

The 6th Science and Technology Foresight (2021-2045)

Discovering Future Technologies

to Solve Major Issues of Future Society

Republic of Korea
September 2022

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1. Summary



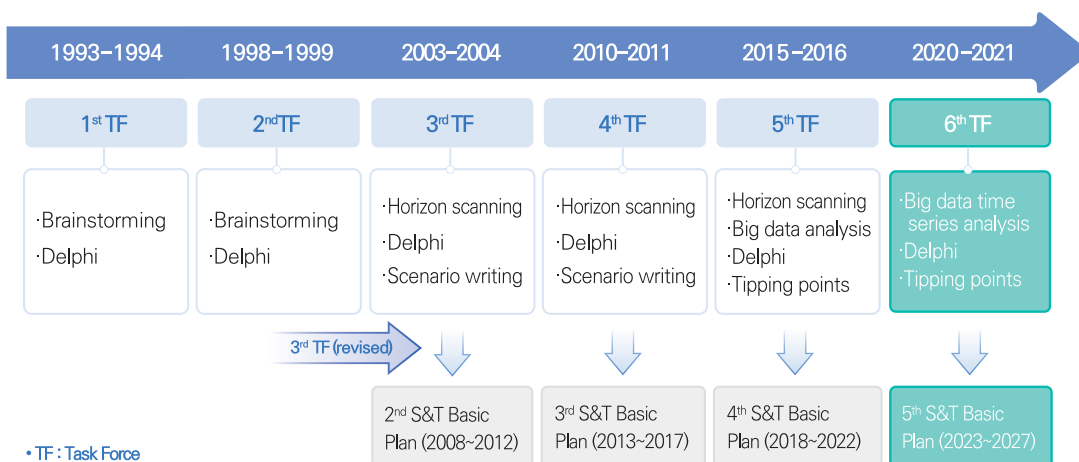
It is becoming increasingly important to establish and implement science and technology policies by predicting the future as digital transformation and the arrival of the contact-less era are accelerating. Since 1994, Korea has been engaged in the Science and Technology Foresight project on a 5-year basis, and in 2021, the 6th Science and Technology Foresight was conducted to formulate the 5th Basic Plan for Science and Technology and technology policies. The 6th Science and Technology Foresight has predicted the future society with 5 megatrends and 12 trends considering the internal and external environmental changes. The foresight exercise also predicted 241 future technologies along with 15 future innovative technologies which are expected to appear until 2045 throughout all fields of science and technology. A two-round Delphi analysis involving science and technology experts was carried out to examine both future technologies and future innovative technologies, and their main characteristics including innovativeness, uncertainty, significance, and technical competitiveness, time of technological realization, predicted tipping points, required government policies, and leading agents. This research presents several implications. We have identified future technologies to address the major issues that are expected to arise in future society in the next 25 years, with regard to societal needs together with the prospects of promising research fields and enhanced our understanding and utilization of future technologies. The results of the 6th Science and Technology Foresight will help researchers to identify new research ideas, policy makers to make systematic planning to prepare for the future and encourage the public to be interested in and prepare for the upcoming future.

2. Introduction



It is becoming increasingly important to establish and implement science and technology policies in order to predict the future uncertainties that will arise from globalization and informatization. In particular, the 6th Science and Technology Foresight was undertaken in the context of greater uncertainty and diversity of changes due to the COVID-19 pandemic and digital transformation. The need for strategic science and technology planning to achieve the development of science and technology with limited resources is increasing. To accomplish this, major countries around the world have been carrying out national science and technology forecasting activities in order to analyze the demand for future change, establish strategic technology planning, and set the direction for research and development activities.

Since 1994, Korea has been engaged in its Science and Technology Foresight project on a 5-year basis, and has been announcing its findings as part of its efforts to anticipate future changes in response to specific circumstances in the country. In 2017, the results of the 5th Science and Technology Foresight were reported and used in establishing the 4th Basic Plan for Science and Technology and other policies. The Science and Technology Foresight is meaningful in that it analyzes the recent changes in the environment, and derives the prospect and demand for future change of our society from a mid-term and long-term viewpoint. It is also leading the field of science and technology prediction in Korea by introducing a new forecasting methodology.



[Figure 1]
Progress of
Science and
Technology
Foresight

Currently, the Science and Technology Foresight is being carried out at the same interval as the Basic Plan for Science and Technology based on Article 13 of the Framework Act on Science and Technology and Article 22 of the Enforcement Decree of the same Act.

Basis for the Science and Technology Foresight

- Framework Act on Science and Technology Article 13 (Science and Technology Foresight)
 - ① The Government shall periodically forecast development trends in science and technology and the accompanying changes of future society, and shall reflect the outcomes of such forecast in science and technology policies.
 - ② The Government shall endeavor to discover and develop new technologies based on the forecasts specified in paragraph ① (hereinafter referred to as “science and technology forecasting”).
- The Enforcement Decree of the Framework Act on Science and Technology Article 22 (Science and Technology Forecasting, etc.)
 - ② The Minister of Ministry of Science and ICT shall forecast trends in the development of science and technology and in the accompanying changes of future society (hereinafter referred to as “science and technology forecast”) as per Article 13 (1) of the Act every five years, and reflect such results in every Basic plan.
 - ③ The Minister of Ministry of Science and ICT shall report the outcomes of the science and technology forecast to the Council and make a public announcement thereof.

※ In accordance with Article 22 ④ of the Enforcement Decree of the Framework Act on Science and Technology, the implementation of the prediction will be entrusted to Korea Institute of S&T Evaluation and Planning

3. Objective and Procedure of the 6th Science and Technology Foresight

Objective

The purpose of the 6th Science and Technology Foresight can be summarized by three broad objectives. The first is to predict the future society considering the internal and external environmental changes, and to predict and analyze the future technologies expected to appear throughout general fields of science and technology. In this research, we have derived future technologies that will emerge until 2045 based on the change of future social demand and the development of science and technology. The second is to contribute to the establishment of science and technology planning and policy that will strengthen the future responsiveness by reflecting the socio-economic demands of future society and the Delphi survey will provide basic data on policy establishment, such as timing of technology realization, importance, and way to realize the future technologies, and will be used to present the future technology information needed to establish the 5th Basic Plan for Science and Technology (2023 – 2027). The third is to predict the tipping point of technology in terms of social spread, focusing on major future innovative technologies related to the real lives of the people. We predicted the expected aspects of the rapid spread of a certain technology in the society and its expected timing, and together with the realization of technology diffusion for future preparation.

The 6th Foresight has identified purpose-oriented future technologies to effectively cope with the major issues of the future society in order to improve the utility of the predicted result. The issues to be coped with were selected and analyzed with a particular focus on Korean society. In order to expand the application range of the results of the Foresight, we have diversified the composition of future technologies, improved the presentation method for

the name of the future technology, and tried to secure the reliability and objectivity of the predicted Delphi survey results by introducing the scientific methodology. To this end, we expanded the Tech-Push¹ future technologies derived through scientific paper analysis, increased the discovery of future technologies to be realized in the distant future by classifying the stage of analysis and prediction, and standardized the names of the future technologies in order to improve understanding and utilization of the derived technology.

The 6th Foresight has identified the future technologies through collaboration with experts in a diverse range of fields including R&D management agencies, government-funded institutes, industry, and academia, and strengthened the links with related government policy such as the Science and Technology Future Strategies 2045². Furthermore, we have identified future innovative technologies which are expected to have a significant impact on the future society where those technologies rapidly diffuse in the society, while also undertaking an in-depth analysis of what the future society will look like.

Procedure and Implementation System

The 6th Science and Technology Foresight was undertaken by four committees including the Future Forecast Executive Committee, the Future Forecast Sub-committee, and the Future Technology Executive Committee, and the Future Technology Sub-committee.

The Future Forecast Executive Committee and Future Technology Executive Committee, composed of experts in science and technology and social science, were responsible for reviewing and coordinating key issues throughout the science and technology forecasting survey. In detail, the committee reviewed

1 The 6th Science and Technology Foresight defines Tech-Push technology as a future technology whose development will be led by development in the related scientific and technological fields.

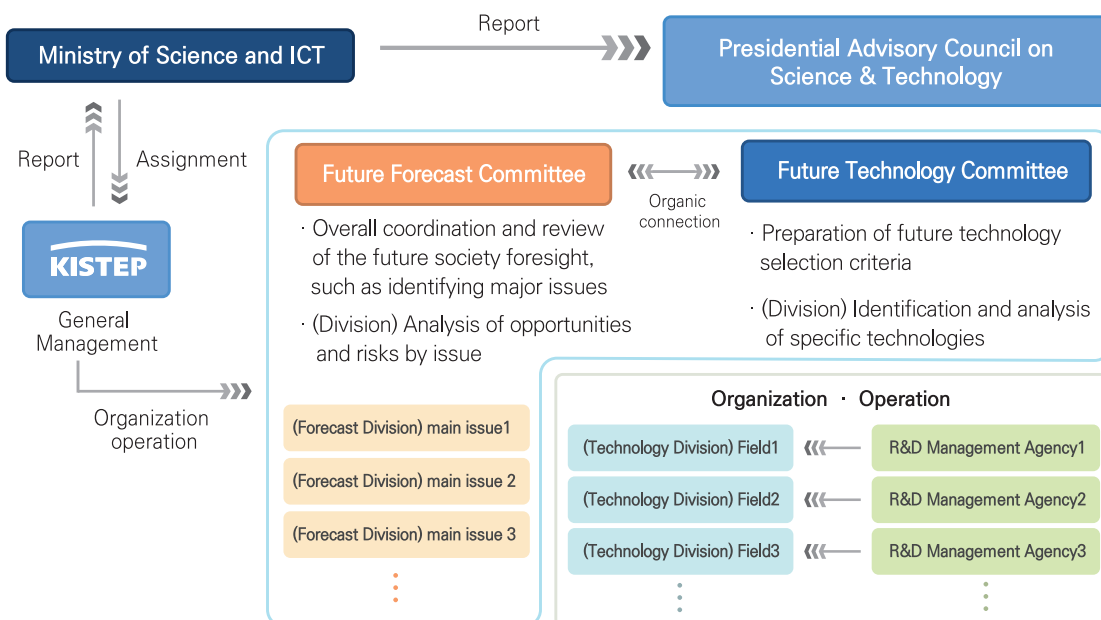
2 The Science and Technology Future Strategies 2045 (announced in 2020) is the outcome of a research conducted by the Science and Technology Policy Institute and KAIST under the supervision of the Ministry of Science and ICT. Eight challenges and 16 proposed directions of technology development which need to be addressed through science and technology efforts at a national level have been derived from a process in which answers to questionnaires are sought.

the draft and the survey result of the future social outlook, selected targets for the technology tipping point analysis, reviewed the draft and the result of the future technology list, reviewed the draft and the result of the 6th Science and Technology Foresight, etc.

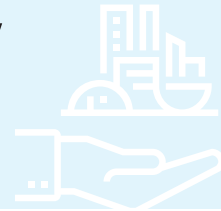
The Future Forecast Sub-committee is composed of five divisions including Digital World Group, Change of Social Structure Group, Global Environmental Change and Resource Exploitation Group, Change of Global Order Group, and Routinized Risk Group. Each division consists of 15 or more members, most of experts in science and technology and social science. The role of the committee was to derive future social issues and needs. In detail, the committee reviewed trend analysis results, identified major issues by trend, reviewed key issues, and derived socioeconomic needs.

The Future Technology Executive Committee made up of experts in the science and technology field and from R&D management agencies assumed responsibility for the review and coordination of to future technologies. The reviews include the results of the future technologies identified and the analysis of those technologies, the results of the future innovative technologies identified and the tipping point analysis, and the results of the 6th Science and Technology Foresight.

The Future Technology Sub-committee consists of six divisions including Digital Transformation Technology, Production and Materials Technology, Human and Life Science Technology, Urban Area and Disaster Technology, Security and Exploitation Technology, and Energy and Environmental Technology. The committee derived future technologies based on future needs and trends in science and technology. In detail, the committee identified the major issues and needs, selected future technology candidates according to the development in science and technology and determined future technologies.

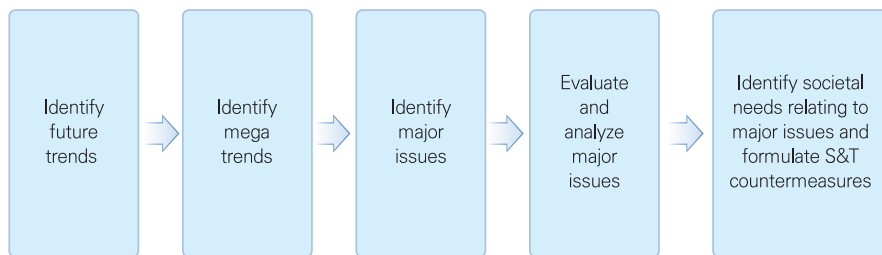
[Figure 2] Implementation System of the 6th Science and Technology Foresight

4. Prediction of the Future Society



Predictions of the future society have been made through a series of processes including identification of future trends and mega trends, identification of major issues, evaluation and analysis of the major issues, and identification of societal needs relating to major issues as well as formulation of science and technology countermeasures.

