

- Development of, and technologies to produce, new high thermal conductive materials applicable to packaging processes

  We seek R&D proposals for thermal conductive materials and packaging technologies that efficiently transfer heat emitted from chips to packages and dissipate it to the outside.

- Low thermal budget manufacturing technologies for insulating materials with excellent heat dissipation properties adaptable to BEOL processes

  We invite R&D proposals for multilayer interconnect insulators and low thermal budget technologies for transferring heat released from semiconductors and insulators to the top surface of chips through multilayer interconnects formed by BEOL and dissipating the heat to the package.

- Research on new materials with high heat dissipation by incorporating materials informatics (MI) methods, etc.

  We seek R&D proposals involving a highly efficient search for a wide range of heat dissipating materials that applies MI and that goes beyond researchers' knowledge, experience, skills and experiments.

d. Power conversion devices, circuits, and control technologies to achieve high efficiency and reliability in large and complex power grids

Achieving carbon neutrality will require not only meeting ambitious power-saving goals for information infrastructure but also reducing electrical energy consumption throughout the entire supply chain, in all its size and complexity, from "production," "transportation," "distribution," and "collection" to the "supply" and "use" of electrical energy. This in turn will require backbone power grids to have

greater efficiency and advanced control and operation methods for the numerous interface devices and circuits that exist in their complex power systems, which run on renewables, hydrogen, and storage batteries. In addition, connecting various distributed energy sources to consumer systems and operating them in coordination from the power grid to equipments in homes and buildings will require the installation of numerous inverters and converters, as well as frequent power conversion to and from the grid, making the advanced control and operation technologies of grid-connected equipment, and the ability to control EMC, among the bottlenecks being faced. In addition, for future high-voltage power conversion, it is important to conduct basic research on the next generation of semiconductor devices that will greatly surpass the performance of conventional devices in terms of such things as drive voltage and current. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Fundamental high-efficiency technologies for the power capacities of voltage and AC-DC converter circuits, which exist in a wide range of applications, from the grid to distributed power systems

  The use of DC and AC power supplies of various voltages in a variety of devices requires a large number of voltage and AC-DC converter circuits. We invite R&D proposals for technologies to radically downsize and increase the efficiency of voltage and AC-DC converter circuits, including higher performance passive devices that work with power devices in these circuits, as well as circuit configurations and control schemes.

- Inverter and converter circuit technologies that can cope with instability and noise in the grid

  We invite proposals for research and development on inverter and converter technologies that can cope with frequency and voltage fluctuations that occur in power grids where DC-driven renewable energy sources (solar power, wind power, storage batteries) have become the main power source, and that can also reduce noise in power conversion systems.

- High-performance gate driver technologies for high-precision power control

  We seek R&D proposals for gate driver technologies to precisely control power conversion circuits (inverters/converters), suppress the breakdown and degradation of on-board power semiconductors, and reduce power consumption and heat generation.

- Intelligent smart inverter technologies that enable the coordinated operation of devices in homes and buildings from the power grid with high reliability and low power consumption

  We invite R&D proposals for intelligent smart inverter technologies that have the ability to autonomously regulate power grids connected to various power sources to stabilize the power

systems, improve power quality, and achieve coordinated power savings for the entire power network.

e. New ideas for semiconductors to achieve carbon neutrality

We expect R&D proposals for semiconductors based on new ideas for achieving carbon neutrality that do not fall into the above categories.

6.5 "Green Computing and DX" Area

Program Officer
KURODA Tadahiro
(Professor, School of Engineering, The University of Tokyo)

Ⅰ. Overview of the Technology Area

The volume of communication and the power consumed by our information and communication systems are increasing exponentially as we develop into a full-fledged advanced information society driven by technologies such as 5G/6G, the IoT, automated driving, and robotics, as well as DX. To achieve carbon neutrality, there is an urgent need to introduce innovative computing architectures that radically reduce power consumption in information and communication systems. In particular, we cannot ignore the problem that the development of a series of intelligent information processing technologies such as AI technologies (prediction, recognition, generation, and optimization), which are supposed to eliminate waste and improve efficiency in human society, have conversely already begun to cause major social problems in the form of explosive increases in communication volume and power consumption. With regard to power transmission, in addition to energy conservation for power infrastructure hardware, there is also a strong need for greater efficiency and less loss throughout the entire complex supply chain, from the "production," "transportation," "distribution," and "collection" of energy to its "supply" and "use."

