EAJ STI2050 Committee

Executive Summary

Aims and goals of the Committee:

The Committee was established in November 2019 with the aim to "conduct an assessment of the current situation, including an inventory of technologies, to create a ‘science, technology, and innovation’ roadmap to materialise the technologies needed for an ideal future in 2050.” Its goals are to review visions for the future proposed both in Japan and abroad to determine an ideal future vision for 2050, or potentially 2100, to identify key or niche technologies that would facilitate the structural transformation of society necessary to realise this vision, to draw a roadmap for social innovation to support these technologies, and to recommend an action plan for realising a sustainable society looking ahead to the 22nd century.

Selection of topics to be addressed:

The Committee has met 18 times since August 2019 to develop the roadmap and action plan with the aim of identifying topics and challenges to be addressed and the necessary technologies and pathways for implementation. Following the example of the “Talanoa Dialogue” held in the run-up to the UNFCCC COP24 to motivate action on climate change, the Committee has asked, (a) “Where are we?”, and (b) “Where do we want to go?” to ascertain where we stand today and to determine the desired future to aim for (goals). Likewise, it asked (c) “How do we get there?” to discuss concrete proposals for actions to realise this future.

As the impacts of COVID-19 became more serious in Japan, discussion on selection of issues changed. The debate was reexamined, and selections were narrowed down to the following three issues.

(1) Realisation of smart cities and comfortable and resilient human settlements
(2) Realisation of sustainable and equitable access to water, food and energy
(3) Realisation of governance based on visualised evidence and tolerance of diverse values

After the COVID-19 pandemic situation worsened, there was much discussion on “Realisation of governance based on visualised evidence and tolerance of diverse values”. Also related to responses to climate change, many agreed that the state of governance in our increasing digital societies is an important key to building a sustainable society.

Accordingly, this report begins with a discussion on the realisation of such governance, then addresses the issue of the water-food-energy nexus, and finally describes a vision of the future in which cities realise the well-being of all people, which can easily become a trade-off with the pursuit of wealth. A summary of each part is provided below.

1. Realisation of governance based on visualised evidence and tolerance of diverse values

In order for science and technology to accurately address and respond to problems faced by human society going forward, it will be necessary for those involved in science and technology to systematically promote policy, research and development, and concrete responses based on facts and data related to these problems, while incorporating the various people and ideas that make up society. In other words, science and technology, which are closely related to society, must respond to changes in society and present compelling facts and options for the best available approaches to fulfill the wishes of as many people as possible. Furthermore, this process must be carried out not only with science and technology, but also with the participation of people and society. As the development of science and technology wields significant impacts on society, this process is governance itself, defined as "decision-making among the actors involved in a collective problem that leads to the creation, reinforcement, or reproduction of social norms and institutions" (Wikipedia), in this case as it pertains to science and technology and society. The formation of mechanisms and platforms for stakeholders to participate in this process and take action is essential. Another key element throughout this process is promoting mutual understanding, as well as a relationship of trust, between society and science and technology.

Therefore, this chapter will first briefly review the increasing complexity of the changing relationship between science and technology and society, and then present an example of how today's cutting-edge science and technology, represented by the use of AI, could visualise the situation and grasp the diverse demands and values of people. We will also outline the development of scientific advice, which is an important process in the relationship between science and technology and society, from the perspectives of scientists and engineers, policymakers, scientific academies and legislative bodies, both as it relates to Japan and the situation overseas. COVID-19 is used as a recent example of how science and technology have responded to problems facing the world. Based on this, we will attempt to present a roadmap for building a better relationship between science and technology and society through the collection and presentation of visual evidence such as facts and data, the creation of a society that tolerates diverse values, and the establishment of systematic governance based on such evidence, while demonstrating a wide range of actions that can be taken by the Engineering Academy of Japan (EAJ).