[Figure 3]
**Future Society
Prediction
Process**



Definitions in Future Society Prediction Process of the 6th Science and Technology Foresight

- Future Trend: Tendency, flow and movement expected to occur in the future society
- Major Issue: Issue with high possibility of affecting Korean society, strong impact (intensity and range) and high solvability through scientific and technological solution
- Societal needs and science and technology countermeasures: Demand for addressing the major issues, and the ‘scientific and technological’ means which can be undertaken

To analyze future trends and mega trends, we first analyzed the trends of future social change throughout the world (spatial axis) that our society should pay attention to in the mid-to-long term perspective, until 2045 (time axis). Then, mega trends were derived by analyzing the connections between the

trends. We analyzed future outlook reports from domestic and international sources, trend analysis, and websites published since the 5th Foresight (2017), and utilized STEEP (Social, Technological, Environmental, Economic and Political) analysis, through which we performed environmental scanning on each category and derived a clustering pattern among the trends. Finally, the 6th Foresight has identified a total of 5 mega trends, 12 trends and 62 major issues.

[Table 1] **5 Mega trends and 12 Trends**

Mega trends	Trends
Digital World	Digital Economy
	Contactless Society
Change of Social Structure	Society with Diversified Values
	Demographic Change
	Urban Change
Global Environmental Change and Resource Exploitation	Changes in Environment and Resources
	Exploring Uncharted Territory
Change of World Order	The Glocal Era
	Changes in the Northeast Asian Situation
	Changing Role of a State
Routinized Risk	Emerging Security
	Extreme Shock

The 6th Foresight has identified the major issues that are expected to have a significant impact on our society, based on the trend analysis results. Specifically, sub-committee consisted of a range of experts worked out candidate groups of the major issues and opportunities and threats, and checked on duplications and similarities between the issues, adjusted their level, and reviewed and modified the titles of issues, leading to a total of 62 major issues. The characteristics of the major issues were analyzed through quantitative evaluation of each issue. The impacts, uncertainty, and countermeasure possibility of science and technology of the major issues were evaluated on a 5-point scale, and the concept, current status, future changes, and policy actions of those issues were analyzed.

[Table 2] 5 Mega trend, 12 Trends and 62 Major Issues

Mega trends	Trends	Major Issues
Digital World	Digital Economy	Mainstreaming the Online Economy
		Prevailing Platform Capitalism
		Growth of Digital Goods Market
		Advent of a Cashless Society
		Job Change in the Digital Society
	Contactless Society	Diffusion of Digital Manufacturing Technology
		Advent of a Connected Society
		Personalized Learning
		Integration of Real and Virtual Space
		Change in the Value of Information
Change of Social Structure	Society with Diversified Values	Changes in Social Communication Methods
		Widespread Customized Services
		Diversification of Values
		Emergence of Value Conflicts
		Emphasis on Public Value
	Demographic change	Aging Population
		Low Fertility Rate
		Increase in Single-person Households
		Progress of a Multicultural Society
		Changes in Life Resulting from Biotechnology Innovation
Urban Change	Accelerated Creation of Hyperconnected Smart Cities	
	Megacity, Megaregion	
	Decline of Small-and-medium Towns in Provincial Areas	
	Abnormal Weather Events Due to Aggravating Global Warming	
	Air Pollution such as Fine Dust	
Global Environment Change and Resource Exploitation	Changes in Environment and Resources	Increased Exposure to Chemicals in Daily Life
		Accelerated Energy Transition Towards Carbon Neutrality
		Future Energy of a Decarbonized Society
		Water Resource Security and Supply Crisis
		Virtuous Cycle of Resources
	Exploring Uncharted Territory	Threat of Microplastics
		Development of Polar Resources and Routes
		Excavation of Deep-sea Resources
		Era of Space Life
		Excavation of Lunar, Martian and Asteroids Resources

Mega trends	Trends	Major Issues
Change of World Order	Glocal Era	Changes in Global Value Chain and Business
		Strengthening Nationalism
		Reinforcement of Non-tariff Barriers by Countries and Reorganization of Domestic Industrial Structure
Change of World Order	Changes in the Northeast Asian Situation	The Rise of China and U.S.-China Relations
		Korea-Japan Relations
		Inter-Korean Relations
	Changing Role of a State	Strengthening the Role of a Government
		Changing Perception of Democracy
		Changing Concept of Government
Routinized Risk	Emerging Security	Emergence of National Defense Technology
		Cyber Security
		Threat of AI-powered System
		Data Security
		Economic Security
		Health Security
		Social and Human Security
		Conflict between Countries due to Environmental Problems
	Extreme Shock	Endangered Honeybees
		Endangered Poultry
		Landfall of Super Typhoon
		Earthquakes Taking Place Directly under Large Cities
		Terrorism Targeting an Unspecified Majority
		Occurrence of Geomagnetic Storms
		Disruption of Power Grid
		Nuclear Accident in Neighboring Countries
		Rapid Change in the Northeast Asian Situation
		Korean Version of Nokia Shock

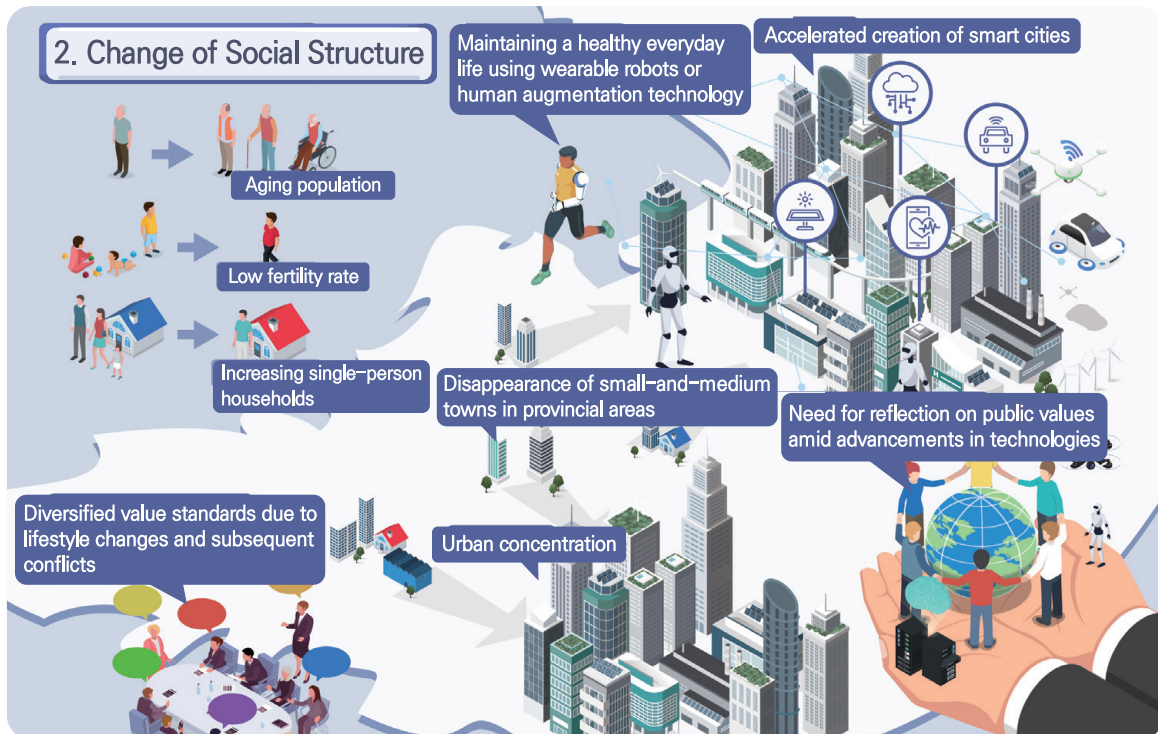
The following figures describe the details of the major issues and illustrates what the future will look like.

