Future Vision

JAEA 2050 +

Proposal of the Solutions for
Sustainable Society through
Nuclear Science and Technology

Japan Atomic Energy Agency

Preface

► Japan Atomic Energy Agency (JAEA) is the sole comprehensive nuclear research and development institution established by Japan's Atomic Energy Basic Act. We have recently issued a future vision titled "JAEA 2050 +※" which outlines the goals we should seek and the actions we should take toward these goals reflecting the opinions of JAEA's young researchers and external experts' opinions.

► In this vision, we focus on the young generation who may become JAEA researchers in the future, and look ahead to 2050. Japan has set a long-term goal of reducing greenhouse gas emissions by 80% by 2050 in the "Global Warming Countermeasures Ordinance" and "The Long-Term Strategy under the Paris Agreement."

JAEA aims to achieve the following goals in 2050.

(1) Nuclear Science and Technology (S&T) would contribute to securing stable energy supply with other various types of energy sources by overcoming challenges associated with enhanced safety, decommissioning, radioactive waste management.

(2) Nuclear S&T would trigger new innovations in the various society fields by collaborating with other fields and create new value, which leads to contribution in alleviating the risk of global climate change issues and realizing future society (Society5.0).

► JAEA aims to draw full potential of Nuclear S&T through collaborations with domestic and foreign research fields, aiming for the realization of decarbonized society as early as possible in the latter half of this century. JAEA will address interactive dialogue with local communities and domestic and foreign people to disseminate its activities, recognizing the need to solve ethical, legal and social issues (ELSI) to make Nuclear S&T acceptable by the society.

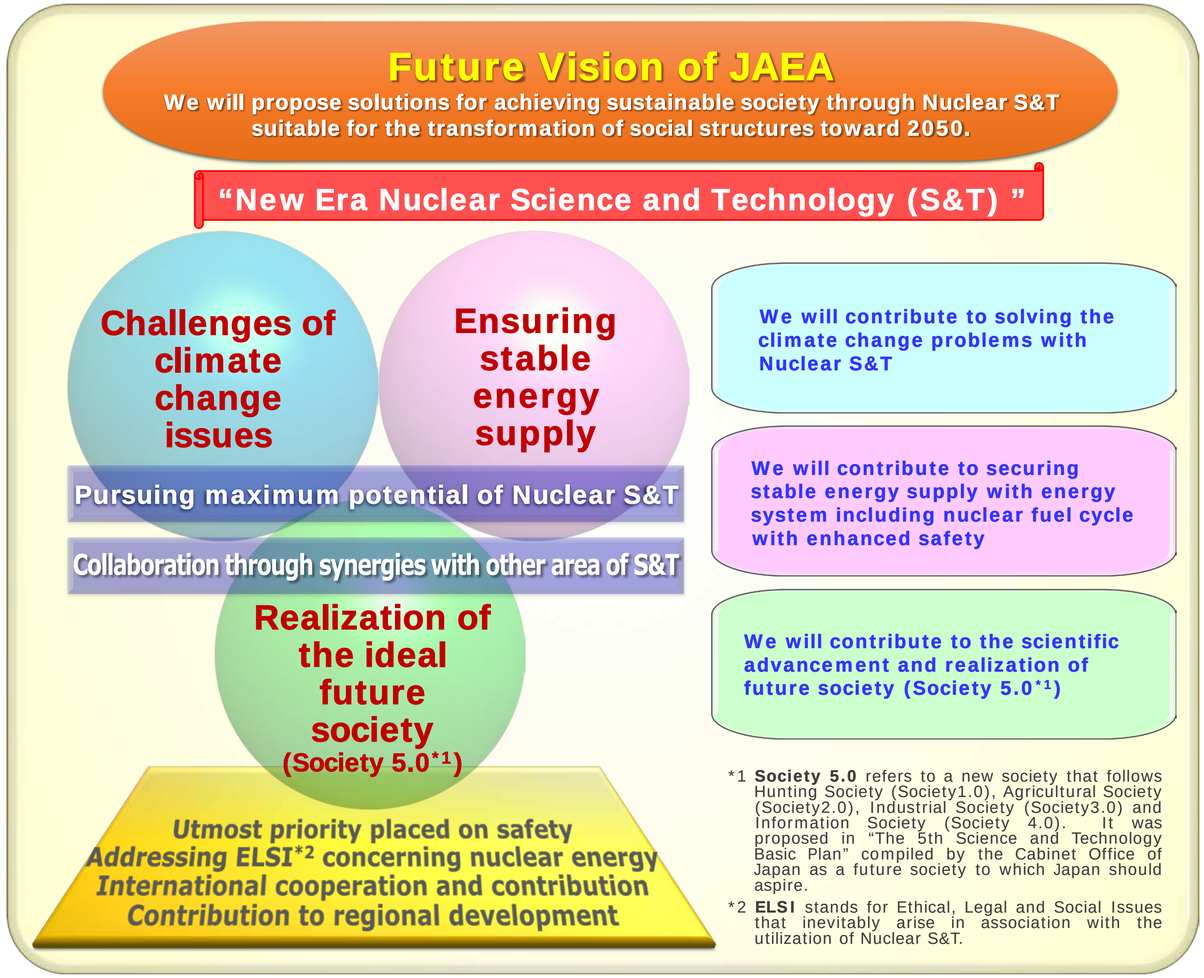
► JAEA will substantiate various strategies for the next "Period of the Medium to Long-Term Objectives", looking ahead for 30 years from now.

► JAEA will flexibly respond to the changing social environment surrounding nuclear technology. JAEA will continue to contribute to society with all its efforts and knowledge. Your continuous support and encouragement would be deeply appreciated.

KODAMA Toshio
President of the JAEA

Our Mission :
On the basic premise of ensuring safety, we will conduct R&D in the field of nuclear energy in a systematic, comprehensive and efficient manner, aiming to secure stable energy supplies, solve global environmental issues and create new science, technology and industry, widely disseminating our R&D achievement, and thus contribute to the improvement of welfare of human society and rise in the national living standard.

※ The vision is titled "2050 +" to indicate that our vision has a long-term perspective, considering Paris Agreement (2016) that aims to achieve a balance between emissions and removals of greenhouse gases (carbon neutrality throughout the world) in the second half of this century.



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Toward the Transformation of Future Society

We will make the maximum use of the potential of Nuclear S&T to alleviate the risk of global climate change problems, to secure stable energy supply and to realize Society 5.0.

One of the most significant transformation we will experience in the future is the transition to decarbonized society

Significant progress in information technology and life science have brought dramatical transformation in our life in the last 30 years. One of the most significant transformation which is expected in the next 30 years by 2050 is the transition to a decarbonized society*1.

"The Long-term Strategy under the Paris Agreement" (Cabinet Decision, June 11, 2019) reads that Japan proclaims a decarbonized society as its ultimate goal and aims to accomplish it ambitiously as early as possible in the second half of this century. To achieve the long-term goal of reducing greenhouse gas emission by 80% by 2050, it also reads that Japan should boldly take measures towards its realization.

Extreme weather events which are thought to be attributed to climate change may have enormous impact on natural environment and human society. Innovation for a decarbonized society is the important key not only for human beings but also for the earth to secure its longevity.

*1 Achieving a balance between emissions and removals of greenhouse gases in the second half of this century (carbon neutrality throughout the world)。

S&T development & social implementation are necessary to solve climate change, ensure energy stability, and realize Society 5.0

Basic viewpoint of the energy policy of Japan is "S+3E", that is "Safety," Energy Security," "Economic efficiency" and "Environment" *2.

The "Long-term Strategy" described above states that it is important that all possible options and innovations are explored, including renewable energy, storage batteries, hydrogen, nuclear energy, CCS and CCU*3 for the challenges of energy transformation and decarbonization toward 2050.

It also states that Japan will strengthen its commitment in realizing Society 5.0*4, which is a human-centered society that balances economic advancement with the resolutions of social issues by a system that highly integrates cyberspace and physical space.

Humankind face unprecedented challenges of social change toward 2050. Therefore, it becomes more critical to address various innovation, to bring together human wisdom, to further develop science and technology and to implement its outcomes to society.

*2 Strategic Energy Plan (Cabinet Decision, July, 2018)
*3 CCS : Carbon Dioxide Capture and Storage
CCU : Carbon Dioxide Capture and Utilization
*4 The 5th Science and Technology Basic Plan (Cabinet Decision, January, 2016)
*5 IoT (Internet of Things) is a system basically connecting any device or things to the Internet

Nuclear S&T has a lot of potential

Nuclear energy is used for electricity generation and power for ships without emitting greenhouse gases by using small amount of uranium fuel. It is also used as nuclear battery for space development and power source for manned exploration probe.