1. Development of tolerance for diverse values, including responses to global warming and other global issues: Outreach to society and participation in international activities
   (1) Spread knowledge in society on the significance of the future aimed for by the SDGs
   Opportunities for public debate at symposiums and dissemination via the web
   (2) Activities to realise SDGs and evaluation of processes aimed at achieving them

Continued deliberations by EAJ members
Participation in international activities by EAJ and its individual members

2. Fostering a culture of governance
   (1) Society and people: Acceptance of the significance of science in co-creation and discovery of diverse opinions in society
   Shared recognition of the multi-faceted nature of issues, need for clarification of scientific perspectives (science that provides evidence), development of communication between science and society
   (2) Policymakers: Interaction with those involved in receipt of scientific advice and policymaking, such as politicians and bureaucrats; calls for policy and requests to the government
   (3) Scientific community: Interaction with EAJ on acceptance of diversity in society and understanding of policy (in cooperation with the Science Council of Japan and science-related non-profit organisations)

3. Systematisation of governance
   (1) Develop draft guidelines on governance, especially on the various standpoints, relationships, and responsibilities of the scientists and engineers who give scientific advice and the policymakers who receive it, and encourage the government to enact them.
   (2) Verify the scale of the groups subject to governance and the effectiveness of governance (for various policies)
   (3) With regard to governance, enhancement of methodologies, especially for scientific advice, and capacity building of those involved

4. Demonstration of science and technology that contributes to assessing the effectiveness of governance

Trial of methods for evaluating the effectiveness of governance through visualisation of evidence and tolerance of diversity.

Example: An attempt to use AI to engineer a way to measure people's well-being, one of the goals of scientific and technological innovation.

The future vision for the ideal relationship between society, policymaking and science that this draft recommendation puts forth is as follows.

The following are characteristics of science and technology: (1) it has its own inherent uncertainties, and the understanding of nature by science and technology involves probability, (2) current science and technology is still in the process of development, and there are limits to our current understanding, and (3) interpretation may vary from one scientist to another, even based on the same facts and data.

The scientific community aims to be a community of scientists and engineers who view science as part of society and who tolerate and understand diverse values. Moreover, it conveys to society the significance of science as a broad and profound human intellectual activity, and based on ongoing research, provides knowledge and information, including explanations and predictions, on various issues facing society, including global-scale issues. Likewise, it offers options for possible scientific and technological measures, and supports better policymaking by providing evidence to be used in decision making on policy.

The aim of the scientific community is to create a society in which people have tolerance for diverse values and utilise intellect as well as emotion to make decisions on various issues supported by the knowledge and information provided by science.

While recognising the diverse values held by people and societies, policymakers should fully respect evidence provided by the scientific community, as well as other grounds, and take personal responsibility for making decisions and clearly explaining the process and rationale for these decisions to the people, society, and the scientific community.

Creating such relationships will strengthen mutual understanding and trust between people, society, policymakers, and the scientific community, and will enable the advancement of a knowledge-based society that can flexibly respond to new events that the world will face in the future. However, the lack of any one of these elements could lead to the estrangement of science from society, a descent into populism, or political stagnation.

Such a knowledge-based society will be one that allows for a variety of challenges and actions to respond to new situations, and supports people and groups that defy conventions. Such efforts, including failures, could also serve as an important reference for developing countries that aim to develop based on scientific and technological innovations.

2. Achieving sustainable and equitable access to water, food and energy

Pursuing a Global Energy, Food, and Water Nexus in 2050:
With a focus on energy

In both developed and developing and emerging countries, achieving sufficiency in energy, water and food for people while taking into consideration the balance between sustainability, the global environment and the economy, namely pursuing the global "energy-food-water nexus" toward 2050, is an extremely major challenge for the current generation.