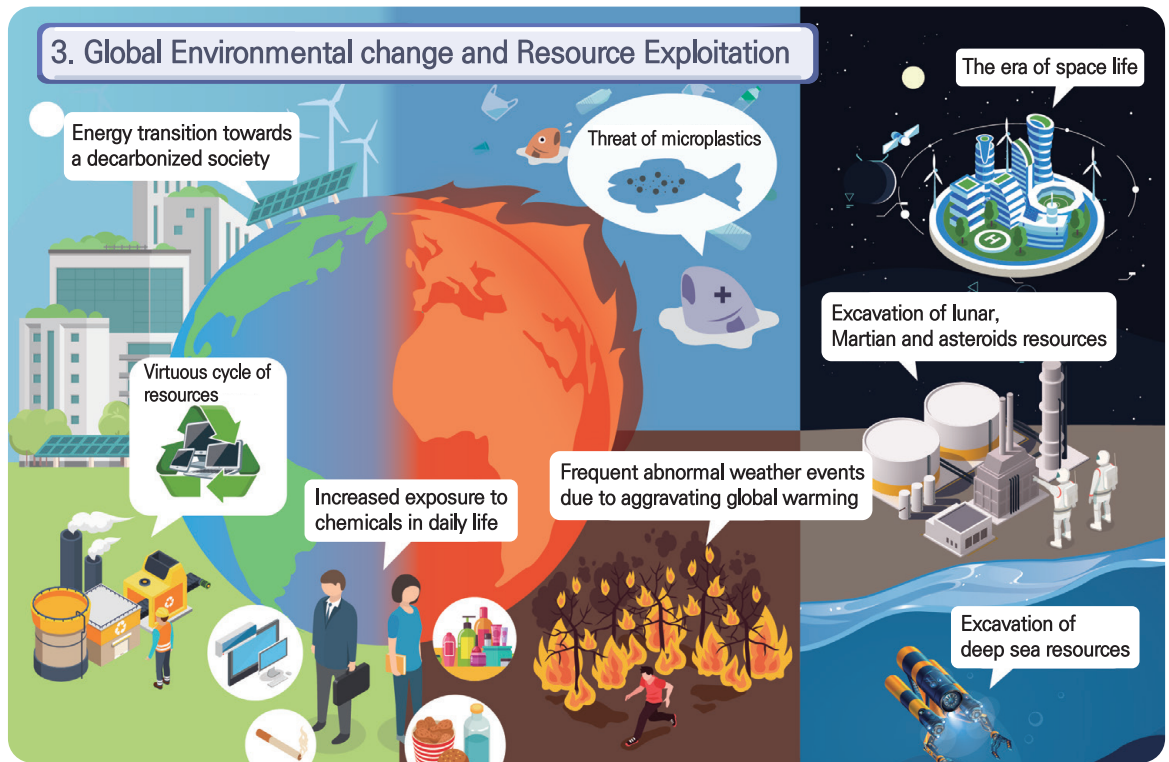
What the Future Will Look Like

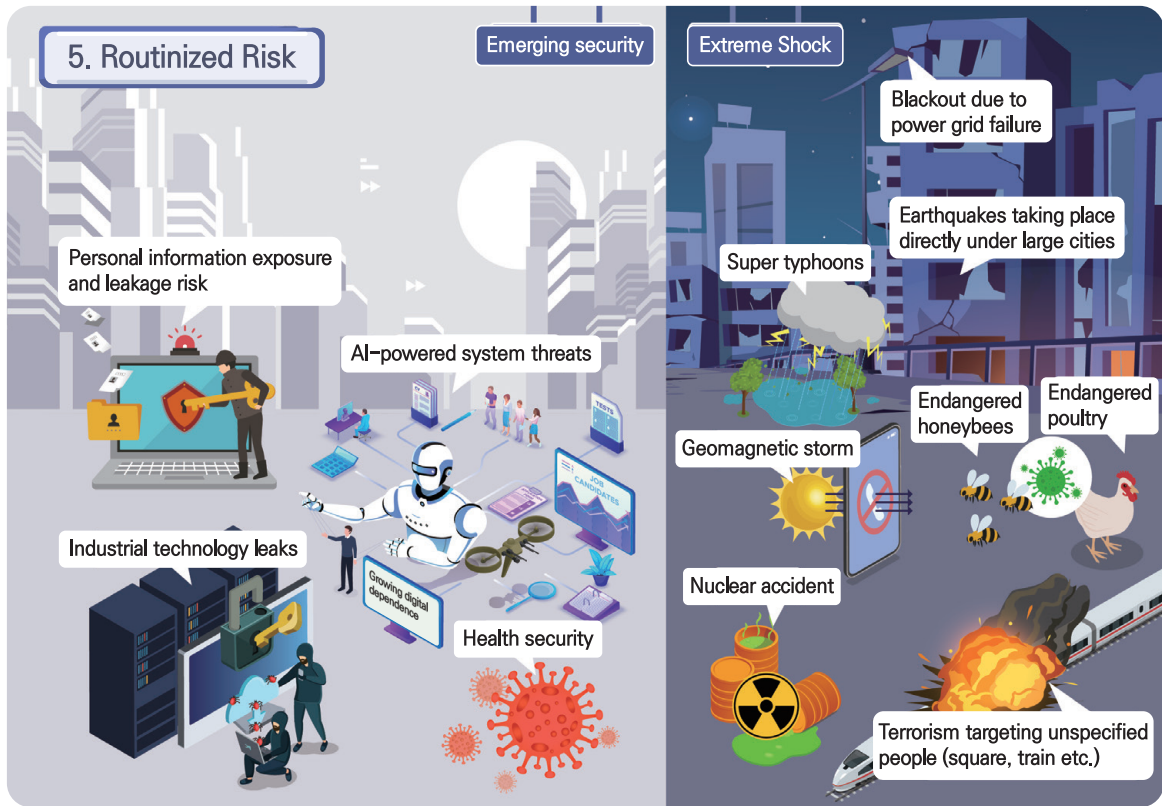
1. Digital World



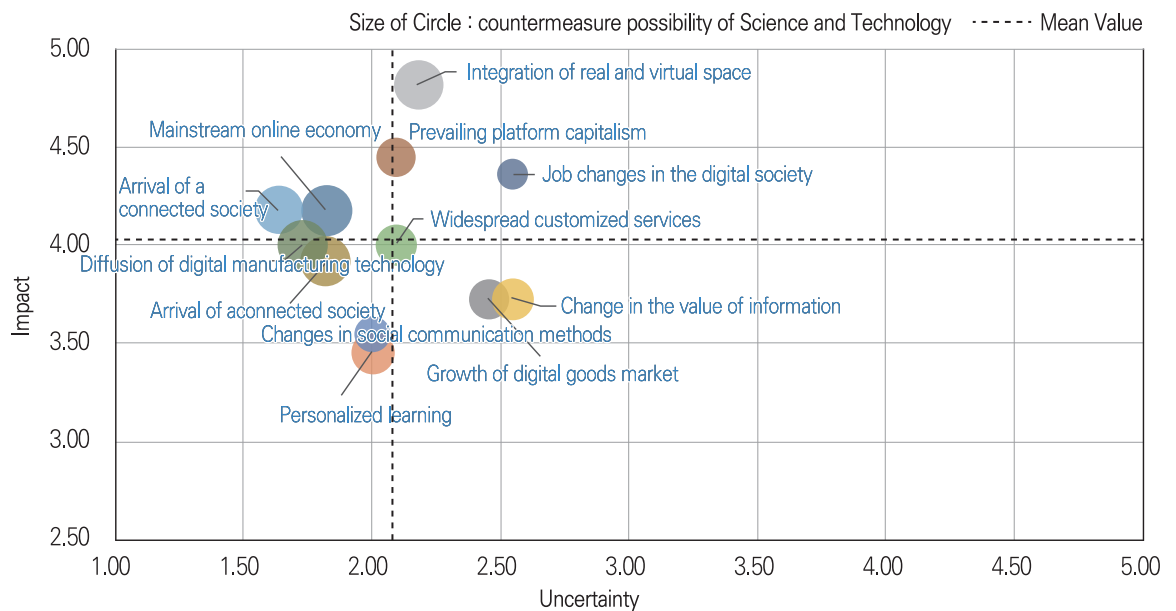
2. Change of Social Structure







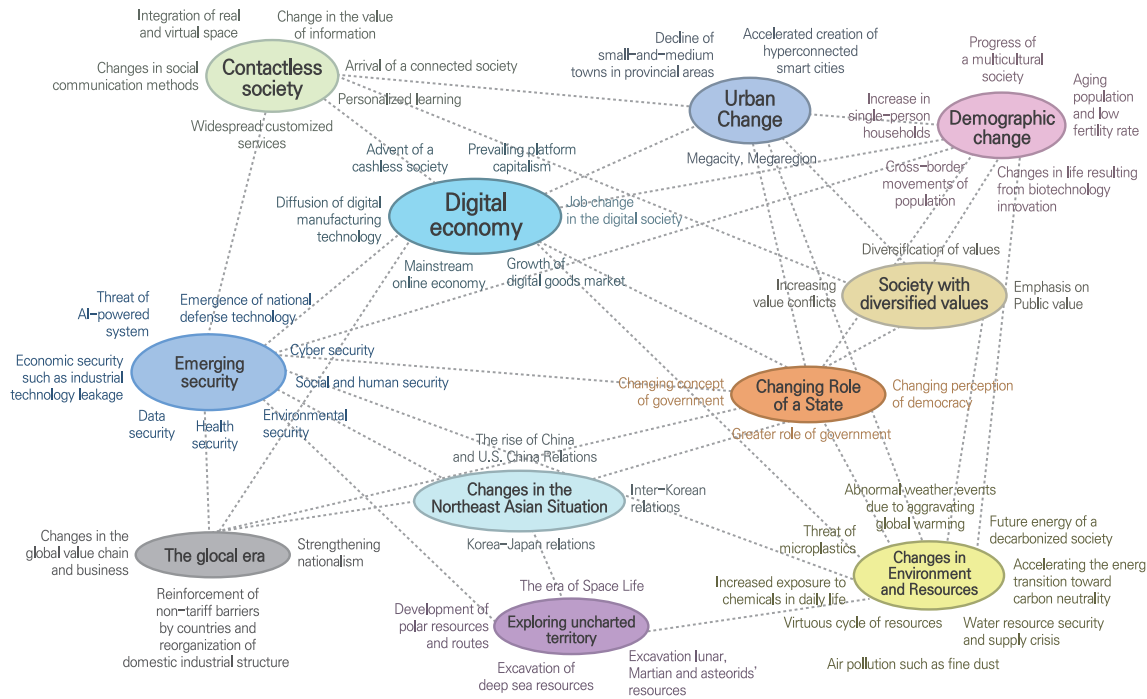
Below is a graphical representation of the evaluation results of trends-related issues, in which the horizontal axis indicates the uncertainty of issues and the vertical axis indicates the impact of the issues, while the size of the circles shows countermeasure possibility of the science and technology in the Korean Society.



* Mean value refers to the average of the issues related to digital world and this figure is the example in digital world related issues.

[Figure 4]
Uncertainty, Impact and Countermeasure Possibility of Science and Technology in Digital World Related Issues (Example)

Big data based network analysis (text mining based on natural language processing) was undertaken through the identification of the relationships among the major issues and issue linking analysis. The findings of big data based network analysis have confirmed that highly linked issues include i) urban change – demographic change – changes in environment and natural resources – digital economy; ii) emerging security – digital economy – contactless society – changing role of a state; and iii) contactless society – society with diversified values – demographic change – issues relating to changing role of a state.



[Figure 5]
Major Issue
Link Map

Needs specific to major issues were derived with the aim of setting up scientific and technological means to cope with the major issues. Based on an in-depth analysis of each major issue, we have presented the detailed socioeconomic demands of the future society in terms of scientific and technological responses. Needs relating to both opportunities and threats have been fully factored in with the purpose of preventing adverse effects that may occur in responding to specific needs.

[Table 3] Needs and Science and Technologys Countermeasure Related to Mainstream Online Economy (Example)

	Related Needs	Science and Technology countermeasures
Needs and countermeasure related with opportunities	Deliver vivid experiences online like offline experiences	• Develop and utilize technology to transmit five senses, such as haptics • Develop VR technology for shopping • Personalized shopping powered by AI technology
	Have a 360-degree understanding of customers and make customized suggestions according to customer's situation and context	• Real-time advertising technology using non-identifiable data • Cross-platform advertising technology linked to computer, TV, and smartphone
Needs and countermeasure related with threats	Enhance store experiences and efficiency using various store technologies	• Develop and support technologies to improve the productivity of offline stores • Sales technology that connects online and offline
	Reconstruct the customer journey based on online and offline connection and provide a personalized service	• Create a digital data ecosystem including DMP (Data Management Platform)
	Lowering the barriers to online and mobile purchases for the elderly	• Develop universal UI/UX considering the elderly and expand its application • Operate online and mobile education channels for the elderly
	Prevent fraud in commercial transactions	• Develop technology to detect and track new abnormal E-commerce transactions

Finally, the relationship between research fields and technology trends were visually identified through quantitative analysis. In addition, new technologies and research fields or emerging research areas were identified through time series analysis. We analyzed research paper data built for a decade (2010 - 2019) across 21 fields by utilizing the list of top one percent researchers with the aim of producing academic papers to be used in identifying tech-push future technologies as candidates. From the interpretation of the results of the research trends, we derived the characteristics of research in the related technology fields, related issues that arose in the past two years, and promising fields for the future.

5. Identification of Future Technologies



Future technology is defined as a specific technology (finished products, parts, materials, source technologies, services, etc.) that is likely to be technologically realized by 2045 and have a significant impact on science and technology, society, and economy in Korea. It also means a technology that will emerge in response to demand for addressing major issues of future society or as a result of advancements in science and technology in the future, and a critical core technology, element technology.

Since the 5th Foresight activity, we standardized the presented names and descriptions of the technologies to improve the understanding and utilization of the results. In this 6th Foresight, we have made it easier to understand the names of future technologies by simplifying them focusing on main keywords, and made the descriptions in more detail to enhance their application. Based on the analysis of the major issues, we have classified future technologies into six groups related to future issues and identified future technologies based on needs related to the major issues under each group. In addition, future technologies necessary to address the needs based on review of future issues and expected to emerge due to advances in science and technology were proposed. Proposed future technology list was reviewed and finalized by the Executive Committee, which produced a total of 241 technologies expected to emerge by 2045 in relation to needs of future society, scientific and technological development and policy formulation to address the major issues.

[Table 4] **Number of Future Technologies of Major Issue Groups**

Technology Division	No. of Technologies	Name of Technology (Example)	Description of Technology (Example)
Digital Transformation	41	AI-based Hyper-personalized Virtual Education Environment System	• Virtual environment system that allows to select education that suits personal preferences and needs • Virtual space-based experience content without time and space constraints • Customized education through interactive rather than one-way communication
Manufacturing and Materials	34	3D/4D Printer-based Human Organ Manufacturing Technology Using Encrypted Personal Body Information	• Manufacturing of medical aids (implants, artificial bones) based on biometric information • Expand medical products that replace body parts to artificial eyes, artificial ears, and artificial heart by resolving information security issues of personal body data and the complexity of the manufacturing process • Personal medical information checked at hospital is sent to the manufacturer based on blockchain or encryption technology, and the manufacturer, in turn, assembles medical aids for the human body using titanium or composite materials to provide to the hospital
Human and Life	47	Custom Gene Therapy Technology to Treat Genetic Diseases Fundamentally and Efficiently	• Fundamentally cure genetic diseases caused by genetic mutations through genetic approaches • Treat by correcting mutations with gene scissors or supplementing normal genes • Gene therapy through gene editing of the patient's stem cells
Urban Area and Disaster	38	Autonomous Unmanned Patrol Robot for Advance Crime Detection	• Develop an unmanned robot equipped with a crime prevention warning function, capable of acquiring advance information on signs of a crime and responding real time • Robots, autonomous driving, detection sensors, deep learning modules, location information, and AI technologies must be developed together

Technology Division	No. of Technologies	Name of Technology (Example)	Description of Technology (Example)
Security and Exploitation	37	Farming Technology Enabling Mass Production in Lunar and Martian Environments	• A technology that can grow a large number of crops using local soil to enable astronauts on the Moon and Mars to live for the longer period • Breeding technology capable of cultivating in the lunar and Martian environments that are different from the earth's such as gravity and soil composition • Farming technologies using local resources such as smart farm system
Energy and Environment	44	Greenhouse Gas-free, Eco-friendly Hydrogen Reduction Steel Making Technology	• A system that uses hydrogen in the ironmaking process which reduces iron oxide of iron ore to metal iron, rather than reduction using coke, which emits a large amount of carbon • The hydrogen-based reduction emits water, not CO₂, from the ironmaking process, which is the key element technology for greenhouse gas reduction • Need to secure a core technology for hydrogen-based reduction (flow reactor for reduction with hydrogen, electric furnace), adjust the unit price of industrial hydrogen to a realistic level, and build a hydrogen supply chain
Total	241		

6. Future Technology Analysis



Delphi Survey

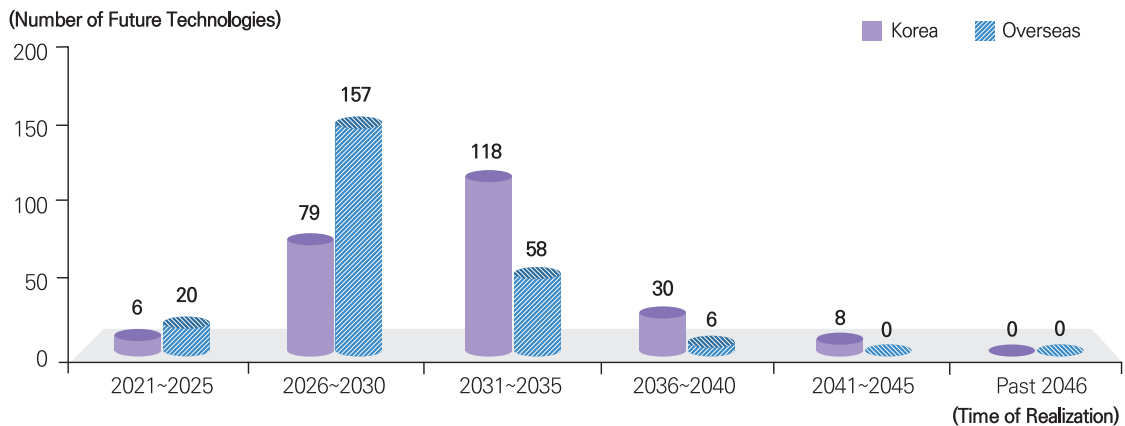
In order to analyze the future technology, 241 future technologies were examined to assess their characteristics, importance, time of technological realization, and required government policies. A two-round Delphi survey was carried out for the analysis of future technologies among the science and technology experts, in which 2,147 respondents (5,149 responses) replied to the 1st survey, and 1,617 respondents (4,044 responses) replied to the second, with a 75.3% follow-up rate.