Radiation and radioisotope are used in medical and industry fields and contribute to society. Neutrons and X-rays enable us to "see" microstructures of materials. Radiation can also help create new materials with new functions, which shows that it has a significant potential in bringing about innovation in the fields of academic and industry.

Nuclear S&T has a wide range of potential, and by utilizing these, we have been producing results that are useful to society, and there is a possibility that new results will be produced in the future.

It is important to contribute to future society by making maximum use of the potential of Nuclear S&T

Nuclear energy is a 'Zero Emission Energy Source', which can realize stable and high density energy supply. It is important to achieve realization of energy mix*6 with appropriate combination of the various primary energy sources for expediting the realization of decarbonization at an early date. The innovation for the safe use of nuclear energy is required all the more for this purpose.

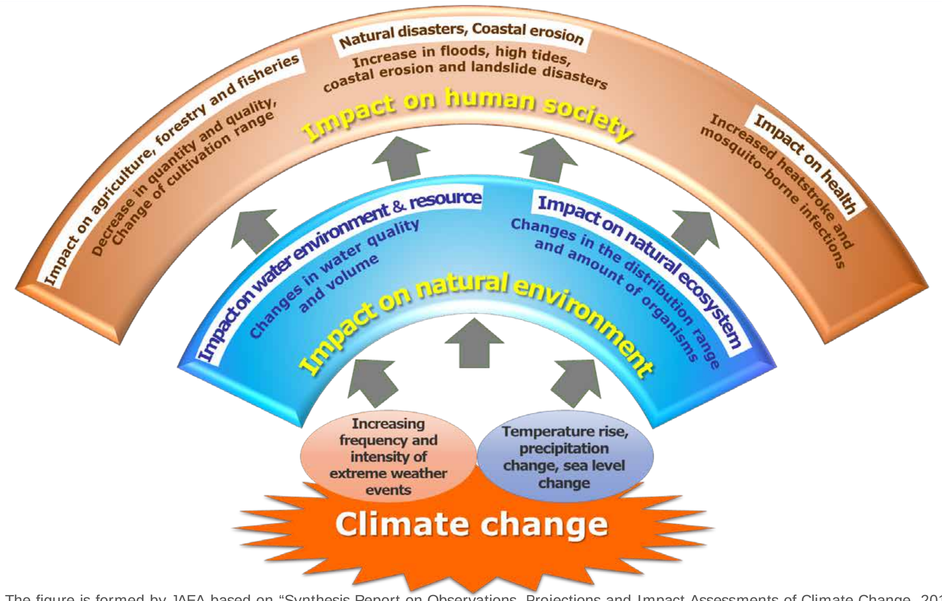
One of the promising CO_2-free technologies is a High Temperature Gas-cooled Reactor that can produce hydrogen utilizing its characteristic high temperature. Innovation for cost reduction of hydrogen production is essential to realize a hydrogen society.

Nuclear S&T has, among other characteristics, the advantage of being the cutting-edge S&T that enables the control of particles and photons that form materials and it requires innovation to create a new value including synergies with other areas of S&T.

Making maximum use of its potential, nuclear energy is expected to contribute to provide solutions to the climate change, ensuring stable energy supply, and realization of Society 5.0.

*6 Energy Mix is the outlook for the future demand and supply, based on the principle of 3E+S and taking measures such as thorough energy conservation, maximum introduction of renewal energy, increased efficiency of fossil plants and reduction of nuclear energy dependency as much as possible.

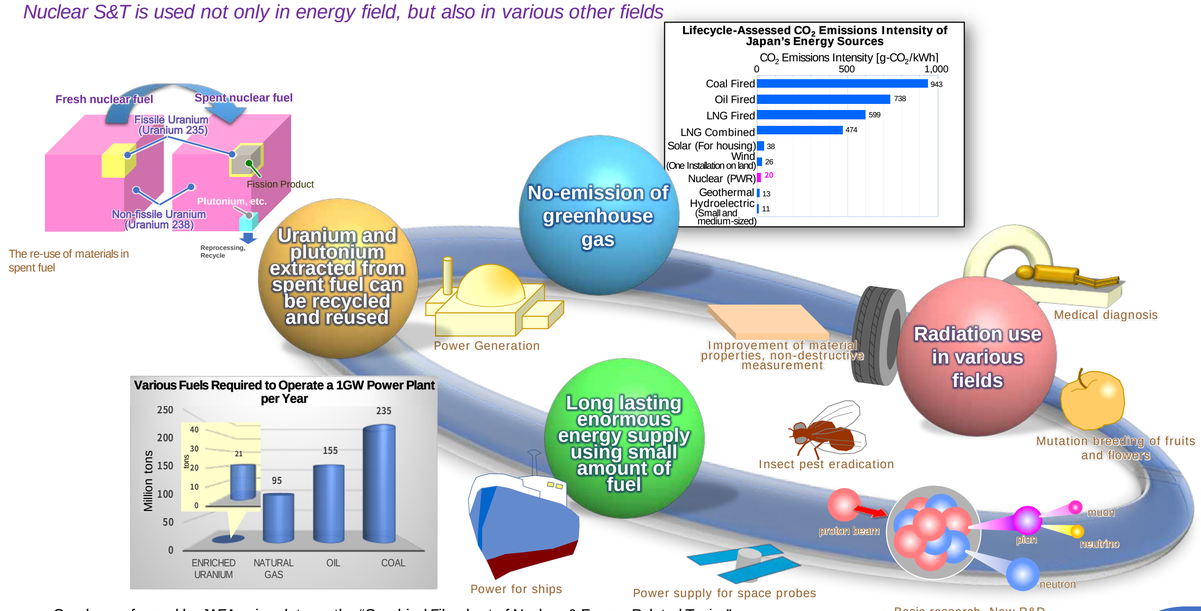
Impact of the global warming on the natural environment and society



The figure is formed by JAEA based on "Synthesis Report on Observations, Projections and Impact Assessments of Climate Change, 2018, Climate Change in Japan and Its Impacts"(Ministry of the Environment(MOE), Ministry of Education, Culture, Sports, Science and Technology(MEXT), Ministry of Agriculture, Forestry and Fisheries(MAFF), Ministry of Land, Infrastructure, Transport and Tourism(MLIT), Japan Meteorological Agency(JMA)) and "Stop Global Warming 2017" (MOE; in Japanese only).

Examples of the uses of Nuclear S&T

Nuclear S&T is used not only in energy field, but also in various other fields



Graphs are formed by JAEA using data on the "Graphical Filp-chart of Nuclear & Energy Related Topics" (Japan Atomic Energy Relations Organization).

Realization of New Era Nuclear S&T

We will propose solutions to various social issues through innovation of nuclear energy. We will actively promote synergies with other area of S&T and create innovation for society.

We will strive for realization of “New Era Nuclear S&T”, reaffirming the value of nuclear safety

While securing energy is indispensable for sustainable social development, the impact from climate change caused by greenhouse gas emissions is threatening the survival of the human race. In order to achieve the challenging goal set in the Paris Agreement, the role that Nuclear S&T plays against the imminent threat of climate change is getting more significant while maximizing the introduction of renewable energies. Nuclear energy is a CO_2-free source that can provide large amount of energy twenty-four seven.

After the oil crisis in 1970’s, Japan actively introduce **d** nuclear energy as “quasi-domestic energy source”. For the realization of the future society, we have to change by reaffirming the value of nuclear safety, reflecting the lessons we have learned from the TEPCO’s Fukushima Daiichi Nuclear Power Station (1F) accident. For that purpose, we name our new effort that aims to contribute to the future society beyond conventional framework as “New Era Nuclear Science and Technology (S&T)”. We aim to realize the following goals.

- Development of Nuclear S&T system that addresses “S+3E” including further enhancement of safety and delivers the solution to social challenges (Nuclear Innovation)
- Active collaboration through synergies with other area of S&T for the purpose of creating innovation in various areas

We will pursue the realization of “New Era Nuclear S&T”, ensuring the interactive dialogue with society.

We will strive for the development of Nuclear S&T systems that address “S+3E” and delivers the solution to social challenges

We will further enhance nuclear safety and contribute to the realization of energy mix, utilizing nuclear energy as one of the indispensable stable energy sources by appropriately combining with various energy sources including renewable energy.

It is essential to try to solve the back-end issues including decommissioning by introducing state-of-the-art technologies.

Creating innovation by collaboration through synergies with other area of S&T

“New Era Nuclear S&T” entails the pursuit of innovation in various fields by using Nuclear S&T. We will create new value by collaboration through synergies with other area of S&T, beyond conventional framework.