Looking at these three elements individually, first of all, energy requires massive infrastructure to build a supply network. Also, on the demand side, it is not always easy to respond to changes in supply patterns due to varying patterns of energy usage and extremely large numbers of users. Indeed, in recent years, distributed energy systems are becoming more technologically and economically feasible, but when viewed as a whole, they remain a large social and economic system. With regard to food, it is noteworthy that natural conditions (e.g. temperature, precipitation, soil) as well as the food culture of people living in any certain area vary, and that it takes a certain amount of time to improve varieties of food. Water is also highly dependent on natural conditions (e.g. temperature, precipitation, condition of rivers and underground aquifers, etc.), as well as local demand patterns for agriculture and daily life, industrial composition, and the state of pollution. What is even more important are the mutual synergies and trade-offs among these three elements. For example, food production and distribution require inputs of water and energy. The production of drinking water and the purification of wastewater also require energy. Moreover, many processes for obtaining energy require the use of water.

In this context, particularly with regard to energy issues, there is an increasingly shared recognition in the world of the need to achieve carbon neutrality by the middle of the century in order to solve global environmental problems while taking into account the balance between society, the global environment and the economy. Energy is representative of issues that need to be approached through engineering to solve complex global environmental problems in a rational manner based on close cooperation among nations. Accordingly, this chapter will focus on the issue of energy and examine the following.

(1) A review of challenges faced by each country and the status of policies and initiatives

(2) Establishment of the following five principles to achieve global carbon neutrality "no later than 2050" and energy sufficiency in all regions of the world "as soon as possible before 2050".

- i) The establishment of a forum (tentative name: FICNES) where developed countries and developing and emerging countries can discuss not only energy and environmental policy, but also industrial policy, agricultural and food policy, urban policy, transportation policy and technology policy.
- ii) For the poorest and least developed countries in particular, allow for a shift in policy towards carbon neutrality from a long-term perspective, while prioritising the achievement of energy sufficiency for the time being.
- iii) For developing and emerging countries with large populations (exceeding 100

million in 2050) that are already achieving high economic growth rates, the world should provide support and investment for measures to simultaneously achieve carbon neutrality and energy sufficiency.

iv) For infrastructure related to renewable energy and energy storage and transport, taking advantage of regional characteristics and construction of infrastructure among multiple countries should be discussed at the abovementioned FICNES forum to build international consensus and promote investment.

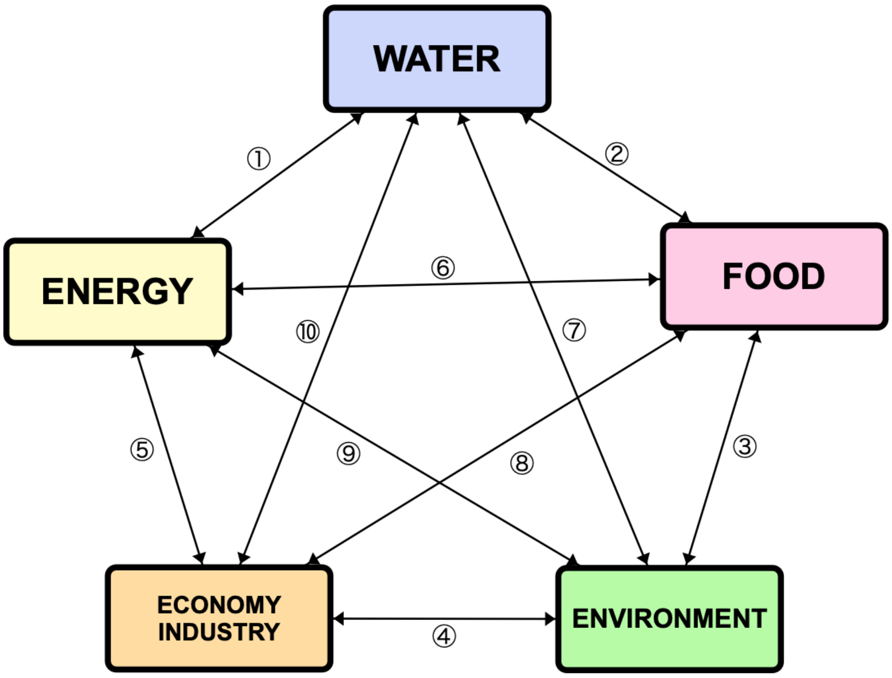
v) The world should monitor CO2 emissions and sequestration, design and build a framework for the steady development and diffusion of new technologies, ensure the safety of nuclear power, manage transitional fossil fuel resources, elucidate CO2 sequestration mechanisms, and recruit and train outstanding human resources in these areas.