Key Analysis Result

Of the 62 major issues, 25 future technologies are aimed to respond to “the Era of Space Life” and 24 involves “the Accelerated Creation of Hyper-connected Smart Cities”, both of which accounts for a large share. Two hundred twenty eight future technologies to address key issues are expected to be realized by 2040 (228/241, 94.4%). It is predicted that those with a shorter timeframe for realization include “Metaverse XR Performance System for Spreading Hallyu Culture (2025)” and “Smart Prevention Technology for Groups Vulnerable to Infectious Diseases (2025)”, while those with a longer timeframe include “Oxygen, Water and Rocket Fuel Production Technology Using Lunar and Martian In-Situ Resources (2044)”, and “Farming Technology Enabling Mass Production in Lunar and Martian Environments (2043)”.

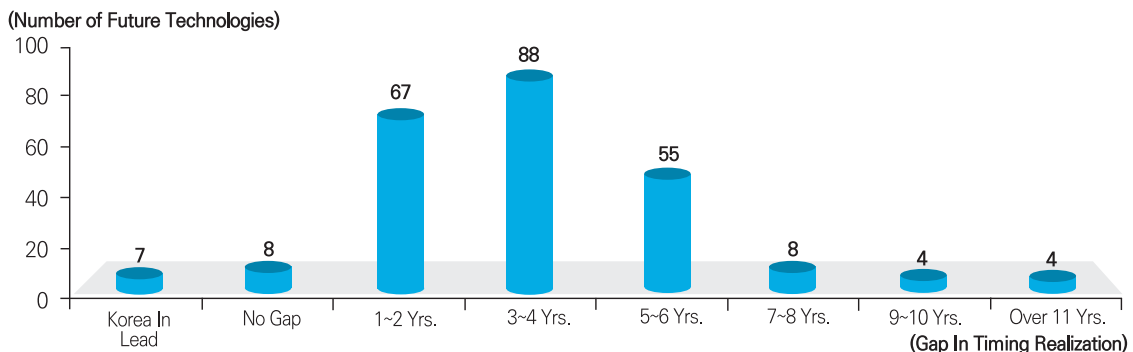
In detail, 228 technologies (94.6%) out of a total of 241 future technologies are expected to be realized between 2026 and 2040. Six technologies are expected to be realized before 2025, while 79 technologies (33.2%) between 2026 and 2030 within a short timeframe (within 10 years). In the longer term (11 years and longer), 148 technologies (61.4%) are expected to be realized

between 2031 and 2040, while eight technologies (3.3%) after 2041. Outside Korea, 157 (65.1%) of the 241 technologies are forecasted to be realized between 2026 and 2030. In a short timeframe, 20 technologies (8.3%) are expected to be realized before 2025, while 157 technologies (65.1%) between 2026 and 2030, and 58 technologies (24.1%) between 2031 and 2035 and 6 technologies (2.5%) after 2036.



[Figure 6]
Expected Time of Realization of Future Technologies

Out of the 241 future technologies, 15 technologies (6.2%) were predicted to be first realized in Korea or at the same time as overseas, while 88 technologies (36.5 %), which tops all segments, showed a 3 to 4 year technology gap between Korea and other countries. Korea exhibited a small gap of between 1 and 2 years in 67 technologies (27.8%) compared to other countries, while showing a gap of 7 years or more in 16 technologies (6.6%).



[Figure 7]
Expected Time
of Realization
Gap between
Korea and Other
Countries

According to the survey, as a means to realize the future technologies, 25.5% of the technologies needed, first and foremost, infrastructure set-up, while 24.6% required an increase in the research funds from government. As for the future technologies that are expected to be realized in the shorter term (within 10 years), it is crucial to provide policy support to increase research funds in addition to the government's infrastructure set-up and a collaboration between industry, academia and research institutes and international research collaborations. As for the technologies with the longer realization time (11 years or longer), the need for infrastructure creation was emphasized, along with demand for an increase in government research funds.

[Table 5] Government Policy Required for the Realization of Future Technology (%)

Classification		Manpower Training	Cooperation Expansion	Infrastructure Establishment	Investment Expansion	Regulation Improvement
Total		17.1	22.6	25.5	24.6	10.2
Timing of Realization	Short-term (~2030)	15.3	23.6	27.1	20.2	13.8
	Long-Term (2031~)	18.0	22.0	24.5	27.3	8.2

Furthermore, the survey showed that research and development activity led by government-funded, national and public research institutes is the most important for the realization of future technologies. Particularly, government-funded, national and public research institutes play a crucial role in realizing long-term technologies, while industry should take the lead in dealing with short-term technologies.

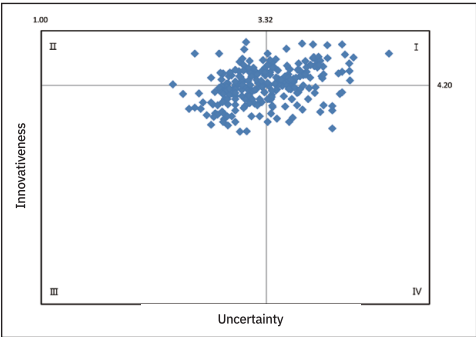
[Table 6] Main Agent in Leading the Research for the Realization of Future Technology (%)

Classification		Industry	Academia	Research Institute
Total		40.5	14.0	45.5
Timing of Realization	Short-term (~2030)	54.6	8.7	36.7
	Long-Term (2031~)	32.8	16.9	50.3

Innovativeness³ and uncertainty⁴ were assessed in order to analyze the characteristics of the future technology.

Of the 241 future technologies, 73 future technologies including “Manned Lunar and Mars Base Construction Technology Utilizing In-Situ Resources” and “Magnetic Field Based Seismic Isolation System Development Technology for Complete Separation of Ground Motions” were classified as Group I technologies (high need of government-level support) due to their high uncertainties as well as their high innovativeness. 45 future technologies were classified as Group II, (extensive investment due to high achievement expectation) with relatively high innovativeness and low uncertainty, including “Big Data and AI-based Smart Airport System”, and “Synthetic Biology Based Cell Factory Construction Technology for the Production of Eco-friendly Biomaterials”.

[Table 7]
Dispersion of
Innovativeness
and Uncertainty
of Future
Technology



Classification	Group I	Group II
No. of Technologies (Percentage)	73 (30.3)	45 (18.7)

Classification	Group III	Group IV
No. of Technologies (Percentage)	83 (34.4)	40 (16.6)

3 The extent to which the result of the research and development causes disruptive innovation and is not an extension of present technology.

4 The extent to which the technology relies on multiple probabilistic factors in research and development, and requires multiplemethodological review including acceptance of failure.

[Table 8] **Technologies High in Both Innovativeness and Uncertainty**
(Group I, Top 10 Techs, 5-point scale)

Tech No.	Future Technology	Innovativeness	Uncertainty
162	Manned Lunar and Mars Base Construction Technology Utilizing In-Situ Resources	4.9	4.7
230	Magnetic Field Based Seismic Isolation System Development Technology for Complete Separation of Ground Motions	4.6	4.6
160	Real-time, Automated Global Environment Monitoring and Disaster Warning System Based on Satellite and High-altitude Unmanned Air Vehicles	4.5	4.5
54	High-strength, Ultra-light, Long-life Carbon Cable Material Technology for Space Elevators	4.5	4.3
66	Memory Restoration Technology that Clones the Human Brain	4.4	4.3
164	Oxygen, Water and Rocket Fuel Production Technology Using Lunar and Martian In-Situ Resources	5.0	4.2
111	Electronic Artificial Brain Technology to Replace Part of the Biological Brain	4.6	4.1
65	Remotely Working Avatar Robot Communicating and Controlled Through an Ultra-thin Five-sensing Suit	4.4	4.1
51	Atom Assembly Technology for Customized Molecular Printing	4.9	4.1
19	Mind Reading Brainwave Communication System	4.7	4.1

** Ranked from highest uncertainty within Group I*

[Table 9] Technologies High in Innovativeness but Low in Uncertainty
(Group II, Top 10 Techs, 5-point scale)

Tech No.	Future Technology	Innovativeness	Uncertainty
148	Big data and AI-based Smart Airport System	4.7	2.6
92	Synthetic Biology Based Cell Factory Construction Technology for the Production of Eco-friendly Biomaterials	4.5	2.7
185	Automated Data Security Level Classification Technology for Secure Data Transaction	4.3	2.7
90	Platform for the Development of Customized Vaccine or Medicine to Fight New Infectious Disease and Its Variant	4.5	2.7
98	AI-based Livestock Disease Prediction, Diagnosis and Control System	4.3	2.7
167	Medical Service, New Drug, and New Material Development Technology Using Microgravity	4.8	2.7
15	Non-contact Coexistent Reality and XR-based Five-sense Interactive Education System	4.5	2.7
60	Bio-affinity Electronic Material Technology Creating Human Sensory Experiences	4.7	2.8
100	Technology for the Development and Management of High Quality Aquatic Organisms Using Genome Information	4.5	2.8
31	6G-based Hyper-immersive Remote Sharing and Collaboration Service Technology for Digital Content Co-creation	4.4	2.8

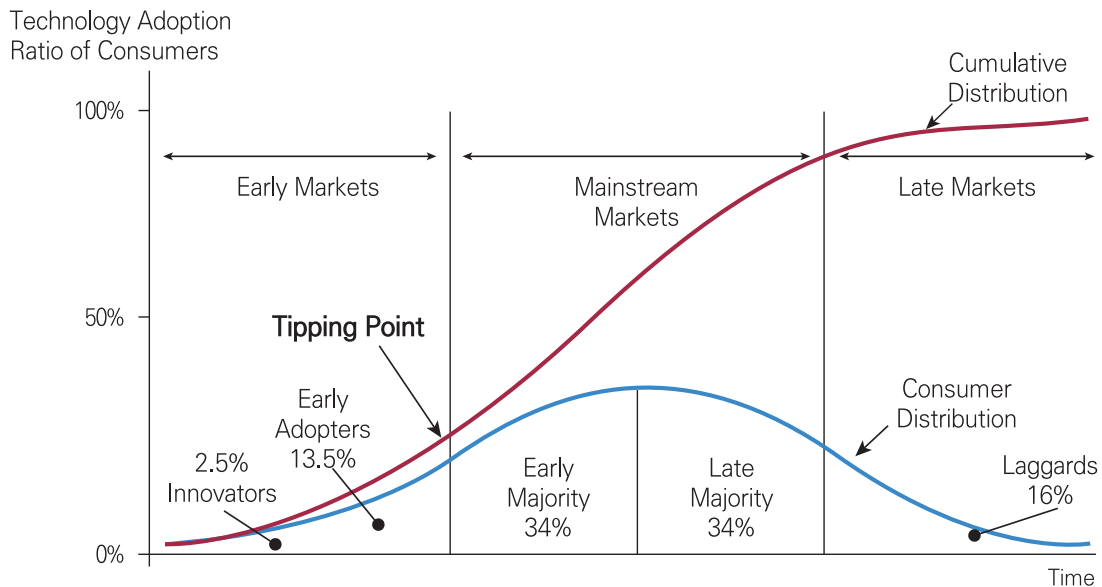
* Ranked from lowest uncertainty within Group II

7. Future Innovative Technology Analysis



Tipping point of future innovative technologies was analyzed in the 6th Science and Technology Foresight, along with prediction of the timing of the realization of future technologies, in regard to policy utilization. Here, "future innovative technologies" are convergence technologies related to the everyday lives, which are expected to have significant ripple effects in future society. The tipping point of the technology is the time at which the technology is rapidly diffused throughout society after passing the chasm.

The 'Technology Adoption Life Cycle Model,' which is a model of the five-stage process through which consumers adopt innovative products or services realized through high-end technologies, was used to define the tipping point. The point when the product/service is diffused from early markets to mainstream markets was set as the standard for the tipping point. This point is quantitatively interpreted as the point when the product has been adopted by 16% of the total number of consumers, including the innovators (2.5%) and early adopters (13.5%). Prediction was made by categorizing social phenomena expected to occur when the tipping point is reached, based on the characteristics of each technology. These categories include: the moment when the new product/service replaces 16% of the original market, the moment when the product/service secures a certain amount of customers, and the moment of first commercialization of the product/service. The analysis focused on determining the tipping point as the point considered crucial in terms of social diffusion, and at the same time when the general public can actually perceive the change.



[Figure 8]
Technology Adoption Life Cycle Model and Tipping Point

The tipping point analysis was conducted as follows. First, candidate technologies expected to have significant effects and impacts on the society and economy in the future were identified based on the analysis of case studies on promising technologies in and outside Korea. A survey was conducted among members of the Future Technology Committee on these candidate technologies, and 15 future innovative technologies were selected by the Committee after discussing and adjusting their names and categories. As 15 major future innovative technologies subject to tipping point analysis, additional research was carried out to examine at which point those technologies would reach diffusion. In addition, an analysis was performed in relation to the degree of significance, government's priority actions, the shape of future change caused by opportunities and impacts as well as the shape of future change caused by risks and potential social conflicts. A two-round Delphi survey was carried out for the analysis of future innovative technologies among the science and technology experts, in which 840 respondents (1,265 responses) replied to the 1st survey, and 678 respondents (1,018 responses) replied to the second, with an 80.7% follow-up rate.