In the energy field, we will develop a coexistence system with various types of energy sources. We will also develop the labor saving, automated, and unmanned technology of operation, maintenance and decommissioning utilizing AI, robotic technology and IoT.

In the non-energy fields, we will collaborate with various industries and non-nuclear S&T sectors through synergies. They include: fields of Manufacturing and value creation, Medical technology, Maintenance of social infrastructures, Securing stable supply of natural resources and food and Security.

We will realize “New Era Nuclear S&T” that contributes to society by creating innovation through these efforts.

We will propose solutions to challenges facing nuclear energy, taking on the challenges, by making full use of Nuclear S&T

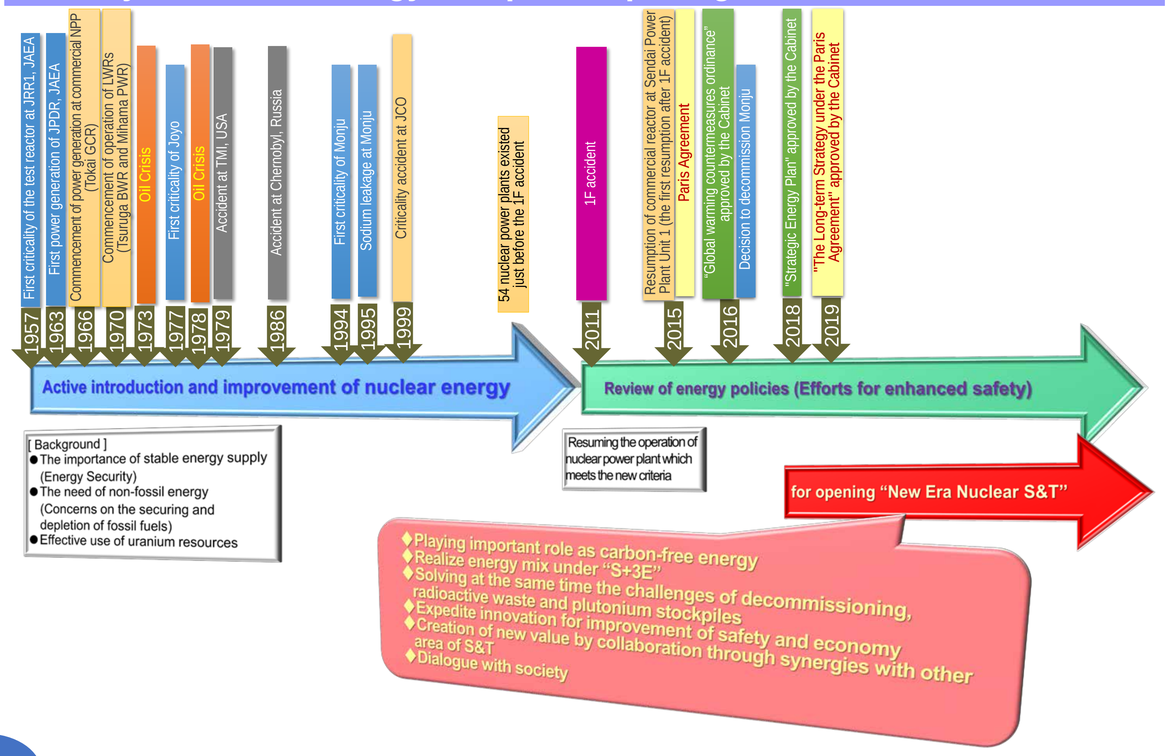
We have inevitably to face ELSI (Ethical, Legal and Social Issues) such as the equitable sharing of the responsibility of dealing with radioactive waste among generations in utilizing Nuclear S&T.

It becomes more important to conduct Responsible Research and Innovation (RRI), complying with relevant laws and regulations, verifying safety during the process from research to social implementation through dialogue with stakeholders in society.

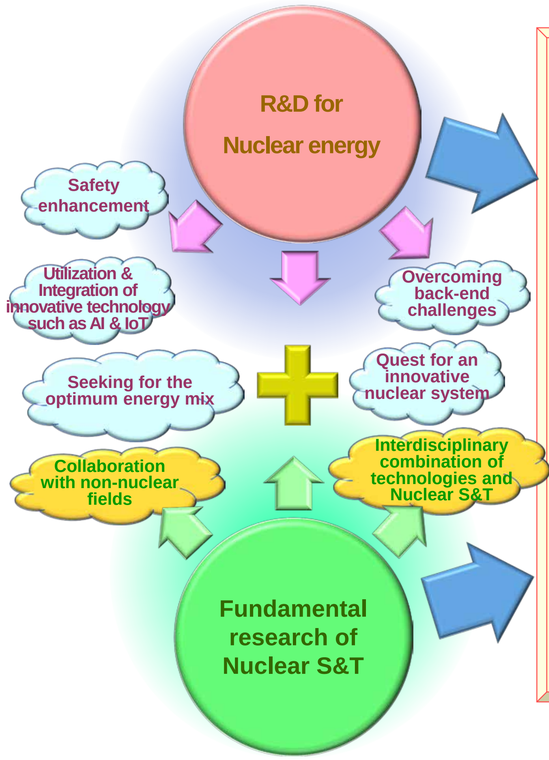
The challenges such as ELSI that nuclear energy faces should be solved not solely through technologies but through cross-sectional initiatives, together with the whole society. New Era Nuclear S&T will tackle these challenges, making full use of Nuclear S&T, while aiming to collaborate with various fields, and present technical options for solving the problems.

For example, we will conduct R&D on the design and safety evaluation of a geological disposal facility for high-level waste considering the intergenerational equity. We will also conduct R&D on innovative reactors such as small modular reactors considering the equity of the plant site and consuming regions.

History of Nuclear Energy in Japan – Opening of “New Era Nuclear S&T”

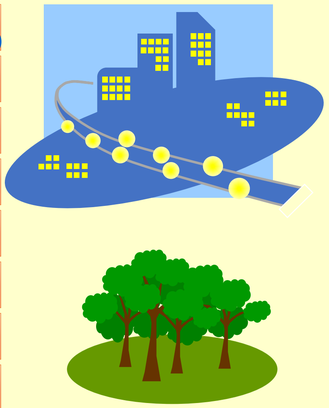


Initiatives for Nuclear S&T



Fields where Nuclear S&T is expected to make contribution by creating innovation

- Measures against climate change
- Ensuring stable energy supply (including saving, creation and storage of energy)
- Realization of Society 5.0
- Securing stable supply of natural resources and food
- Securing food safety, living environment and occupational safety
- Upgrading medical technology
- Maintenance of social infrastructures
- Manufacturing and value creation
- Response to natural disasters
- Security (countermeasures against international terrorism)
- Space/Ocean development



Contribution to the realization of wellbeing of people

Aiming at Nuclear S&T that Continuously Contributes to Society

We will propose solutions for achieving sustainable society by proceeding with R&D to alleviate the risk of global climate challenge, to ensure stable energy supply and to realize Society 5.0.

We aim at Nuclear S&T that continues to contribute to society

We will propose solutions for sustainable society, proceeding with R&D for climate challenge risk alleviation, stable energy supply, and Society 5.0. We will strive for collaboration through synergies with various areas of S&T innovation to create new intellectual concept as well as for creating new value by collaboration and combination with non-nuclear fields. We will also establish a system to conduct R&D and to propose technological solutions, ensuring dialogue with society about ELSI over nuclear S&T.

With these efforts, we aim for nuclear S&T that continues to contribute to society for the future.

Six research themes for making “New Era Nuclear S&T” a reality

To aim Nuclear S&T which makes continuous contribution for the future, it is critical to promote multidimensional R&D strategically taking a cross-sectional approach, bringing out full potential of Nuclear S&T. With this in mind, JAEA will conduct R&D establishing six themes to pursue.

Aim to realize a nuclear energy supply system that meets the demand of future society

Japan will select energy sources that satisfy “sophisticated S+3E” toward future society. JAEA will conduct R&D of the use of nuclear energy on the four main themes to alleviate the risk of climate change and ensuring stable energy supply.

“**Pursuit of safety**”: We will pursue nuclear energy with enhanced safety by promoting R&D on severe accident, accident tolerant fuel, and safer and more economical small modular reactor system. We will also contribute to further strengthening nuclear non-proliferation and improvement of nuclear security.

“**Quest for innovative reactor system**”: For nuclear energy use which meets “sophisticated S+3E”, we will conduct conceptual study of various reactor systems including fast reactor system and contribute to hydrogen society by utilizing the heat from high-temperature gas-cooled reactors. We will explore the various options to realize the optimal combination of energy mix.