(3) Based on these five principles, specific countries that could be called upon to simultaneously achieve carbon neutrality and energy sufficiency were selected based on four criteria, and the nature of cooperation to resolve any issues was examined (of these, the seven countries identified as “particularly important target nations for cooperation” were India, Nigeria, Pakistan, Indonesia, Egypt, the Philippines, and Vietnam).

(4) In addition to an examination of the various technology options currently advocated in the three areas of energy supply, energy demand, and energy distribution, critical issues for engineering to create a sustainable society were identified.

(5) Since the readiness of individual technologies remains unclear and we are not at the stage of narrowing down the list, a “Policy Framework Roadmap” was developed which includes four elements: “policy and international cooperation”, “human resource development”, “technology assessment systems” and “investment guidance schemes”. In addition, in order to identify timescales and challenges, a Technology Roadmap was developed as a general framework for technology. Both roadmaps need to be continually updated by the relevant communities, and it is important that they are always discussed as a 'pair'. This is because achieving carbon neutrality and energy sufficiency requires both top-down and bottom-up approaches.

(6) Finally, based on the above, we examine the realisation of the “Energy-Food-Water Nexus”.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5. Smart cities for comfortable and resilient human settlements

This chapter describes what technologies, including AI, are needed to ensure human security and well-being during both normal times and outbreaks to realise comfortable and resilient cities, and how these technologies should be integrated.

Why are cities the key to well-being through STI?

The urbanisation rate was 13% in 1900 (urban population of 220 million), then 29% in 1950 (732 million). It exceeded 50% in 2007, and is expected to reach 60% (4.9 billion) by 2030 (WUP2018). In order to ensure the well-being and better survival of humanity under ever-increasing population stress, fastidious responses based on science, technology and innovation (STI), including AI, will be necessary.

What should people living in cities pass on from generation to generation?

From the viewpoint of energy and entropy, the upper limit of the number of people who can live in a city is determined by the number of people who can survive (environmental carrying capacity). What is called for in today's age is coexistence with diverse life forms and empathy for a diversity of people. These are the culture and values that should be passed on from generation to generation.

How will pandemics change cities and the people who live in them?

The increasing concentration of human activity in cities is considered to simultaneously be the primary cause of the destruction of natural ecosystems by human artefacts, global warming, and outbreaks such as pandemics. Pandemics can be an opportunity to restore human humility and a strong sense of empathy in the development of civilisation.

A 'new local' based on multi-AI in a new normal era

In the context of Japan's aging, many cities are expected to suffer the effects of urban shrinkage and spongification. In this 'new normal' era, where an ageing population and infectious diseases are routine, Japan's low self-sufficiency in food and energy has long been described as a weakness. In order to escape from this precarious situation and ensure human security and well-being, we must rebuild starting from new local living areas that have a high degree of independence and autonomy, networked by multi-AI.

Why do we need multi-AI networked cities?

The concept of a multi-AI networked city is based on preventing the total collapse of a city under any outbreak. The Multi-AI Well-being Survey System (MAWSS) is designed to quickly detect signs of an outbreak and carry out preventative control by networking cities which are considered to be a set of living areas. MAWSS is a system in which humans and AI work together in normal times to collect information on living areas and prepare for outbreaks in order to ensure resilience to the challenges Japan faces, including a declining and ageing population, the threat of major disasters, global climate change, unstable supplies of water, food and energy, and infectious diseases.