Tipping point analysis for 15 future innovative technologies are as follows:

[Table 13] Definitions and Expected Tipping Points of Future Innovative Technologies

Innovative Technology	Definitions of Tipping Points	Expected Tipping Point	
		Overseas	Korea
 Fully Autonomous Air Vehicle	When fully autonomous air vehicles account for 8% in the air vehicle market	2031 (U.S.)	2036
 Fully Autonomous Vehicle	When Level 4+ autonomous vehicles account for 1.6% in the market	2030 (U.S.)	2033
 Personalized Vaccine	When a vaccine is typically developed within one year from the spread of the pathogen to the start of a clinical trial	2025 (U.S.)	2029
 Hydrogen Energy	When there is a transition to high-efficiency storage with mass hydrogen and annual hydrogen demand from industry and transportation reaches more than 2.4 million tons	2030 (U.S.)	2032
 Hyper-personalization using AI	When the percentage of users using personalized AI services on their devices reaches 16%	2029 (U.S.)	2031
 Biochip	When the proportion of biometric authentication technology in personal authentication methods in financial services reaches 16%	2030 (U.S.)	2033
 Response System for Compound Disaster	When the first rapid response system for hybrid disasters is introduced and deployed in cities with a population over 1 million	2029 (U.S.)	2032
 Quantum Cryptography Communication Technology	When mobile carriers transmit security data over 100km using network-based quantum cryptography communication technology without integrated quantum cryptography communication networks and quantum repeaters	2030 (U.S.)	2034
 AI Semiconductor Chip	When the AI semiconductor chip accounts for 5% of the total logic chip market	2028 (U.S.)	2030
 Autonomous Working Robot	When the penetration rate of autonomous mobile and working robots reaches 10% or more in manufacturing (production automation, logistics, etc.)	2028 (U.S.)	2030

Innovative Technology		Definitions of Tipping Points	Expected Tipping Point	
			Overseas	Korea
	Small Nuclear Battery	When small nuclear batteries (or microreactors) obtain permits and licenses and demonstrate the supply of energy (power or heat)	2030 (U.S.)	2035
	Disaster Prediction	When the average prediction accuracy of individual disaster elements reaches 70% or more	2029 (U.S.)	2033
	Carbon-neutral Fuel	When carbon-neutral fuel is certified as a new and renewable fuel, and the mandatory blending ratio of new and renewable fuels turns 10% or more	2030 (U.S.)	2034
	Carbon Cycle Observation Technology	When the integrated/hybrid observation network is realized as carbon observation by ground, air, drone, and satellite becomes possible	2029 (U.S.)	2033
	Cell Reprogramming Technology	When the cell reprogramming technology is covered by public health insurance as a treatment for aging-related diseases	2030 (U.S.)	2034

8. Conclusion



The 6th Science and Technology Foresight has characteristics different from the previous foresight activities as follows. First, the Foresight has generated the future technologies from the collaborative effort of experts from R&D management agencies, government-funded institutes, industry and academia, with the aim of forecasting mid- and long-term future of our society and addressing major issues expected to emerge in line with future trends. Second, we have included more diverse fields of future technologies and enhanced the way the technologies are named and presented for the outcome of the exercise to be applicable more broadly, while strengthening the link with government policy exploiting ‘Science and Technology Strategies 2045’. Third, in the 6th Foresight activity, future technologies have been identified based on the promising research areas derived from quantitative analysis and interpretation of research papers along with societal needs.

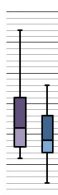
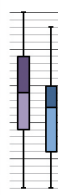
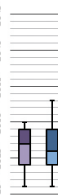
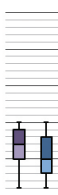
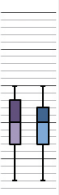
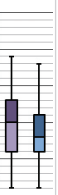
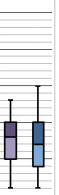
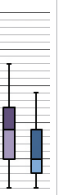
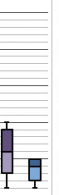
In relation to how to realize the future technologies, the 6th Science and Technology Foresight presents several implications. First, the top priority in securing the future technologies includes government’s infrastructure creation and more research funding, requiring a leading role of government-funded, research institutes and industry. Second, the government needs to strategically develop policy measures according to the nature of future issues. Third, different agents should be involved in research for technical realization based on the issues and characteristics of related technologies. Fourth, strategic investment based on the characteristics of technologies is critical.

New technologies are created to meet the needs of a society, which is rapidly changing due to increasing uncertainty of the future and more diversified changes, such as digital transformation and the COVID-19 pandemic, which further highlights the importance of a foresight activity. The predictions of

the future technology and realization time made in this Foresight exercise may be inaccurate due to uncertainties that necessarily entail in any predictions of the future. Nevertheless, the greatest benefit of the exercise is that it suggests what is necessary to assess the readiness of productive discussions and preparation for the future. The results of the 6th Science and Technology Foresight will help researcher to identify new research ideas, policy makers to make systematic planning to prepare for the future and encourage the public to be interested in and prepare for the upcoming future.

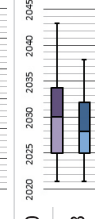
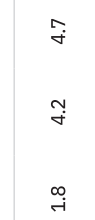
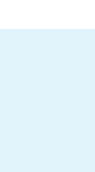
Annex Major results of Future Technology Analysis

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
1	AI-based Hyper-personalized Virtual Education Environment System	4.1	2.9	2.6	4.2	4.4	4.3	Korea 2028 Overseas 2027		Fostering Human Resources
2	Autonomous Self-evolving IoT Integration Platform that Connects All Devices and Things	4.4	3.1	3.0	4.4	4.3	4.7	Korea 2030 Overseas 2028		Infrastructure Creation
3	Personalized Self-evolving Robot As a Companion Empathizing with and Understanding People	4.5	4.1	3.4	4.4	4.4	4.1	Korea 2036 Overseas 2033		Increase in Research Fund
4	Human Assistance System Using Remote Collection of Biosignals	3.8	3.2	2.7	4.1	4.2	4.1	Korea 2032 Overseas 2029		Fostering Human Resources
5	Ultra-high Frequency Terahertz Communication Technology for Hyper-connected VR/AR Devices	4.3	3.4	2.5	4.5	4.1	4.5	Korea 2029 Overseas 2029		Promoting Cooperation
6	Anonymous Confirmed Case and Contact Tracking Management System Based on Hyper-connected Network	3.6	2.9	3.3	3.8	4.3	3.9	Korea 2027 Overseas 2026		Infrastructure Creation
7	RIS Production and Control Technology For QoS Enhancement of 6G IoT Device	4.7	3.5	2.4	4.6	3.9	4.3	Korea 2029 Overseas 2029		Increase in Research Fund
8	6G and AI-based Hyper-immersive Extended Reality (XR) Technology	4.5	3.3	2.5	4.4	4.1	4.8	Korea 2029 Overseas 2028		Promoting Cooperation
9	Autonomous Drone Technology Using 6G Communication IoE Network	4.5	3.7	2.6	4.6	4.4	4.4	Korea 2029 Overseas 2026		Infrastructure Creation
10	Complex Reasoning Professional Assistant Technology Capable of Real-life Expert Knowledge Consulting	4.1	3.4	3.2	4.1	4.5	4.2	Korea 2030 Overseas 2028		Promoting Cooperation

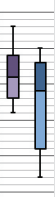
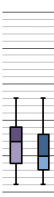
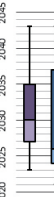
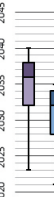
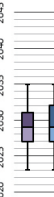
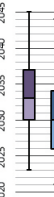
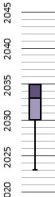
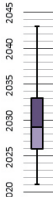
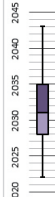
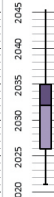
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
11	Zero UI Universal Real-time Interpretation System Enabling Conversations without Language Barriers	4.1	3.1	2.0	4.1	4.4	4.4	Korea 2031		Infrastructure Creation
12	Artificial Sensory-Neural Network Connection Technology that Compensates for Lost Sensory Function with Other Senses	4.7	3.4	2.6	4.6	4.6	4.3	Korea 2034		Promoting Cooperation
13	XR System for Virtual Shopping that Links Online and Offline	3.9	2.9	2.3	3.8	3.4	4.4	Korea 2027		Promoting Cooperation
14	Metaverse XR Performance System for Spreading Hallyu Culture	4.3	2.8	2.2	3.8	3.8	4.2	Korea 2025		Infrastructure Creation
15	Non-contact Coexistent Reality and XR-based Five-sense Interactive Education System	4.5	2.7	2.5	4.4	4.6	4.1	Korea 2027		Infrastructure Creation
16	Metallife System Using Alternative Reality Technology	4.1	3.8	3.7	4.0	3.8	4.3	Korea 2030		Infrastructure Creation
17	Evolutionary UI/UX Technology for Senior Services	4.0	3.3	2.4	4.0	4.8	4.3	Korea 2030		Promoting Cooperation
18	Technology for Creating Virtual Learning System Identical to the Real World	4.2	3.0	2.4	4.4	4.4	4.3	Korea 2028		Infrastructure Creation
19	Mind Reading Brainwave Communication System	4.7	4.1	3.1	4.6	4.6	4.3	Korea 2035		Fostering Human Resources
20	Personalized Digital Treatment Technology for the Prevention, Treatment, and Management of Mental Illness	4.3	3.4	3.1	4.2	4.7	4.2	Korea 2029		Promoting Cooperation
21	Blockchain-based Network Platform with Enhanced Security for Public Communication	3.8	2.5	2.2	4.0	4.6	4.5	Korea 2026		Infrastructure Creation
22	Meta-communication Technology for Communication among Members of Society	4.0	2.8	2.8	4.1	3.7	4.2	Korea 2029		Infrastructure Creation

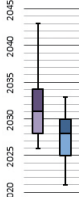
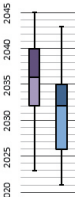
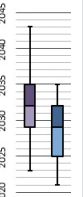
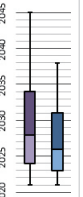
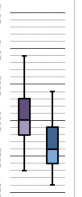
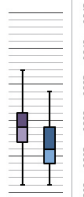
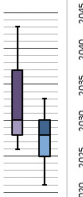
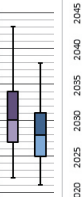
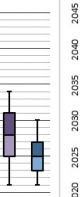
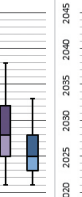
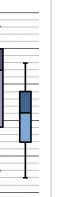
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)					Government Policy (Top Priority)		
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial	2029	2035	2045	2055				
23	Ultra-precise Positioning System for Seamless Coexistence of All Moving Objects in Indoor and Outdoor Environments	4.3	3.4	3.3	4.4	4.2	4.5	Korea		2029		2035		2045	Increase in Research Fund
24	Quantum Network Technology that Connects Quantum Systems and Stores Quantum Mechanical Information	4.8	3.9	2.5	4.8	4.2	4.3	Korea		2035		2050		Fostering Human Resources	
25	High-resolution Imaging Technology Exceeding Conventional Resolution Based on the Principles of Quantum Mechanics	4.0	3.7	2.6	4.6	4.1	4.3	Korea		2034		2045		Fostering Human Resources	
26	Quantum Repeater Technology to Secure Complementarity and Increase Communication Distance in Quantum Cryptography Communication	4.4	4.0	2.6	4.6	4.2	4.2	Korea		2034		2050		Fostering Human Resources	
27	3D Quantum Device Technology for Maximizing Quantum Computing Performance	4.2	4.1	2.4	4.9	4.2	4.3	Korea		2038		2045		Fostering Human Resources	
28	Microscopy Technology for the Measuring of Single-molecule Nanocomposite Materials in the Real Environment	4.3	3.4	1.8	4.7	4.1	4.3	Korea		2031		2045		Fostering Human Resources	
29	Invisibility Cloak System Capable of Concealing from RF, Light, and Ultrasonic Detection	4.7	3.8	3.3	4.2	3.9	4.1	Korea		2034		2045		Increase in Research Fund	
30	Remote Operation Technology of Unmanned System Using Cranial Nerves	4.4	3.9	3.4	4.4	3.9	3.9	Korea		2038		2050		Infrastructure Creation	
31	6G-based Hyper-immersive Remote Sharing and Collaboration Service Technology for Digital Content Co-creation	4.4	2.8	2.3	4.1	4.0	4.5	Korea		2029		2045		Infrastructure Creation	
32	Hyper-realistic XR Automated Twin Generation Technology	4.5	3.1	2.4	4.5	4.2	4.5	Korea		2033		2045		Increase in Research Fund	
33	Full Three-dimensional Hyper-realistic Digital Holographic Display Technology	4.6	3.8	2.8	4.3	3.9	4.2	Korea		2033		2045		Increase in Research Fund	