“**Management of radioactive materials**”: Aiming to promote more rational means of radioactive waste treatment and disposal, we will conduct R&D on reduction of the volume and radiotoxicity of radioactive wastes with partitioning and transmutation technology.

“**Decommissioning evolution**”: We will optimize the entire process of decommissioning including technology development, and steadily advance safe, speedy and efficient decommissioning of our various retired facilities with state-of-the-art technologies.

Development of sciences through Nuclear S&T

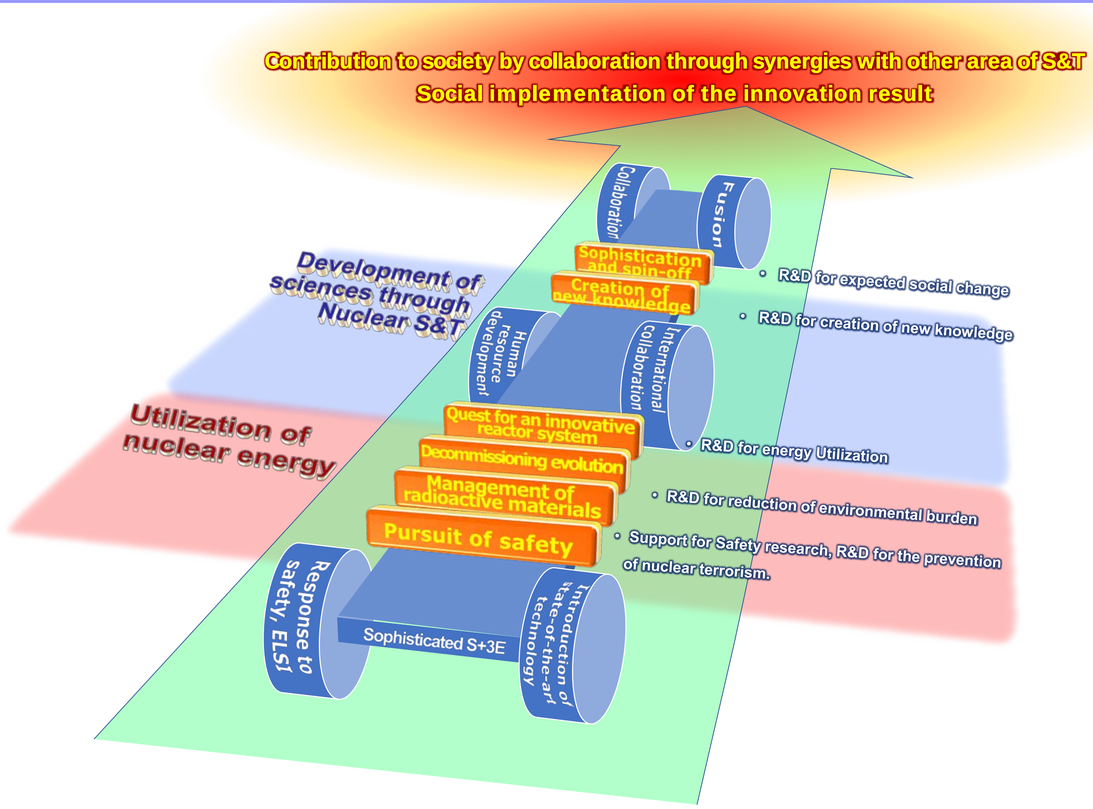
Societal needs for science and technology will change drastically toward the transformation of future society such as a decarbonized society. We will conduct R&D to achieve further sophistication with application of state-of-the-art knowledge and to create and discover the new knowledge and intellectual concepts without being constrained by the barriers of previous nuclear research and development.

“**Sophistication and spin-off**[*1]”: Through active sharing our facilities with external organizations, we will sophisticate the technologies and will renovate the conventional technologies while contributing to the application of our technologies to non-nuclear fields and to the combination with various technologies.

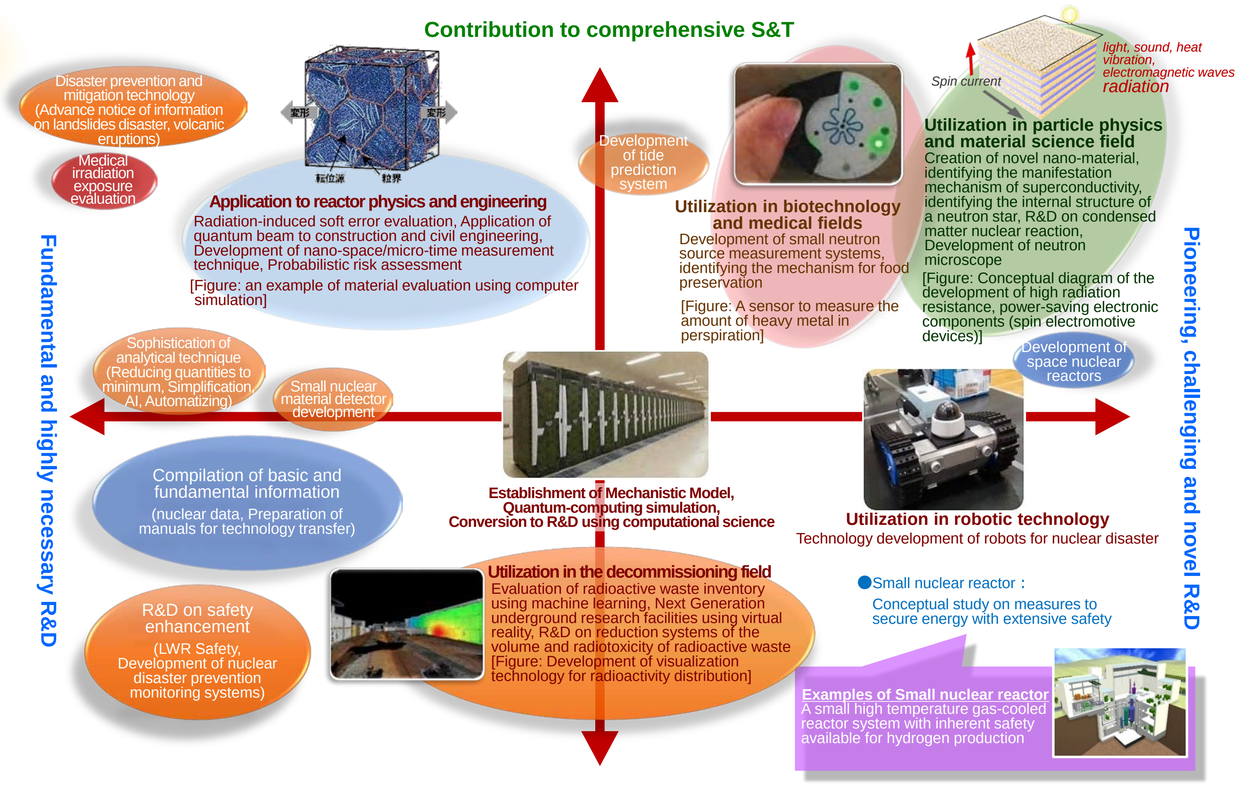
“**Creation of new knowledge**”: By utilizing facilities such as accelerators and test reactors, we will create new knowledge and intellectual concepts applicable to not only nuclear fields but non-nuclear fields.

*1 Application of the technology developed in a certain domain to other domains.

Six R&D themes for making “New Era Nuclear S&T” a reality



Examples of future R&D



Ideal Organization and Human Resources for JAEA

Collaborating and associating with various sectors, we aim for an organization that contributes to society and securing / fostering human resources of a wide range of fields

We aim for an organization to make a societal contribution with a future society in mind

We will strive to be an organization, persistently challenging the issues of alleviation of the risk of global climate change, ensuring stable energy supply and realizing Society 5.0 with collaboration through synergies with other area of S&T, for creating innovations.

We will also strive to be an organization to face various ethical, legal and social issues and propose technical solutions while ensuring interactive dialogue with society.

We will construct the organization with functionality and mobility where diverse human resources with various specialties can fully demonstrate their abilities.

We will contribute to society by collaboration & cooperation with various sectors

We will utilize technologies and knowledge that we have accumulated for meeting various needs of society and responding to uncertainties flexibly.

We will respond to the R&D needs of domestic and overseas through sharing our various facilities and disclosing and sharing information on R&D seeds, and contribute toward socio creation and innovation.

We will conduct R&D, collaborating and cooperating with other sectors beyond the nuclear community to solve social challenges. We will disseminate the research findings to society and ensure interactive dialogue with society to encourage public understanding on Nuclear S&T. We will contribute to the realization of the safe and affluent life.