With the goal of dramatically reducing the power consumption of information and communication systems, this technology area aims at a paradigm shift from general-purpose computing, which consumes large amounts of power, to low-power computing with limited application areas. Specifically, we will promote the research and development of innovative domain-specific non-Von Neumann computing architectures and edge chips based on them, as well as efficient data control techniques to address the problem of the data traffic explosion between edge and cloud computing. In addition, to achieve higher efficiency and less loss throughout the entire power system, we will also promote R&D for innovative architectures that can estimate and predict power system component status as well as human behavior and intentions through analysis of data collected by IoT sensors.

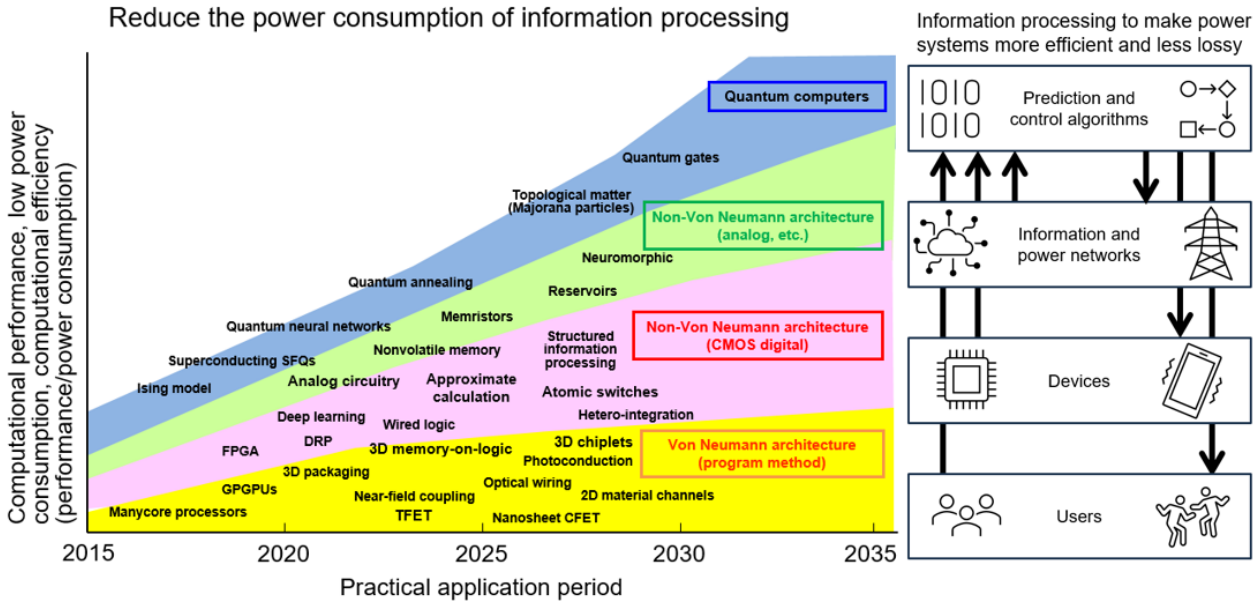

Figure 5: Target technologies in the "Green Computing and DX" area

(Modified from the JST-CRDS Strategic Proposal (CRDS-FY2017-SP-02))

Ⅱ. Technological Elements Expected to Be Proposed

In the "Green Computing and DX" area, we are seeking R&D proposals in the following categories:

a. Innovative non-von-Neuman digital computing architecture for domain-specific applications
b. Innovative computing systems for power saving in AI processing
c. New architectures to appropriately control the vast amount of information collected at the edges between the edge and the cloud
d. Data collection, sharing, and distribution architecture for power saving and energy management technology using this architecture
e. New ideas for green computing and DX to achieve carbon neutrality

a. Innovative non-von-Neuman digital computing architecture for domain-specific applications