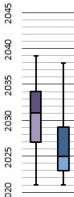
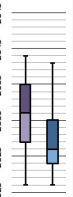
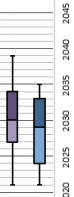
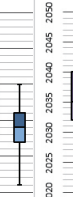
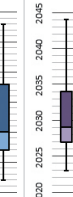
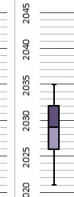
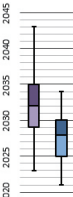
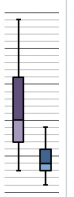
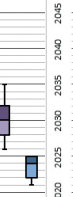
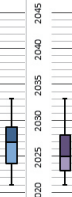
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)					Government Policy (Top Priority)	
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial							
34	PIM(Processing-In-Memory) AI Semiconductor Technology	4.6	3.2	2.0	4.7	4.4	4.9	Korea	2029		Overseas	2028		Promoting Cooperation
35	Next-generation Intelligent Process Technology for AI	4.6	3.2	2.2	4.6	4.5	4.9	Korea	2030		Overseas	2029		Fostering Human Resources
36	Nanophotonics-based Photoelectric Fusion Semiconductor Technology for Ultra-high-performance Low-power Computing	4.4	3.8	2.4	4.4	4.0	4.4	Korea	2035		Overseas	2033		Fostering Human Resources
37	Post-CMOS Semiconductor Device and Interconnect Technology	4.4	3.5	1.9	4.1	4.1	4.6	Korea	2028		Overseas	2028		Promoting Cooperation
38	Ultra-high-efficiency Semiconductor Technology Combining Digital and Analog Computing	4.3	3.3	2.3	4.4	4.1	4.1	Korea	2034		Overseas	2031		Promoting Cooperation
39	Next-Generation High-efficiency Power Semiconductor Technology for Electric and Motive Power	3.9	3.1	2.1	4.5	4.4	4.5	Korea	2029		Overseas	2024		Increase in Research Fund
40	Chiplet-based Ultra-high Density Wafer-level Integration, Packaging, and Testing Technology	4.2	2.4	1.8	4.3	4.0	4.5	Korea	2027		Overseas	2027		Promoting Cooperation
41	Human-level Language Processing Technology Capable of Complete Semantic and Pragmatic Analysis	4.5	3.6	2.8	4.5	4.4	4.5	Korea	2023		Overseas	2029		Fostering Human Resources
42	3D/4D Printer-based Human Organ Manufacturing Technology Using Encrypted Personal Body Information	4.4	3.4	3.2	4.7	4.5	4.0	Korea	2034		Overseas	2029		Fostering Human Resources
43	Smart Factory Technology for Humans and Environmental Protection Based on Hazardous Substance Shielding Technology	4.0	2.8	2.0	4.1	4.6	4.1	Korea	2026		Overseas	2026		Infrastructure Creation
44	Predictive Maintenance and Operation Technology for Equipment Based on AI-based Recognition and Precision Location Determination Technology	4.3	2.9	2.3	4.6	4.4	4.8	Korea	2031		Overseas	2027		Promoting Cooperation

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)						Government Policy (Top Priority)		
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial									
45	Autonomous Working Robot for Smart Farm Operation Based on Shape Recognition of Fruit Trees and Vegetables	3.8	2.8	2.2	3.8	4.4	4.3	Korea	2030							Infrastructure Creation
46	High-capacity, Ultra-light Secondary Battery Technology for Flying Cars	4.5	3.9	2.6	4.3	3.9	4.4	Korea	2033							Increase in Research Fund
47	Large-capacity Flexible Secondary Battery Technology Used As a Power Source for Wearable Device	3.9	3.1	2.9	4.1	3.6	3.9	Korea	2028							Promoting Cooperation
48	Ultra-lightweight Graphene-based High-capacity Overhead Power Line Material Technology	3.9	3.9	2.6	3.8	3.9	3.8	Korea	2032							Promoting Cooperation
49	Non-replicable Nano Security and Authentication Material and Device Technology	4.5	3.3	2.5	4.1	4.0	4.0	Korea	2028							Increase in Research Fund
50	Super Strong Fiber Material Technology for Artificial Muscle	4.5	3.7	2.3	4.3	4.5	4.2	Korea	2035							Fostering Human Resources
51	Atom Assembly Technology for Customized Molecular Printing	4.9	4.1	2.5	4.7	4.4	4.7	Korea	2038							Increase in Research Fund
52	Photoactive Material Technology for Ultra-high Efficiency Solar Cells	4.4	3.8	2.0	4.6	4.3	4.2	Korea	2030							Increase in Research Fund
53	Metal Junction Based Carbon or Organic-inorganic Hybrid Structural Material	3.9	2.9	2.1	4.3	3.8	4.4	Korea	2029							Fostering Human Resources
54	High-strength, Ultra-light and Long-life Carbon Cable Material Technology for Space Elevators	4.5	4.3	2.7	4.3	3.7	3.8	Korea	2039							Promoting Cooperation
55	Naturally Occurring Polymer-based Plastic Material that Can Replace Petroleum-based Plastics and Technology to Use It	4.1	3.1	1.8	4.2	4.7	4.3	Korea	2030							Infrastructure Creation
56	Biocompatible Nanomaterials Technology with Target Orientation, Drug Delivery, and Biosensing Functions Simultaneously	4.3	3.1	2.5	4.5	4.4	4.5	Korea	2032							Increase in Research Fund

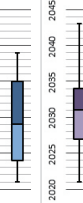
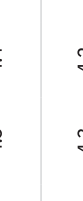
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)					Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial						
57	Wearable Robot for Strengthening the Muscles of Workers and the Military	3.9	3.4	2.6	4.2	4.1	4.1	Korea	2032		Overseas	2029	Promoting Cooperation
58								Korea	2030		Overseas	2028	
59	Single Crystal Diamond-based Power Semiconductor Technology	4.6	4.0	2.3	4.4	4.1	3.9	Korea	2034		Overseas	2030	Fostering Human Resources
60								Korea	2036		Overseas	2037	
61	Ferroelectric Photonics Material Technology for Terabit Data Communication	4.5	3.4	2.6	4.6	4.3	4.2	Korea	2033		Overseas	2031	Increase in Research Fund
62								Korea	2032		Overseas	2029	
63	Technology for Long-life Super Battery without the Need of Replacement for Electric Vehicles	4.5	3.9	2.8	4.7	4.5	4.7	Korea	2034		Overseas	2033	Promoting Cooperation
64								Korea	2032		Overseas	2029	
65	Remotely Working Avatar Robot Communicating and Controlled Through an Ultra-thin Five-sensing Suit	4.4	4.1	2.6	4.3	3.9	4.1	Korea	2037		Overseas	2034	Increase in Research Fund
66								Korea	2039		Overseas	2036	
67	On-site Mobile 3D Printing System	4.3	3.4	2.5	4.2	4.0	3.9	Korea	2032		Overseas	2029	Promoting Cooperation
68								Korea	2033		Overseas	2029	

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
69	XR Smart Glass Technology Based on Brain Wave Input Controlling Technology	4.2	4.5	3.8	4.0	3.2	3.3	Korea 2036 Overseas 2034		Fostering Human Resources
70	Processing State Detection and Manufacturing Technology Using Real-time Image and VR Technology	4.2	2.8	2.2	4.1	3.9	4.3	Korea 2027 Overseas 2025		Infrastructure Creation
71	High-capacity Reversible Hydrogen Storage Alloy Technology for Transportation Equipment	3.9	4.1	2.5	3.9	3.8	3.8	Korea 2030 Overseas 2034		Promoting Cooperation
72	Rare-earth-free Permanent Magnet Technology for Energy Conversion	4.7	3.6	2.2	4.5	4.1	4.7	Korea 2030 Overseas 2026		Fostering Human Resources
73	Technology for Healing Damaged Tissues with Biodegradable Metals	3.8	3.3	2.6	4.0	4.2	3.9	Korea 2036 Overseas 2032		Promoting Cooperation
74	Stretchable Display Technology without Limitation of Installation Space	4.2	3.0	1.7	4.2	3.4	4.5	Korea 2029 Overseas 2029		Promoting Cooperation
75	Ultra-small Portable Holographic Display Technology	4.7	3.8	2.4	4.5	3.7	4.1	Korea 2033 Overseas 2032		Promoting Cooperation
76	Custom Gene Therapy Technology to Treat Genetic Diseases Fundamentally and Efficiently	4.5	3.5	3.3	4.7	4.4	4.6	Korea 2033 Overseas 2030		Increase in Research Fund
77	Personalized Tissue Regeneration Technology for Damaged Organ Repair	4.6	3.5	2.6	4.7	4.7	4.5	Korea 2033 Overseas 2031		Increase in Research Fund
78	Customized or Synthetic Biology-based Immunotherapy Technology that Can Completely Cure Solid Cancers	4.4	3.0	2.5	4.5	4.6	4.6	Korea 2029 Overseas 2025		Increase in Research Fund
79	Innovative Disease Treatment Technology Using Genetically Modified Microbiome	4.2	3.5	2.9	4.2	4.2	4.2	Korea 2031 Overseas 2029		Increase in Research Fund
80	Theranostic System that Secures and Uses Biometric Data Including Genome Information	4.3	3.1	3.0	4.5	4.4	4.4	Korea 2032 Overseas 2028		Improve Regulation

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
81	Universal Flu Vaccine Technology	4.1	3.5	2.1	4.4	4.7	4.4	Korea 2031 Overseas 2028		Increase in Research Fund
82	Cell Reprogramming Technology for Long-lasting Anti-aging Treatment	4.3	3.9	3.5	4.5	4.4	4.3	Korea 2036 Overseas 2032		Increase in Research Fund
83	Digital-Biomarker Technology for Precise Diagnosis of Depression	4.5	3.2	2.4	4.3	4.7	4.3	Korea 2032 Overseas 2029		Increase in Research Fund
84	Digital Twin System for Personal Health Care and Disease Risk Prediction Using Digital Technology Including AI and Blockchain	4.4	3.0	2.5	4.3	4.3	4.6	Korea 2028 Overseas 2026		Improve Regulation
85	Technology for Developing New Varieties of Crops and Feeds to Respond to Climate Change	4.2	3.0	2.5	4.5	4.6	4.5	Korea 2027 Overseas 2024		Increase in Research Fund
86	Smart Farm Technology for the Production of Highly Functional Crops Based on Growth Modeling System	4.2	2.8	2.2	4.3	4.2	4.2	Korea 2029 Overseas 2026		Infrastructure Creation
87	Technology for Maximizing the Efficiency of Seed Development Using Chromosomal Crossover Regulating Genes	4.5	3.4	3.1	4.4	4.1	4.4	Korea 2030 Overseas 2028		Infrastructure Creation
88	AI-based Technology for Disease and Pest Prediction and Diagnosis of Agricultural and Forestry Crops	4.3	3.1	2.1	4.4	4.5	4.2	Korea 2030 Overseas 2028		Infrastructure Creation
89	AI-based Constant Monitoring and Early Warning System for Emerging Infectious Disease and Its Variant	4.2	4.0	2.3	4.2	4.8	3.8	Korea 2028 Overseas 2023		Infrastructure Creation
90	Platform for the Development of Customized Vaccine or Medicine to Fight New Infectious Disease and Its Variant	4.5	2.7	2.5	4.7	4.8	4.8	Korea 2028 Overseas 2025		Increase in Research Fund
91	Microrobot for Vascular Occlusion Diagnosis and Treatment	4.7	3.6	2.9	4.6	4.5	4.5	Korea 2037 Overseas 2031		Increase in Research Fund

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial	Korea	Overseas	
92	Synthetic Biology Based Cell Factory Construction Technology for the Production of Eco-friendly Biomaterials	4.5	2.7	2.0	4.8	4.5	4.8	2031	2025	Infrastructure Creation
										
93	BioFoundry-based High-speed, Low-cost DNA Synthesis System for Data Storage and Biomanufacturing	4.9	3.1	2.4	4.8	4.5	4.7	2031	2026	Infrastructure Creation
										
94	Bacterial-based Biotherapeutics Development Technology	4.1	2.9	3.0	4.1	4.4	4.4	2030	2029	Increase in Research Fund
										
95	De Novo Design Based Therapeutic Protein Drug Products Development Technology	4.6	3.3	2.4	4.7	4.3	4.6	2031	2029	Increase in Research Fund
										
96	Multifunctional Microbiome Modulator Development Technology for Maintaining Health in Space Flight	4.2	3.6	2.4	3.5	3.2	2.6	2035	2030	Infrastructure Creation
										
97	Technology for the Development of Cultured Meat that Substitutes for Livestock (Chickens, Cattle, Pigs) and Aquatic Products	4.1	3.3	3.0	4.1	3.7	4.0	2029	2024	Infrastructure Creation
										
98	AI-based Livestock Disease Prediction, Diagnosis and Control System	4.3	2.7	2.1	4.6	4.8	4.7	2029	2025	Infrastructure Creation
										
99	Technology for Predicting Changes in Fishery Resources Due to Climate Change	3.9	3.7	2.3	4.3	4.6	4.0	2032	2028	Infrastructure Creation
										
100	Technology for the Development and Management of High Quality Aquatic Species Using Genome Information	4.5	2.8	2.5	4.8	4.5	4.8	2030	2024	Increase in Research Fund
										
101	Next-generation Smart Onshore Aquaculture Platform Creation Technology	4.2	2.6	1.9	4.2	4.5	4.4	2030	2024	Infrastructure Creation
										
102	Infectious Disease Precision Diagnosis System for On-site Testing	4.2	3.2	1.9	4.4	4.8	4.3	2026	2022	Promoting Cooperation
										
103	Smart Epidemic Control Technology for Groups Vulnerable to Infectious Disease	4.2	3.0	2.1	4.4	4.8	4.4	2028	2024	Infrastructure Creation
										