Securing and training human resources from a wide range of fields

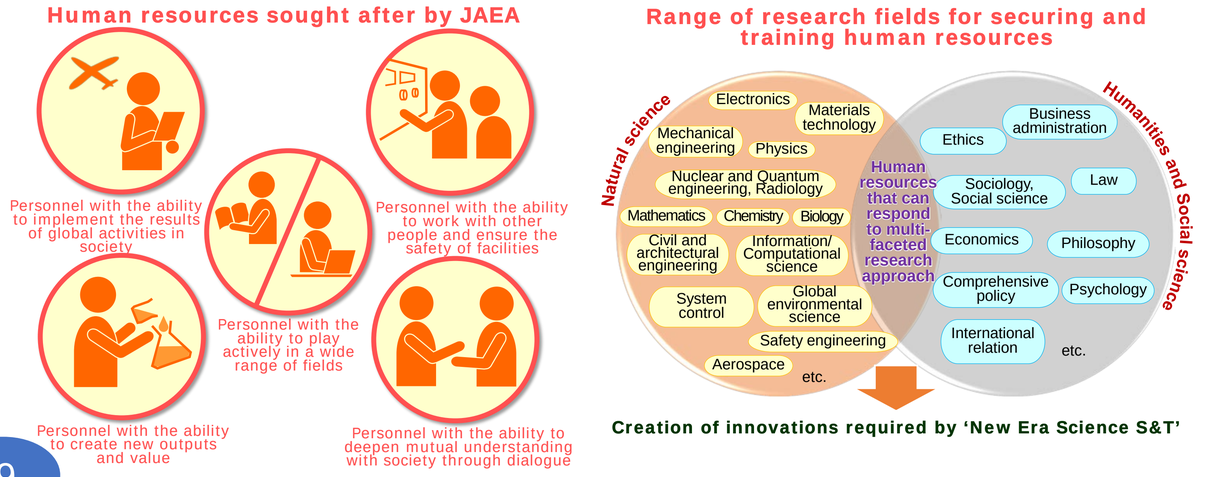
The vision of the human resources sought after by JAEA.

- Personnel who is mindful of contributing to society, and conducts social implementation, giving results of global activities back to society, making use of his/her originality and innovativeness.
- Personnel who actively utilizes his/her expertise in collaborating with various sectors inside and outside of JAEA and contributes to ensuring the safety and operation of facilities.
- Personnel who creates new outputs and values by utilizing and applying Nuclear S&T, combining it with technology of other fields.
- Personnel who has the ability to play an active role at international and domestic agencies in a wide range of fields by utilizing the knowledge and experience in JAEA.
- Personnel with diverse perspectives who can deepen mutual understanding with society through S&T dialogue while giving heed to how things are perceived by society when the technology is implemented.

We propel “Diversity” in securing and training human resources.

It is important to take interdisciplinary approaches to proceed with innovations that ‘New Era Nuclear S&T’ requires. Based on proactive dialogue and personal exchanges between natural science and humanities and social science, we will secure and train personnel who can respond to multi-faceted research approaches.

Combining knowledge of various fields



International Cooperation and Contribution

We will promote nuclear R&D globally

Cooperation & collaboration as a member of the international community

We will actively engage in R&D cooperation with advanced nuclear energy countries, contribution to international nuclear community such as IAEA, and emerging nuclear energy countries, as well as dissemination and outreach of the R&D results.*1

We will seek international contribution by continuous and enhanced international personnel mobility. We also promote an initiative for the international center of excellence by striving to hire more excellent foreign researchers, and enhance JAEA’s presence in the world.

*1 JAEA, Strategy for the International Cooperation (2017)

Contribution to the strengthening of the nuclear non-proliferation / security

Considering the nuclear expansion in India, China etc. and growing concerns over the proliferation of sensitive nuclear technology, weapon-grade nuclear material and nuclear terrorism, it is an era that requires the comprehensive implementation of nuclear safety and nuclear non-proliferation.

We will seek the world without the threat of nuclear proliferation and terrorism while developing technologies for measurement, and verification of nuclear material. We will strive to contribute to the strengthened nuclear non-proliferation/security regime, and denuclearization, developing human resources in emerging nuclear energy countries.

Our plutonium (Pu) for the use of R&D is subject to strict application of IAEA safeguards. Non-reusable Pu is subject to consideration in cooperation with international society to examine all options including development of the technology of making separation impossible.

JAEA international efforts

Regional Development

Conduct of R&D as Regional Member

Beyond the framework of the conventional attitude toward coexistence with local communities

We will strive to take all measures to ensure safety in local residents’ peaceful daily lives and further develop a sense of trust of local residents through interactive communication.

We will make efforts to cultivate a better understanding of local residents on the technology, R&D findings and technological information.

Through these activities, we will strive to develop a sense of trust of them in Nuclear S&T. We will also contribute to the region as a member of community, collaborating in the creation of measures for community development responding to the future regional image, and aspire to make our facilities the symbol that encourages people to settle down in the region.

We will contribute to the life of the region

Under the various strategies which aims for regional revitalization responding to depopulation, low birthrate and longevity, various policies have been advancing in Japan.

With this in mind, we will consider how we would apply our R&D findings to better benefit daily life of the region, using analytical and analysis techniques for various substances in the environment and disaster prevention and mitigation in the area, etc.

Establishing reliable partnership with local community is necessary for decommissioning that takes long time. We will conduct decommissioning with local community together, securing and developing human resources needed for decommissioning.

We will conduct R&D and other projects through dialogue with local residents to gain their deeper understanding and make our work contribute to the local community.

We will contribute to developing future scientists and engineers

Looking into the future, we will promote activities that contribute to nurturing future scientists and engineers through Science Café and Science College for local children, students and ambitious workers to provide opportunity to experience science and technology.

Sustainable Utilization of Nuclear S&T

We will tackle back-end issues steadily and establish R&D cycle for Nuclear S&T, and also aim for sustainable nuclear energy utilization that is trusted and accepted by society.

Establishment of R&D cycle for the long-term use of Nuclear S&T

Since the Japan's Atomic Energy Basic Act came into effect in 1955, more than 60 years have passed, and various facilities have completed their missions and are moving to the decommissioning stage. Thereby, the efforts to tackle back-end issues have become important. For the realization of New Era Nuclear S&T, establishing a sustainable cycle for R&D and tackling back-end issues are necessary for the long-term use of nuclear, which is one of the options of decarbonized energy, while ensuring stable energy supply and contributing to the creation of new value for the realization of Society 5.0.

We have various facilities which have been supporting R&D of Nuclear S&T and have completed their missions, such as "Monju", "Fugen", and Tokai Reprocessing Plant (TRP). We have also various types of radioactive material and radioactive waste generated through R&D. It is indispensable for us to steadily work on the nuclear legacy, radioactive waste management and decommissioning evolution in order to gain trust of society and make Nuclear S&T sustainable well into the future.

The needs for these activities will increase in Japan and abroad. Considering safe, efficient and rational decommissioning, disposal of radioactive waste as our important tasks, while expecting contribution to the creation of new industrial fields for the future, we will actively conduct R&D, technology development and securing and training human resources.*1

*1 "Back-End Roadmap" (2018), "the Medium/Long-Term Management Plan of JAEA Facilities" (2019)

Challenges to reduce environmental impact

Along with a responsible approach to "Nuclear Legacy", the viewpoint of how to reduce the environmental impact is also important. We will conduct R&D on recovery and reuse of useful metal and on nuclear transmutation technology to make the scale of geological repository smaller by reducing radiotoxicity and heat.

Responsible "Nuclear Legacy" initiatives must be optimized, including economic efficiency, on the premise of ensuring safety at every phase of back-end process from understanding characteristics of radioactivity of waste to characteristics examination of the geological disposal site and environmental monitoring. With enhanced cooperation on the common goals of research and analysis technology development such as research on the behavior of radioactive material in the environment and lessons learned from 1F accident, it is important to incorporate state-of-the-art technologies such as AI and robotic technology in collaboration through synergy with other areas of S&T. We will aspire to establish system for passing on skills and knowledge to young generations as well as development of knowledge database for these efforts.

Some waste generated from our facilities have low level radioactive concentration below the standard value and is available for reuse or disposal as general waste after obtaining permission of the authorities. This may lead to the promotion of recycling of resources and the reduction of disposal volume, on which we will proceed collaboration with industry.