The dramatic growth of the development and utilization of AI processing has increased demand for advanced chips such as GPUs, which has led to explosive growth in the power consumption of data centers where these GPUs are installed. In mobile applications, in addition to conventional PCs and smartphones, there is a growing trend toward expanding AI processing in edge devices that require advanced intelligent decision making, such as robots and self-driving cars, which is expected to cause

a significant increase in power consumption in the future. However, AI processing using the current von-Neumann architecture consumes a large amount of energy for data transfer between the processor and memory, so there are hopes for the development of AI technologies and other data processing technologies that will involve adopting new, domain-specific, non-von Neumann next-generation computing technologies to achieve innovations in this area.

In this category, we invite R&D proposals for game-changing non-Von Neumann next-generation computing architectures, AI processing technologies based on them, and the chips to enable them. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Innovative architectures such as domain-specific non-von-Neumann computing for automated driving, robotics, etc.

  We invite research and development proposals for AI technologies and other data processing technologies by means of adopting new, domain-specific, non-von Neumann next-generation computing technologies.

- Novel computing architectures that perform computation by switching arithmetic units without memory, such as with structural information processing

  We invite research and development proposals for innovative computing architectures that use structural information processing to perform operations by controlling the connection of logic circuits without using memory.

- Novel edge computing architecture that uses power only when necessary, such as intermittent computing

  We invite research and development proposals for computing architectures that reduce power consumption by dynamically controlling the operation of logic and memory, such as intermittent computing, in which logic and memory are operated only when operation is required.

- Ultra-low power computing using uncertainty, such as with probabilistic computing

  We invite research and development proposals for innovative computing architectures that allow for error tolerance and probabilistic information processing, rather than traditional deterministic computing.

- In-memory and near-memory computing architectures that reduce power consumption by processing information in or near memory

  We seek research and development proposals for computing systems and chips that radically reduce the power required to transfer information between logic and memory by moving the

CPU and memory closer together or embedding logic in memory.

b. Innovative computing systems for power saving in AI processing

With the explosion of generative AI, the computational processing required to train transformers will be enormous, potentially leading to an explosion in power consumption in the cloud. To prevent this, a new computing architecture is needed that can achieve the performance required for the application even with lightweight learning. Along with power savings in cloud learning, it will be important to also have power-saving models, architectures, and implementation techniques that perform learning independently at the edge.

In this category, we invite R&D proposals for game-changing next-generation AI models with power saving as the main objective, as well as proposals for optimal computing architectures and the chips that will enable them. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- AI models that achieve radical power savings for generative AI, and the optimal computing architecture for them

  We seek R&D proposals for AI models that achieve dramatic power savings, such as large-scale language models and multimodal architectures, which are the core of generative AI, as well as for optimal computing architectures for these models.

- Development of ultra-low power circuits based on innovative AI architectures such as Brain-Inspired AI Architecture, and chips that use them

  We invite R&D proposals for innovative low-power AI architectures for brain-inspired AI built on mathematically clarifying the learning and information processing system of the brain with 20W power consumption.

- Develop on-device, on-site learning technologies and edge chips based on them that do not require large-scale learning in the cloud

  We seek R&D proposals for power-saving AI models, architectures, and implementation techniques that learn independently at the edge (on-device and on-site), as well as proposals for edge device architectures and chip systems that efficiently perform relearning and other tasks at the edge.

- New models, algorithms, and computing architectures for information processing based on knowledge of biological information processing

  We invite research and development proposals for the establishment of new mathematical

information processing models based on the science of information processing models for sensory organs (sensors) and neural networks, and for computing architectures based on these models.

- Development of domain-specific power-saving AI accelerators for robots, etc.