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
104	Organoid-based System for Pathogen Testing for Infectious Disease and Evaluation of Efficacy of Medicines and Vaccines	4.3	3.8	2.8	4.6	4.3	4.3	Korea 2030		Increase in Research Fund
Overseas 2026										
105	AI-based Technology for Discovering Treatment for New or Variant Viruses and Drug-resistant Bacterial Infections	4.5	3.3	2.4	4.7	4.8	4.2	Korea 2031		Promoting Cooperation
Overseas 2026										
106	Targeted Genetical Modification Based Crop Protection Technology	4.2	3.3	3.2	4.3	4.2	4.3	Korea 2032		Infrastructure Creation
Overseas 2026										
107	Artificial Vision Technology for Augmentation of Visual Information	4.0	3.3	2.5	4.0	4.1	3.8	Korea 2034		Increase in Research Fund
Overseas 2031										
108	Computational Brain Science Based Brain Simulation Technology for Diagnosing the Mechanism of Brain Diseases	4.5	4.0	2.4	4.5	4.7	4.2	Korea 2035		Fostering Human Resources
Overseas 2032										
109	Non-invasive Deep Brain Stimulation Technology for Controlling Intractable Brain Diseases	4.3	3.1	2.4	4.5	4.7	4.4	Korea 2030		Promoting Cooperation
Overseas 2027										
110	Brain Implantable Neurotransmitter Measurement Technology for Constant Monitoring of Brain Function	3.8	3.9	3.4	4.2	3.9	3.5	Korea 2041		Fostering Human Resources
Overseas 2037										
111	Electronic Artificial Brain Technology to Replace Part of the Biological Brain	4.6	4.1	3.1	4.6	4.2	4.2	Korea 2041		Fostering Human Resources
Overseas 2035										
112	Treatment Technology for Intractable Neurodegenerative Diseases Using Low-dose Radiation	4.2	3.5	3.2	4.1	4.5	4.0	Korea 2031		Increase in Research Fund
Overseas 2028										
113	Diagnosis and Treatment Technology for Aging and Incurable Diseases Using Exosomes	3.8	3.2	2.8	4.2	3.7	3.8	Korea 2033		Increase in Research Fund
Overseas 2028										
114	Development Technology for Patch or Gel-type Pharmaceutical with Anti-inflammatory Action and Skin Closure Function	3.8	2.6	2.1	3.9	3.9	4.0	Korea 2029		Promoting Cooperation
Overseas 2025										

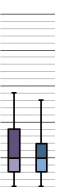
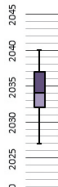
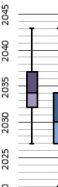
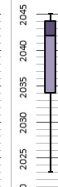
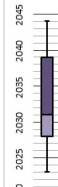
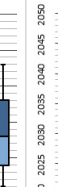
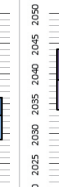
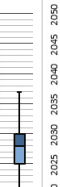
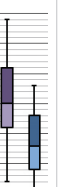
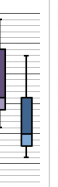
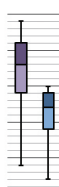
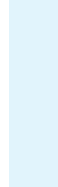
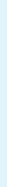
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)			Government Policy (Top Priority)
		Innovativeness		Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
115	Productivity Improvement Technology through Strengthening of Microbiome of Livestock	4.4	3.1	2.0	4.3	4.3	4.2	Korea 2033		Promoting Cooperation	
116	Livestock Excreta Treatment and Resource Recycling Technology that Minimizes Environmental Pollution	3.3	2.1	1.6	4.2	4.8	4.4	Korea 2033		Infrastructure Creation	
117	New Livestock Breeding Technology to Secure Future Animal Protein Food	4.3	3.0	3.1	4.3	4.3	4.5	Korea 2030		Promoting Cooperation	
118	Smart Food Packaging Technology Enabling Real-time Quality Information Sharing with Consumers	3.9	2.7	2.1	3.9	4.5	4.5	Korea 2029		Fostering Human Resources	
119	Customized and Non-destructive, Compact Spectral Image Analysis Technology for Real-time Food Quality and Safety Evaluation	3.9	4.0	2.5	4.0	4.2	3.9	Korea 2029		Infrastructure Creation	
120	Personalized Precision Gut Microbiome Controlling Technology for the Prevention and Treatment of Chronic Metabolic Diseases	4.3	3.2	2.4	4.3	4.2	4.0	Korea 2031		Increase in Research Fund	
121	Personalized Precision Nutrition Healthcare Service Technology Tailored to Personal Life Cycle for Health Promotion and Disease Prevention	3.9	2.8	2.1	4.1	4.4	4.0	Korea 2030		Fostering Human Resources	
122	3D Printing Technology for Manufacturing Diverse Customized Homemade Foods in Small Quantity	4.2	3.5	2.4	4.1	4.2	4.5	Korea 2030		Fostering Human Resources	
123	Autonomous Unmanned Patrol Robot for Advance Crime Detection	4.6	3.5	3.5	4.3	4.4	4.0	Korea 2034		Promoting Cooperation	
124	Space-intensive Smart Urban Farm Building Technology	4.0	3.0	2.1	4.3	4.2	4.3	Korea 2031		Infrastructure Creation	
125	Integrated Smart Urban Defense Facility Technology for Defend Against Nuclear WMD	4.0	4.0	2.3	3.9	4.2	3.0	Korea 2037		Infrastructure Creation	

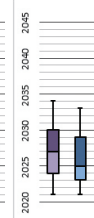
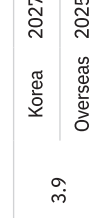
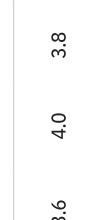
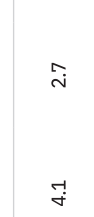
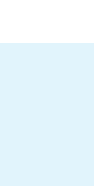
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
126	Cloud-based Situational Awareness System for the Self-diagnosis, Safety Warning, Management of SOC Facilities	4.2	3.6	2.4	4.4	4.7	4.2	Korea 2032 Overseas 2030		Promoting Cooperation
127	Renewable Energy-linked Building-Integrated Technology	3.8	3.0	2.4	4.3	4.4	4.5	Korea 2030 Overseas 2028		Improve Regulation
128	Autonomous Charging Robot for Electric Vehicles in Parking Lot	3.9	2.5	2.0	3.9	4.3	3.9	Korea 2029 Overseas 2028		Infrastructure Creation
129	Smart Unmanned Automated Parking System	3.9	2.4	2.3	3.8	4.2	4.1	Korea 2029 Overseas 2025		Infrastructure Creation
130	Self-diagnosis and Maintenance Technology for Vehicles Based on AI Predictive Maintenance	4.5	3.0	2.1	4.3	3.7	4.1	Korea 2030 Overseas 2025		Promoting Cooperation
131	Blockchain and Big data Based Digital Logistics Infrastructure Creation Technology	4.5	3.3	2.4	4.2	4.4	4.8	Korea 2029 Overseas 2026		Infrastructure Creation
132	Near-vacuum High-speed Transportation Train System (Hypertube)	4.7	4.1	3.2	4.4	4.1	3.9	Korea 2037 Overseas 2032		Infrastructure Creation
133	Train-to-train(T2T) Communication-based Automated Driverless Train System	4.1	3.2	2.6	3.9	3.9	3.8	Korea 2030 Overseas 2029		Infrastructure Creation
134	Satellite-based Train Signal and Communication System	3.8	3.3	2.7	4.5	3.9	4.1	Korea 2030 Overseas 2026		Increase in Research Fund
135	IoT-based Rapid Response System of Facilities to Earthquake-induced Compound Disaster	4.1	3.2	2.2	4.1	4.7	4.1	Korea 2024 Overseas 2021		Infrastructure Creation
136	AI-based High-precision Integrated Urban Ground and Underground Space 3D Information System	4.0	3.3	2.2	3.9	4.3	4.0	Korea 2024 Overseas 2023		Increase in Research Fund
137	Smart Public Data Platform for Natural Disaster Prediction, Warning and Response	4.0	3.5	2.1	4.3	4.6	4.0	Korea 2025 Overseas 2022		Infrastructure Creation

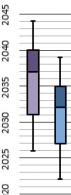
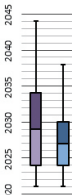
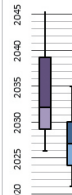
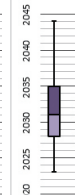
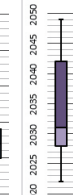
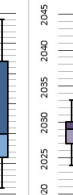
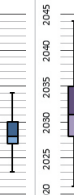
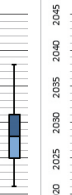
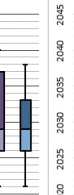
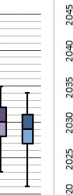
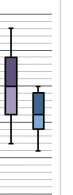
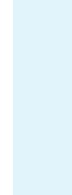
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
138	Smart Construction System for the Control of Air and Environment in City Block, Building and Building Cluster	4.2	3.0	2.6	4.1	4.4	4.1	Korea 2035		Infrastructure Creation
		Overseas 2030								
139	Building and City Based Technology for Response to Extreme Natural and Man-made Disasters	3.9	3.5	2.4	4.0	4.5	4.3	Korea 2033		Infrastructure Creation
		Overseas 2028								
140	Building and City-Integrated Butler Robot Butler-based System for Safe Buildings and Cities	4.0	2.9	2.2	4.0	4.2	4.5	Korea 2032		Increase in Research Fund
		Overseas 2029								
141	AI-based Technology for Customized Residential Environment Creation System for Residents	4.1	3.0	2.7	3.7	3.5	4.1	Korea 2028		Infrastructure Creation
		Overseas 2026								
142	Fast Custom Block-type Modular Housing Technology Using Metaverse	4.3	3.4	2.7	3.9	4.3	4.1	Korea 2031		Infrastructure Creation
		Overseas 2029								
143	Energy Storage and Integrated Management System to Use Large Amounts of Renewable Energy as an Energy Source for Cities and Industrial Complexes	4.0	2.9	2.4	4.1	4.3	4.3	Korea 2032		Infrastructure Creation
		Overseas 2030								
144	Large-capacity Hydrogen Liquefaction System for Safe and Low-cost Hydrogen Supply to Cities	4.1	3.9	3.3	4.2	4.2	4.5	Korea 2031		Infrastructure Creation
		Overseas 2025								
145	Offshore Floating Structure Technology for the Construction and Operation of Artificial Islands for Large-scale Renewable Energy Production	4.2	3.4	2.9	4.3	4.2	4.3	Korea 2034		Promoting Cooperation
		Overseas 2030								
146	Carbon-neutral, High-strength, Long-life Infrastructure Construction and Structural Material Technology	4.1	3.1	2.2	4.2	4.4	4.2	Korea 2031		Promoting Cooperation
		Overseas 2028								
147	Automated Unmanned Integrated Administration System of Plant Engineering, Procurement, and Construction, and Operation & Management	4.1	2.8	2.1	4.3	4.1	4.4	Korea 2030		Fostering Human Resources
		Overseas 2027								
148	Big Data and AI-based Smart Airport System	4.7	2.6	2.2	4.5	4.5	4.5	Korea 2029		Infrastructure Creation
		Overseas 2027								

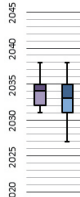
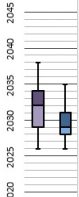
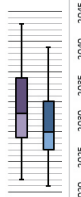
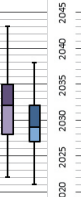
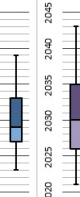
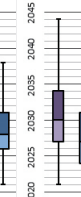
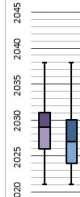
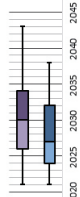
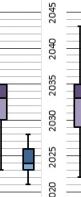
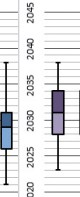
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
149	High-precision 3D Traffic Support System Deployment Technology that Organically Connects Ground Transportation and Future Air Transportation	4.4	3.8	2.4	4.4	4.3	4.5	Korea 2031 Overseas 2030		Improve Regulation
150	Ball Wheel Vehicle System for Convenient Moving Used for Short-distance, and in Transit Centers and High-rise Buildings	3.8	3.2	2.9	3.4	3.5	3.5	Korea 2027 Overseas 2026		Promoting Cooperation
151	Autonomous Emergency Response System through Resident's Situational Awareness	3.8	2.8	2.2	4.0	4.9	4.1	Korea 2028 Overseas 2028		Infrastructure Creation
152	Eco-friendly Electric Propulsion Aircraft Technology Supporting Remote Control and Autonomous Flight	5.0	3.8	2.3	4.7	4.8	4.6	Korea 2035 Overseas 2025		Infrastructure Creation
153	High-speed, No-delay Communication- based Remote Fully Autonomous Driving Technology (Level 5)	4.7	3.9	3.0	4.6	4.5	4.6	Korea 2034 Overseas 2031		Infrastructure Creation
154	Eco-friendly, Economical Artificial Rain Technology	3.8	4.1	2.9	4.1	4.2	4.5	Korea 2034 Overseas 2030		Increase in Research Fund
155	Broadband Nature-inspired System Technology for Risk Factor Detection	4.2	3.7	3.2	4.8	4.1	4.1	Korea 2033 Overseas 2029		Fostering Human Resources
156	High-precision, Broadband and Low-cost Infrared Monitoring Technology for Human body and Environment Monitoring	4.2	2.4	2.4	4.6	4.3	4.2	Korea 2033 Overseas 2026		Increase in Research Fund
157	Autonomous Geomagnetic Storm Response System	3.3	4.0	2.2	4.1	4.3	3.4	Korea 2035 Overseas 2025		Increase in Research Fund
158	Digital Twin Land Platform and Control Technology Applicable to Megacity	4.2	2.7	2.5	4.0	3.9	3.9	Korea 2030 Overseas 2029		Infrastructure Creation
159	Smart City-type Personalized Disease Prevention and Management System Based on Daily Activity Space	4.3	3.5	2.8	4.7	4.8	4.4	Korea 2029 Overseas 2028		Infrastructure Creation