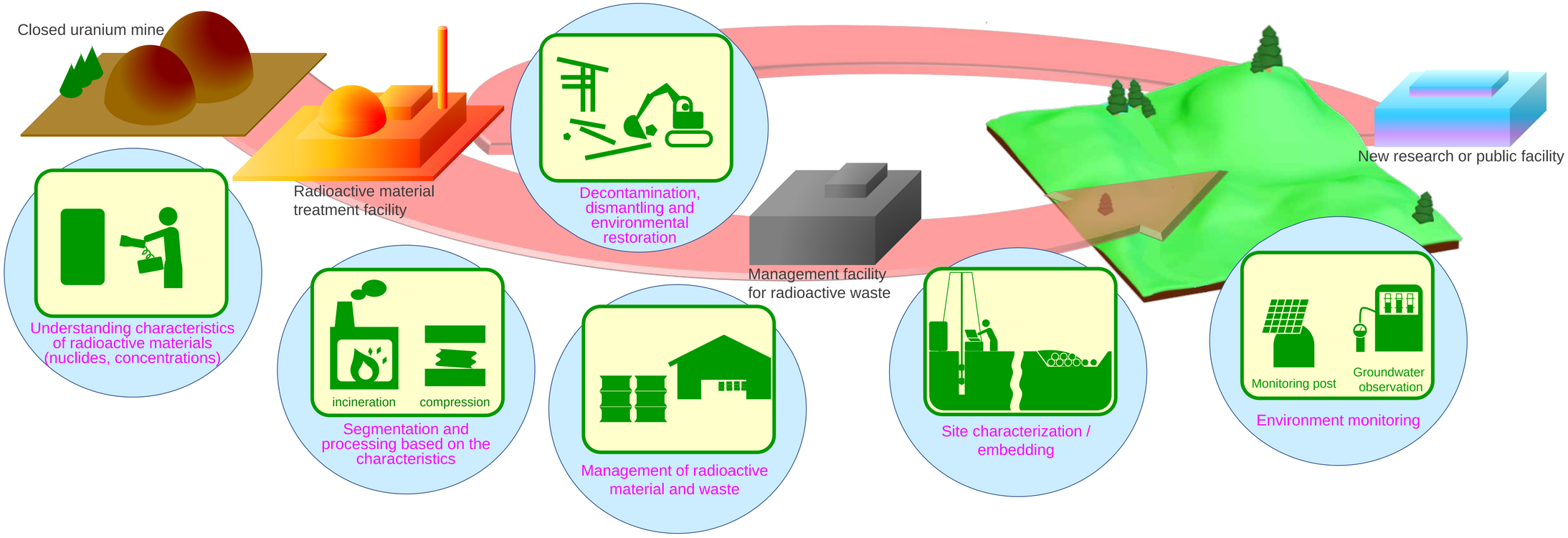
Sustainable utilization of Nuclear S&T which creates new value with trust and acceptance from society

In proceeding these efforts, we will disseminate correct information in a timely manner having dialogue with society. We will actively disseminate research results, reflecting them on decommissioning efforts, and aim to contribute to the advancement of science and technology. Some decontaminated facilities and restored sites will be utilized as new R&D or public facilities while confirming their safety.

We aim to achieve sustainable nuclear utilization that is trusted and accepted by society by solving the back-end issues through dialogue with society as well as technology development, and by establishing a sustainable cycle for R&D.

With efforts described above, JAEA will contribute to securing stable energy supply by energy mix as well as to realize the society that contributes to the realization of Society 5.0, alleviation of the risk of global climate change.

The image of the efforts on back-end issues indispensable for establishing a cycle for R&D



Opinions on Future Vision

We received various opinions from outside experts for the future of JAEA

The Future Vision Advisory Committee which consists of external experts reviewed the draft from various perspectives based on Japan's climate change countermeasures, the social situation surrounding energy, and the situation of JAEA.We have reflected these valuable opinions in our Future Vision. We will take the following opinions as the guidelines for the future and move our Future Vision into concrete actions.

The role of nuclear S&T in the future

- Nuclear energy is essential technology in terms of energy supply stability and countermeasures against climate change. For Japan, which has a low energy self-sufficiency rate, nuclear power generation is significant with utmost priority placed on safety, based on the sincere reflection of the 1F accident, as well as efficient utilization of renewable energy, hydrogen and fuel cell. While considering the realization of a decarbonized society, it is important for JAEA to engage in R&D of Nuclear S&T aspiring for energy mix. It is also necessary to steadily implement the development of technology such as safety enhancement, R&D on small module reactors, and heat utilization and hydrogen production fully being mindful of ELSI at the same time.
- It is essential to deepen society's understanding of nuclear potential through application of nuclear S&T to non-nuclear sectors such as medical fields, manufacturing and creating values, maintenance of infrastructure, food safety and national security.
- It is important to tackle head on the issues of decommissioning making full use of the technologies cultivated in the back-end field. It is also important to establish the system to proceed with decommissioning as a new global industrial field, adopting state-of-the-art technologies and making it attractive, and collaborating with local region with its support.

Expectations for JAEA

- For ensuring domestic and global energy security and developing technologies including the sophistication of nuclear safety technology, JAEA should focus on securing and training human resources, especially on young generation by arousing their interest in nuclear R&D.
- JAEA should contribute to the peaceful use of nuclear energy and aspire to realize the world without the threat of nuclear proliferation and terrorism through technology development and global human resources development.
- The cooperation of technology development and social science is indispensable for social implementation of technology. It is necessary to think carefully about how society perceives, and that leads to the development of a sense of trust. The mission of research institutes is to deepen mutual understanding through S&T communication among public, researchers and engineers. JAEA is expected to become the organization trusted by society, while securing and training human resources that have diverse perspectives.
- Since the efforts to realize future society will attract attention of younger generations, JAEA is expected to create a vision full of dream.
- JAEA staff members are expected to work with a high sense of mission and ethics and to continue to contribute to society in harmony with the domestic and international society.

Future Vision Advisory Committee Members

(in alphabetical order)

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We sincerely thank committee members for their support.

Expected Future Society

It is important to develop science and technology and to implement to society, bringing together human wisdom for tackling the challenges such as decarbonization for society in 30 years.

Technological innovation has changed our lifestyle drastically

Our lifestyle has been changed drastically by technological innovation such as digitalized communication technology since 1980s. Information devices such as personal computers and mobile phone have become everyday information equipment due to the spread of the Internet. Technologies have advanced in the fields of mobility and medical fields. AI is also being put into practical use and application to robotics, speech recognition, etc. is in progress.

Innovation promotion with reconfirmation of the value of nuclear safety is required

Although the primary energy supply in Japan has increased by 20% since 1980s, Energy White Paper, 2019 reveals that over 80 % of the electricity is generated from fossil fuel.

The amount of nuclear power generation increased after the Oil Crisis in 1970s as a non-fossil fuel source in Japan. In the middle of 1990s, the share of nuclear power generation has exceeded 30%. However, since 1F accident, energy-saving efforts and introduction of renewable energy have progressed, while the share of nuclear has remained low. It is an era when we have to re-acknowledge the value of nuclear safety and nuclear-related technical innovation is required.

Climate change countermeasures under the Paris Agreement are urgently needed

One of the most significant transformation which is expected by 2050 is expected to be the transition to a decarbonized society.

In recent years, extreme weather events which are thought to be attributed to climate change has been reported all over the world. The Paris Agreement, which entered into force in 2016, announced to set long-term global goal for holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, noting the importance of the concept of “Climate Justice”.

To achieve these goals, “The Long-term Strategy under Paris Agreement” reads that Japan proclaims a decarbonized society as its ultimate goal as early as possible in the second half of this century. To achieve the long-term goal of reducing greenhouse gas emission by 80% by 2050, it also reads that Japan should boldly take measures towards its realization.

The “2030 Agenda” was adopted by the United Nations General Assembly in September 2015, which set Sustainable Development Goals (SDGs). While reducing greenhouse gas emissions can be a trade-off with the realization of other SDGs such as no poverty, zero hunger, to ensure availability of water and access to energy, climate change is considered as the biggest factor that can influence the achievement of other SDGs. It is necessary for Japan to promote climate change countermeasures in line with elements of SDGs other than climate change.

Science and technology development and social implementation are necessary to solve the issues of Future Society

For Japan to sustain and develop society in the future, it is necessary to take measures against various issues such as the low birthrate and longevity as well as the depletion of food and resources. Basic viewpoint of the energy policy of Japan is “S+3E”, that is Safety, Energy security, Economic efficiency and Environment. Japan also strengthens the efforts to introduce AI, IoT, big data analytics, robotics and sensor device technologies into industry.