MAWSS: Multi-AI Well-being Survey System

To cope with natural disasters and the spread of infectious diseases such as COVID-19, and simultaneously as a formula for achieving human security and well-being, we are proposing multi-layered, multi-scale living areas/urban areas. With the support of a multimodal AI network, the linkages between the various layers of each living area, and linkages between living areas, would be maintained by AI. Many government programmes require decision making that is multi-aspect, multi-scale and multi-state in nature, making it extremely difficult for AI alone to make optimal decisions. Yet, AI has the capacity to report on the current state of various conditions and present a list of scores based on a variety of criteria to assist in human decision making.

Technology roadmap for achieving Multi-AI networked cities

For the next 30 years leading up to 2050, cities need to be not only economically efficient, but also function in a way that lowers their environmental impact, typified in carbon neutrality, and makes them convenient, comfortable and safe. Furthermore, with the increase in recent years of pandemics and outbreaks associated with global climate change, it is also important for cities to be resilient (i.e. able to recover from disturbances). The multi-AI networked city would be supported by a network of living areas, but the solutions presented by MAWSS may not be the best for each individual living area in terms of the actual operation of the city. This is because the MAWSS would take into account the well-being of the city as a whole, not just of individual living areas. For this reason, the technology roadmap is not merely a process for materialising technologies, but also encompasses the building of consensus in society on new technologies based on measurement and analysis of well-being.

Technology transfer to emerging countries with a regional focus

In developing countries (DCs), the pace of urban change is exceeding the pace of necessary social reform. While the greater part of populations has problems with water, sanitation, waste water, healthcare and schools, some countries have not conducted a population census during the last 15-20 years. Long-term and widespread challenges in DCs include: a) creating urban visions; b) inheritance of local culture; c) enhancement of rural well-being; d) urban-rural coexistence; and e) responses to outbreaks, which are primarily suited to top-down central government action. On the other hand, short-term and localised issues, such as f) land registration systems; g) durable housing; h) water and sanitation infrastructure; i) renewable energies; and j) development and diffusion of small urban EVs, are more suited to bottom-up action by local governments and businesses. In DCs, unlike in developed countries, there are many areas with undeveloped infrastructure, including public transport, electricity, water and sewage, etc. Likewise, necessary technologies must be selected in consideration of the local culture and lifestyle. Here, we propose implementation, in advance developed countries, of the multi-AI networked city that connects the technologies needed for a) to j) above. Above all, there is a great possibility that the urban population of DCs will double by 2050, and that mono-polar concentrated cities that prioritise economic efficiency, as developed countries did in the 20th century, will continue to arise.

Summary

1) We propose a "multi-AI networked city", where the pursuit of well-being is centred on human beings, with the aim of ensuring comfort in normal times and safety and security during outbreaks.
2) The multi-AI networked city would consist of autonomous and independent decentralised

living areas that do not destroy current urban structures, and would prevent the collapse of the entire city under any circumstances, while at the same time guaranteeing human security and well-being.

3) The multi-AI networked city would involve a MAWSS (Multi-AI Well-being Survey System), which would allow people and AI to cooperate in the autonomous management of the city with a variety of data moving freely between networked living areas.
4) The multi-AI networked city would be a cyber-physical city to ensure resilience to the challenges Japan faces, including the declining and ageing population, impending mega-disasters, global climate change, unstable supplies of water, food and energy, and outbreaks of infectious disease.
5) The multi-AI networked city would differ from conventional urban planning in that it encompasses a process whereby the city is initially multi-polarised by multiple cyber living areas, but ultimately forms physical, independent and autonomous living areas.
6) To realise the multi-AI networked city, it is necessary to continuously communicate the concept of this city to society in order to garner social acceptance and consensus, based on the recognition that a city is a place of shared purpose and cultural inheritance across generations from the perspective of STI (science, technology and innovation).