  We seek R&D proposals for the development of AI accelerator software, circuits, and chips optimized for applications such as automated driving and robotics.

c. New architectures to appropriately control the vast amount of information collected at the edges between the edge and the cloud

Society 5.0 is expected to be realized through CPS, which achieves a sophisticated integration of the physical world of smart robots, automated driving, the IoT, etc., and cyberspace consisting of various data and information on computers and networks, to enhance human capabilities and support human activity, aiming for safe, comfortable living and a vibrant society. However, the huge amount of data collected by sensor devices and transmitted to the cloud for information processing not only requires a staggering amount of communication energy, but also causes a bottleneck due to high latency, which prevents CPS and the IoT from being fully effective in areas where real-time performance is required.

In this category, we invite research and development proposals for a new architecture that will appropriately control the vast amount of information collected at the edge (e.g. IoT sensors) between the edge and the cloud, and fundamentally recommend power consumption for the entire communication system. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Ultra-low power edge-cloud information transfer and processing architecture using multi-access edge computing

  We invite research and development proposals for ultra-low power edge-cloud information transfer and processing architectures using multi-access edge computing.

- Domain-specific edge-cloud cooperative information processing architecture for smart robotics, automated driving, etc.

  We seek R&D proposals for edge-cloud cooperative information processing architectures that reflect the unique data distribution characteristics of each domain, such as smart robotics and automated driving.

- Ultra-low power AI control technologies based on collaboration between edge AI and cloud AI

We invite R&D proposals for AI algorithms and architectures that enable distributed cooperative processing to minimize AI processing power throughout the edge and the cloud.

- Chip architectures and systems that efficiently handle distributed learning of AI models such as federated learning

  Federated learning reduces the cost of data collection by distributing AI models to a distributed environment for modeling, but it requires models to be exchanged between a central server and clients, which requires a different system to be considered. We seek proposals for R&D on chip architectures and the systems to realize them.

d. Data collection, sharing, and distribution architecture for power saving and energy management technology using this architecture

In energy management systems, there is a strong need for higher efficiency and less loss throughout the entire complex supply chain, from the "production," "transportation," "distribution," and "collection" of energy to its "supply" and "use."

Therefore, in order to achieve significant energy savings throughout the entire energy system, it is necessary to collect and analyze data on the edge of the system in real time, including data on human behavior, preferences, and psychology, in addition to sensor information, equipment operation information, and surrounding environment information, and to optimize the relationship between energy supply and demand throughout the entire system in a new fusion of fields spanning not only engineering but also social science.

In this category, we invite research and development proposals related to methods for anonymizing data collected by IoT sensors; understanding the status of systems and components through data analysis; estimating and predicting human behavior, intentions, preferences, and psychology; and algorithms for secure and efficient data sharing and distribution. For example, we expect research and development proposals to solve the following bottleneck issues, but we are looking for innovative proposals not limited to these.

- Integrated algorithms to minimize power consumption by estimating, predicting, and guiding consumer behavior and intentions based on data

  We invite R&D proposals for algorithms to predict human behavior and guide people toward better energy conservation in order to formulate and implement strategies for power conservation by utilizing collected power data.

- Development of technologies and distribution methods for generating synthetic data on electricity

use and the movement of people and goods

We seek R&D proposals for technologies that collect and analyze data from the edge in real time, including sensor information, equipment operation information, and surrounding environment information, as well as data related to human behavior in the system, to guide human behavior and optimize the relationship between energy supply and demand throughout the entire system.

- Methods for securely collecting, managing, and sharing data from hierarchical IoT devices and innovative algorithms that enable data to circulate efficiently across the entire power network

  We invite R&D proposals for innovative algorithms that securely collect and share consumers' user data, which is the most significant challenge for implementing power savings in society.

- Temporal/spatial multi-scale energy demand forecasting technologies

  We invite R&D proposals for technologies that enable energy demand forecasting and demand guidance in complex power systems in which renewable and hydrogen energy systems and storage batteries are connected to the backbone power grid.

e. New ideas for Green Computing and DX to achieve carbon neutrality

We expect R&D proposals for Green Computing and DX based on new ideas for achieving carbon neutrality that do not fall into the above categories.