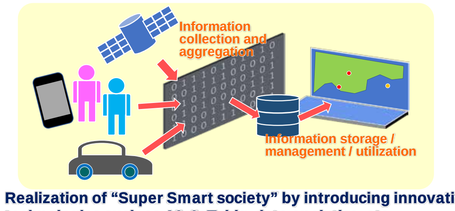
Humankind will face unprecedented challenges of social change toward 2050. Therefore, it becomes more critical to bring together human wisdom and to develop science and technology. It also becomes important to create innovation through implementation of its outcomes to society.

Nuclear S&T, which is the cutting-edge technology that controls elementary particle and photon as well as zero-emission energy, has potential to lead the science and technology in other areas. IAEA states that nuclear S&T contributes to nine of the 17 SDGs, which are zero hunger, good health and well-being, clean water and sanitation, affordable and clean energy, industry, innovation and infrastructure, climate action, life below water, life on land, and partnership for the goals. Placing utmost priority on continuous nuclear safety based on the 1F accident, new technologies that further improve economic efficiency are required of nuclear S&T for making contribution to society.

Future forecasts (focusing on climate change countermeasures, nuclear S&T)

Field	10 years from now (around 2030)	30 years from now (around 2050)
Climate change counter-measures	Paris Agreement: Holding global average temperature increase to well below 2°C and pursuing to limit the temperature increase to 1.5°C [Target] n Japan’s reduction target of greenhouse gas: 26% (compared to FY2013) n Japan’s target of renewable energy power ratio: 22-24%	[Target] n Japan’s reduction target of greenhouse gas: 80% n Making Japan’s renewable energy an economically self-supporting main source of electricity
	(Forecast (example)) l Spread of CO_2-free hydrogen production, commercialization of hydrogen production/storage, commercialization of hydrogen power generation, spread of thermoelectric conversion and waste heat power generation using unused waste heat in Japan l Practical application of large-scale electricity storage system for post lithium-ion batteries such as all-solid-state batteries, metal-air batteries, and Redox flow batteries. → Practical application of next generation solar batteries, Cost down of FCV to gasoline-powered vehicle l Practical application of technology of CO_2 recovery/effective utilization/ storage. Mass-production of methanol from CO_2 by artificial photosynthesis	
Nuclear energy	l Japan’s target of nuclear energy generation power ratio: 20-22% l Decommissioning of 1F. (fuel-debris recovery) l Efforts to reduce environmental burden (Selection of candidate sites for geological disposal of high-level radioactive waste, construction of disposal facility of radioactive waste generated from research, industrial, and medical facilities, etc.) l Nuclear Fusion −Plasma ignition at ITER and commencement of operation	l Promotion of the innovation of nuclear related technology (Quest for an innovative reactor system enhanced in safety, economy and mobility) l Decommissioning of 1F l Efforts to reduce environmental burden (Commencement of geological disposal of high-level radioactive waste, Commencement of the operation of disposal facility of radioactive waste generated from research, industrial, and medical facilities, etc.) l Nuclear Fusion - Judging the transition to a prototype reactor (check & review) → Construction of a prototype reactor and its operation
(For reference) Population of the world and Japan	l Global population: 8.6 billion (7.7 billion in 2019) l Japan: Population of age 15-64 decreases by 9% (75 million in 2019)	l Global population: 9.8 billion l Japan: Population of age 15-64 decreased by 30%

Energy conservation and securing stable energy supply that meets S+3E



Realization of “Super Smart society” by introducing innovative technologies such as AI, IoT, big-data analytics, etc.

The charts above have been prepared by JAEA with reference to the documents below: “Annual Report on the Aging Society”(June, 2019), “Strategic Energy Plan”(July, 2018), “Research and analysis report on energy-related technologies for 2050”*(March, 2018), “International Statistical Compendium”*(March, 2019), “Future Timeline”*(Hakuhodo Institute of Life and Living), “Mid-and-Long-Term Roadmap Towards Decommissioning of TEPCO’s Fukushima Daiichi Nuclear Power Station”(September, 2017), “Final Disposal Plan for Specified Radioactive Waste”*(March, 2008), “A Roadmap for Energy-Related Technology Development”*(December, 2014), “A Roadmap toward Fusion DEMO Reactor (first report)”(July, 2018). [*: in Japanese only]

SDGs（Sustainable Development Goals）

(Source: United Nations Information Centre)

Reference 2

Innovation for Realizing Decarbonized Society

Various technological innovation is necessary to realize decarbonized society for the continued existence of all humankind

Nuclear energy is one of the energy options required to realize decarbonized society. In implementing nuclear R&D for society in 2050, we should deepen our understanding on the issues of climate change countermeasures, etc.

It is necessary to suppress global temperature rise

Extreme weather events which are thought to be attributed to climate change may have enormous impact on natural environment and human society. Changes in sea level may impact the natural ecosystem and industry and may cause floods in coastal area and river basins.

According to the “Special Report on Global Warming of 1.5°C adopted by the IPCC in October 2018, human-induced warming reached approximately 1.0°C above pre-industrial levels in 2017, climate-related risks to health, livelihoods, food security, water supply, human security* and economic growth are projected to increase with global warming of 1.5°C, and increase further with 2°C. Furthermore, it is suggested that emission pathways limiting global warming to 1.5°C would require rapid and far-reaching transitions in energy, land, urban and infrastructure, and industrial systems. It also indicates that limiting global warming to 1.5°C can only be achieved if global CO_2 emissions start to decline well before 2030.

Innovation for decarbonized society is the important key for the earth and human being and to secure its longevity.

* human security: Complementary concept for “state security”. It aims to protect people from critical and pervasive threats to human lives, livelihoods and dignity and to encourage people to promote sustainable independent individuals and society through protection and empowerment so that the rich potential of people can be fully realized.

Various innovation is necessary to realize decarbonized society

Japan plans to reduce dependency on nuclear power as much as possible and fade out from inefficient coal use, while making renewable energy its main power source of electricity. (Strategic Energy Plan) Renewable energy is an important energy source which can contribute to energy security as it can be domestically produced free of greenhouse gas emissions. However, it needs innovation such as stable supply, cost reduction, improving power transmission efficiency and storage batteries with large capacity.

Nuclear energy can realize stable and high density energy supply. It is also an important base-load power source, contributing to the stability of the energy supply-demand structure in the long term, on the major premise of ensuring of its safety. It is important to achieve realization of energy mix with appropriate combination of the various primary energy sources for expediting the realization of decarbonization at an early date.

For realization of decarbonized society, not only in the fields of energy but that of materials production like steel and transportation, innovation is necessary to reduce the greenhouse gas emission.

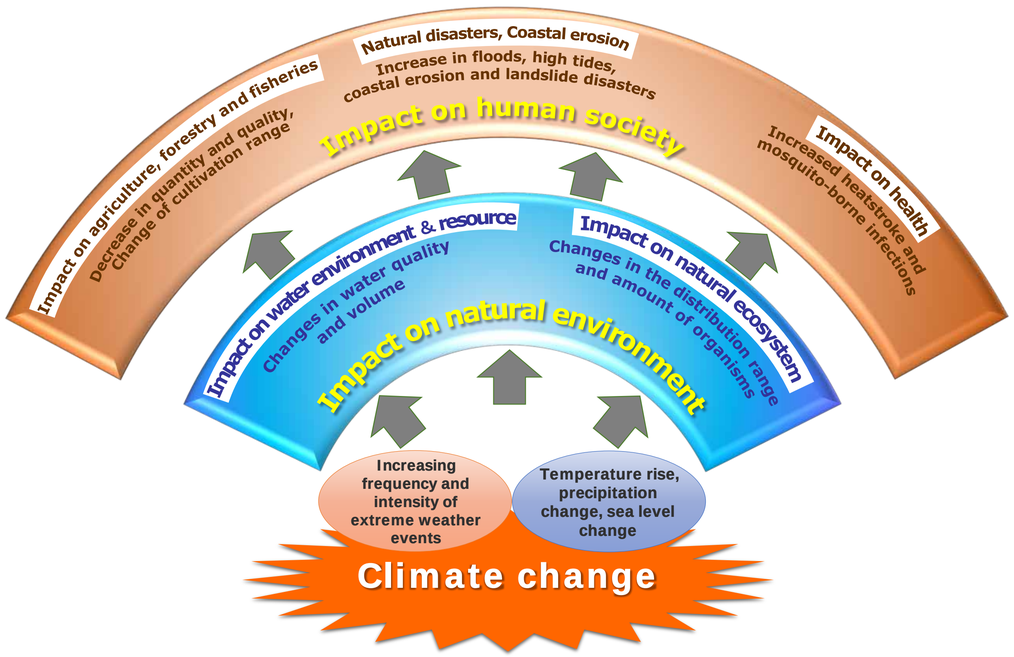
“Lifestyle innovation” is also necessary to promote energy conservation including active introduction of LED lights in our individual lives.

"The Long-term Strategy under the Paris Agreement" states that disruptive innovation that is heretofore unconventional is essential to alleviate the risk of global climate change, and that it is necessary to collaborate closely between public and private sectors in the key areas for decarbonization, while all possible options are explored. It also states that it is important to promote “Innovation for the practical application and wide use” putting together the innovation for creating cutting-edge technologies.

For example, a fundamental issue in constructing a hydrogen society is the stable supply of large volume of CO_2-free hydrogen at an affordable price and the innovation of reducing hydrogen production cost significantly. Hydrogen production utilizing high temperature of the HTGR is one of the promising technologies. Furthermore, steel production by hydrogen reduction using generated hydrogen is expected to make contribution to industry.

Reference

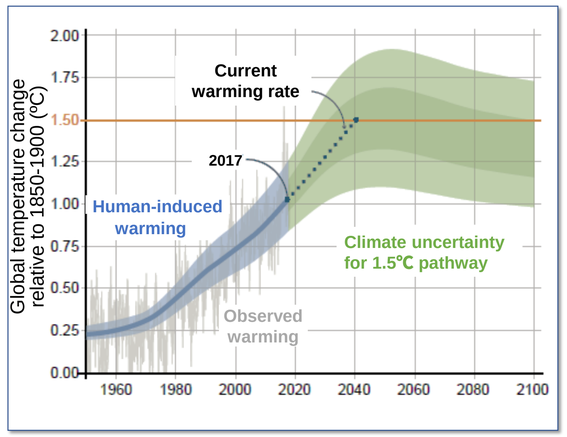
Impact of the global warming on the natural environment and society



The figure is formed by JAEA based on “Synthesis Report on Observations, Projections and Impact Assessments of Climate Change, 2018, Climate Change in Japan and Its Impacts”(Ministry of the Environment(MOE), Ministry of Education, Culture, Sports, Science and Technology(MEXT), Ministry of Agriculture, Forestry and Fisheries(MAFF), Ministry of Land, Infrastructure, Transport and Tourism(MLIT), Japan Meteorological Agency(JMA)) and “Stop Global Warming 2017” (MOE; in Japanese only).

Prediction of temperature change and Major impacts of climate change

Prediction of temperature change
(Comparison with pre-industrial levels)



Major impacts of climate change

		1.5ºC warming	2ºC warming
Temperature in extremely hot and cold areas	Temperature in extremely hot area in mid-latitudes	increase approximately 3ºC	increase approximately 4ºC
	Temperature in extremely cold area in high-latitudes	increase approximately 4.5ºC	increase approximately 6ºC
Effect of sea level rise	Frequency of a sea ice-free Arctic Ocean during summer	once in a century	once in a decade
	Sea level rise(-2100)	0.26 - 0.77m	+0.1m more than 1.5ºC warming
	Number of people effected by coastal flooding (-2100)	31 - 69 million people	32 - 79 million people
Effect on Human being	Number of people effected by heatwaves	3546 - 4508 million people	5417 - 6710 million people
	Proportion of population effected by water scarcity	More than 4%	More than 8%
	Number of people exposed to lower crop yield	32 - 36 million people	330 - 396 million people
	Number of people vulnerable to poverty	24 - 357 million people	86 - 1220 million people
	Amount of decrease in annual catch for marine fisheries	approximately 1.5 million tons	approximately 3 million tons
Effect on Biodiversity, ecosystem	Terrestrial land area affected by ecosystem transformations	approximately 4%	approximately 13%
	Number of species projected to lose over half	insect: 6%, plants: 8%, vertebrates: 4%	insect: 18%, plants: 16%, vertebrates: 8%
	Decrease rate of coral reefs	70 - 90%	› 99%

The charts above have been prepared by JAEA with reference to the documents below: “Paris Agreement”(adopted in December, 2015), “Special Report on Global Warming of 1.5°C”(IPCC, October, 2018), “Japan’s Long-term Strategy under the Paris Agreement”(Cabinet decision in June, 2019), “The Plan for Global Warming Countermeasures”(Cabinet decision in May, 2016), Web-sites of Ministry of the Environment

Pursuing the Potential of Nuclear S&T for the Future

Creation of new value, overcoming issues of the negative aspects to take full advantage of the potential of Nuclear S&T

Nuclear S&T has many possibilities

Nuclear S&T has a wide range of potential. It has a lot of potential to make a significant contribution to society by putting various R&D results into practical use.

Nuclear energy is used for electricity generation without emitting greenhouse gases by using small amount of atomic nucleus such as uranium. In addition, it is used as power source for icebreakers and submarines because it does not need refueling for a long period. It is also used as nuclear battery for space development and power source for manned exploration probe. There are countries that are working on the development of nuclear rocket engines.

Plutonium extracted from spent nuclear fuel can be reused for power generation.

R&D to realize the ultimate energy source using nuclear fusion reactions is now promoted at National Institutes for Quantum and Radiological Science and Technology (QST), etc. with a focus on international project. This technology uses unlimited deuterium and tritium for its fuel, has inherent safety and does not generate high-level radioactive waste.

Radiation and radioisotopes are used in a various aspects of our daily life. They are used in the medical fields for diagnosis, treatment, examination and sterilization, and in archaeology using dating techniques. In the field of industrial production, it is used for increasing water resistance and hardness of materials such as plastic and rubber as well as nondestructive inspection. In the fields of agriculture and food, there are cases of improving fruits to resistant to diseases. Thus, Nuclear S&T is used in a many fields and is useful for people. It is also used as an essential tool for basic research such as protein structure analysis, and elucidation of manifestation mechanism of high temperature superconductivity and magnetism as well.

R&D using Nuclear S&T is conducted around the world. There are more than 220 research reactors in the world and they are used for nuclear-related R&D, education, training and production of radioisotopes for medical and industrial uses and silicon semiconductor production.

Neutrons and X-rays generated from test reactors and accelerators enable us to help “create” new materials with new functions and to help “see” microstructures of materials, which shows that they have a significant potential in bringing about innovation in the fields of academic and industry.

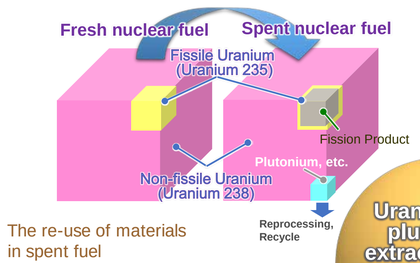
Creation of new value of Nuclear S&T

For future society, it is important to create new Nuclear S&T for safety enhancement of the nuclear energy system and measures of radioactive waste, reflecting the lessons we have learned from 1F accident and re-acknowledging the value of nuclear safety.

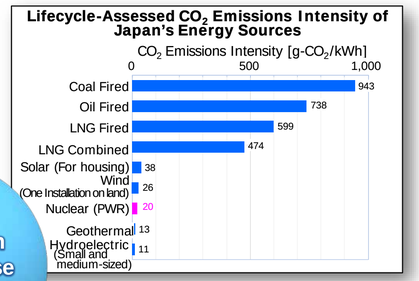
It is necessary for the progress of S&T to pursue new Nuclear S&T that continues to contribute to society, by taking full advantage of the potential Nuclear S&T with collaboration through synergies with other areas of S&T.

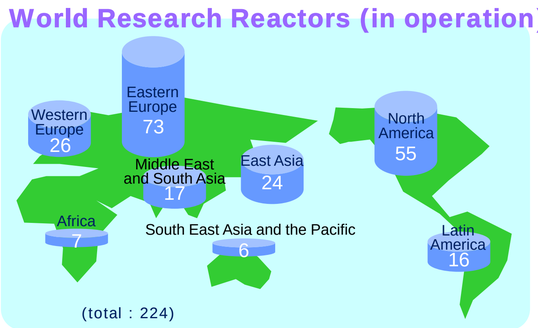
Example of Nuclear Utilizations

Nuclear S&T is used not only in energy field, but also in various other fields

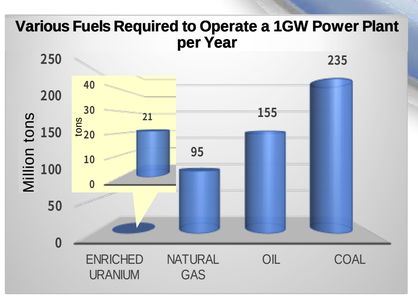


The re-use of materials in spent fuel





As of October 2019, IAEA Research Reactor Database



Graphs are formed by JAEA using data on the “Graphical Filp-chart of Nuclear & Energy Related Topics” (Japan Atomic Energy Relations Organization).

memo

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