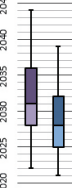
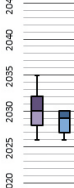
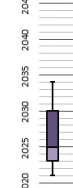
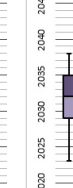
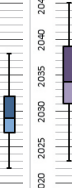
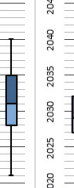
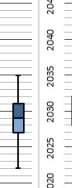
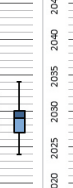
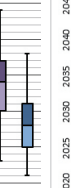
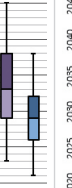
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
160	Real-time, Automated Global Environment Monitoring and Disaster Warning System Based on Satellite and High-altitude Unmanned Air Vehicles	4.5	4.5	1.6	4.8	4.9	4.3	Korea 2035		Infrastructure Creation
								Overseas 2029		
161	Farming Technology Enabling Mass Production in Lunar and Martian Environments	4.6	3.8	1.6	4.6	4.7	4.6	Korea 2043		Increase in Research Fund
								Overseas 2035		
162	Manned Lunar and Mars Base Construction and Operation Technology Utilizing In-situ Resources	4.9	4.7	2.2	4.8	4.1	4.3	Korea 2042		Increase in Research Fund
								Overseas 2030		
163	3D Printing Technology for Manufacturing Building Materials Using Lunar and Martian Minerals	4.8	3.8	2.1	4.8	4.5	4.4	Korea 2042		Increase in Research Fund
								Overseas 2036		
164	Oxygen, Water and Rocket Fuel Production Technology Using Lunar and Martian In-Situ Resources	5.0	4.2	2.1	4.8	4.2	4.2	Korea 2044		Increase in Research Fund
								Overseas 2035		
165	Earth-Moon-Mars Space Internet Communication Technology	4.2	3.0	1.8	4.8	4.4	3.9	Korea 2033		Increase in Research Fund
								Overseas 2028		
166	Intercontinental Unmanned Aerial and Navigation Technology Utilizing Low-orbit Communication Satellite and AI Technology	4.6	3.1	2.6	4.4	4.2	4.2	Korea 2035		Increase in Research Fund
								Overseas 2032		
167	Medical Service, New Drug, and New Material Development Technology Using Microgravity	4.8	2.7	2.1	4.3	4.2	4.5	Korea 2039		Increase in Research Fund
								Overseas 2033		
168	Micro Space Debris Detection, Identification and Tracking Technology	4.5	3.6	2.1	4.5	4.6	3.3	Korea 2037		Infrastructure Creation
								Overseas 2029		
169	Quantum Encryption Key Distribution Technology Secure from Attacks on Quantum Light Sources and Measurement Devices and Independent of Devices	4.8	3.7	1.6	4.9	4.2	3.9	Korea 2034		Fostering Human Resources
								Overseas 2032		
170	A New Cryptographic System Technology Secure Against by Quantum Computer Decryption Attacks on Cryptographic Infrastructure	4.7	4.1	3.0	4.8	4.3	4.4	Korea 2034		Infrastructure Creation
								Overseas 2029		

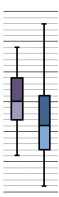
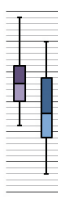
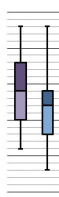
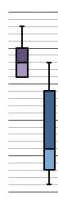
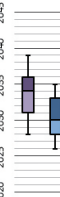
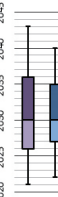
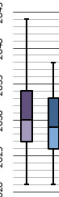
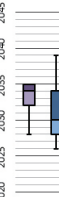
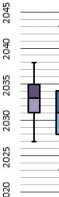
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)					Government Policy (Top Priority)		
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial								
171	Security Technology Capable of Performing Operations on Encrypted Data	4.0	3.4	2.1	4.1	4.0	4.1	Korea	2025						Fostering Human Resources
								Overseas	2025						
172	Digital Twin-based Remote Autonomous Drilling and Safety Assessment Technology for Surface, Deep Sea, and Glacier Using Smart Robot	4.2	2.8	2.6	4.1	4.0	3.8	Korea	2034						Promoting Cooperation
								Overseas	2030						
173	Customized All-weather Autonomous Unmanned Vehicle Technology for Polar Exploration	3.9	3.3	2.3	4.1	3.9	3.7	Korea	2034						Promoting Cooperation
								Overseas	2030						
174	Long-distance Wireless Charging and Supply Technology for Independent Microgrid	4.0	2.5	2.1	3.8	3.8	4.3	Korea	2042						Promoting Cooperation
								Overseas	2029						
175	Multiplatform for the Real-time and Unmanned Observations of the Arctic Routes' Atmosphere, Ocean and Sea Ice	3.8	2.7	2.1	4.0	4.1	4.4	Korea	2031						Infrastructure Creation
								Overseas	2028						
176	Integrated Autonomous Control System for Civil-Military, Manned-Unmanned Air and Space Assets	4.3	3.8	2.5	4.5	4.5	4.2	Korea	2042						Infrastructure Creation
								Overseas	2033						
177	Spacecraft Technology Based on Complex Propulsion System that can be Reused and Re-entered the Earth	4.6	4.0	2.4	4.8	4.3	4.5	Korea	2039						Increase in Research Fund
								Overseas	2028						
178	Active Protection Technology against High-energy and High-power Laser Weapons	4.2	3.6	3.1	4.3	4.1	3.9	Korea	2034						Infrastructure Creation
								Overseas	2029						
179	Very High Resolution Earth Observation Satellite System with a Resolution of Centimeters	4.0	3.3	1.9	4.3	4.6	4.3	Korea	2035						Increase in Research Fund
								Overseas	2028						
180	Super-intelligent Command Decision Support Agent Technology for Future Warfare Command and Control	4.3	3.9	2.8	4.5	4.2	3.9	Korea	2036						Fostering Human Resources
								Overseas	2030						
181	Multispectral Signal Fusion and Detection Technology for Threat Detection and Tracking in Cyber and Physical Space	4.1	3.4	2.4	4.0	3.7	3.7	Korea	2038						Fostering Human Resources
								Overseas	2032						

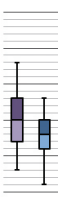
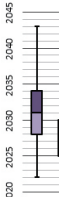
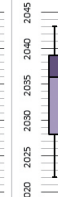
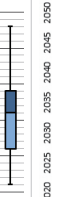
No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)					Government Policy (Top Priority)		
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial								
182	Automated Supply Chain Threats Screening Technology for Security Control over Technological Threats in Import and Export	4.0	3.0	2.8	3.9	3.9	3.6	Korea	2025						Infrastructure Creation
183	Technology for High-performance Marine Vessel with Autonomous Navigation System for Transportation Using Arctic Routes	4.3	3.4	2.4	4.2	4.1	4.4	Korea	2030						Promoting Cooperation
184	Technology for Obtaining New Materials Using Useful Substances from Deep Sea Creatures	4.4	4.0	1.8	4.7	4.1	4.0	Korea	2029						Infrastructure Creation
185	Automated Data Security Level Classification Technology for Secure Data Transaction	4.3	2.7	2.4	4.3	4.2	4.5	Korea	2029						Improve Regulation
186	Digital Asset Authentication Technology for Smart Transaction and Intangible Asset Verification	3.8	2.7	2.5	3.8	4.1	4.3	Korea	2027						Promoting Cooperation
187	Biochip Technology for User Authentication	4.4	3.4	4.5	4.4	3.7	3.9	Korea	2030						Improve Regulation
188	AI-based Intelligent Monitoring Technology for Security Incident Detection and Autonomous Response	3.8	3.3	2.3	4.2	4.4	4.1	Korea	2027						Infrastructure Creation
189	Intelligent Self-Sovereign Identity Management Technology for Identification and Verification	3.9	2.9	2.7	4.1	3.9	4.2	Korea	2025						Infrastructure Creation
190	Automated Advance Detection of Personal Information and Constant Data De-identification Technology for Data Leakage Prevention	3.8	2.4	2.8	3.8	4.3	4.0	Korea	2029						Promoting Cooperation
191	Data Acquisition, Security and Monitoring Technology Using Blockchain	4.1	2.7	3.6	4.0	3.8	3.9	Korea	2027						Infrastructure Creation
192	Lunar and Martian In-Situ Resources Mining Robot	4.5	3.3	1.9	4.6	3.9	4.7	Korea	2034						Increase in Research Fund

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
193	Self-sufficient Seabed Base Construction Technology for Long-term Stay and Exploration	4.5	3.4	2.5	4.3	4.5	4.3	Korea 2037		Infrastructure Creation
Overseas 2032										
194	Cyber Security Self-diagnosis and Vaccine Technology for Active Treatment	4.0	3.3	2.8	3.8	4.2	4.5	Korea 2029		Infrastructure Creation
Overseas 2027										
195	Wide-area Surveillance and Strike System Deployment Technology Using Satellites and Unmanned Aerial Vehicles	4.2	3.6	2.5	4.3	4.3	4.1	Korea 2032		Promoting Cooperation
Overseas 2027										
196	Eco-friendly Fully Autonomous Vertical Take-off and Landing Air Vehicle Technology for Cargo and Passenger Transportation	4.5	3.7	2.4	4.5	4.3	4.4	Korea 2031		Infrastructure Creation
Overseas 2029										
197	Autonomous maritime Situational Awareness Based Research Vessel Technology	4.0	3.2	2.2	4.5	4.2	3.8	Korea 2033		Infrastructure Creation
Overseas 2027										
198	Greenhouse Gas-free and Eco-friendly Hydrogen Reduction Steel Making Technology	4.5	3.3	2.2	4.6	4.8	4.6	Korea 2031		Infrastructure Creation
Overseas 2030										
199	Eco-friendly Large-capacity Hydrogen Production Plant Technology Using Organic Waste-based High-quality Biogas	3.7	2.4	1.9	3.6	4.5	3.8	Korea 2029		Infrastructure Creation
Overseas 2028										
200	Offshore Wind Power Generation System for Deep Sea Using a Floating Structure	4.0	3.3	2.6	3.9	4.2	4.0	Korea 2031		Infrastructure Creation
Overseas 2028										
201	High-efficiency, Ultra-lightweight Superconducting Generator Technology for Wind Power Generation System	4.5	3.5	2.5	3.9	3.8	4.0	Korea 2029		Infrastructure Creation
Overseas 2029										
202	Hybrid Power Generation System Integrating Hydrogen Fuel Cell and Gas Turbine	4.3	3.0	2.3	4.2	4.4	4.1	Korea 2030		Promoting Cooperation
Overseas 2029										
203	Carnot Battery Thermal Storage Technology for Low-cost, Long-term and Large-scale Energy Storage	3.9	3.7	2.0	3.8	4.0	3.8	Korea 2035		Promoting Cooperation
Overseas 2031										

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
204	Ultra-High Temperature Thermal Energy Storage, Transfer and Conversion (UHTES) System Using Thermal Energy Grid Storage Using Multi-Junction Photovoltaics (TEGS-MPV)	4.2	3.4	3.2	4.1	4.1	4.1	Korea 2034 Overseas 2033		Increase in Research Fund
205	MW-scale Anion Exchange Membrane Water Electrolysis System	4.2	3.7	2.3	4.6	4.2	4.1	Korea 2032 Overseas 2029		Promoting Cooperation
206	Integrated CCU Process and Application Technology for Carbon-neutral Fuel (e-fuel) Production	4.2	3.4	2.4	4.3	4.5	4.3	Korea 2033 Overseas 2030		Infrastructure Creation
207	Transparent Solar Cell Technology Installable in Buildings or Automobiles	4.2	3.1	2.3	4.3	4.1	4.2	Korea 2032 Overseas 2029		Increase in Research Fund
208	AI Decision-making Based Technology for Resource Leaks and Maximization of Energy Efficiency	4.2	3.1	2.4	4.5	4.5	4.5	Korea 2031 Overseas 2029		Infrastructure Creation
209	Advanced Waste Recycling and Monitoring Technology Using IoT	3.6	2.6	2.0	3.9	4.8	4.1	Korea 2030 Overseas 2028		Infrastructure Creation
210	Hazardous Waste Resource Recycling and Alternative New Material Development Technology to Reduce Environmental Pollution	4.2	3.2	2.3	4.4	4.8	4.4	Korea 2030 Overseas 2027		Infrastructure Creation
211	Chemical Recycling Technology of Waste Plastics	4.1	2.9	2.4	4.2	4.8	4.5	Korea 2029 Overseas 2027		Infrastructure Creation
212	Waste to Renewable Energy and Emission Verification Technology	4.0	3.3	2.3	3.9	4.7	4.3	Korea 2030 Overseas 2027		Infrastructure Creation
213	Technology for Marine Ecosystems Protection from Radioactive Contaminated Water	4.0	4.5	3.0	4.6	4.9	4.4	Korea 2033 Overseas 2024		Infrastructure Creation
214	Energy Independent Smart Community Operation Technology	4.3	3.1	2.3	4.3	4.5	4.2	Korea 2033 Overseas 2029		Promoting Cooperation
215	Highly Reliable and Safe Real-time Control Power Grid System	4.1	2.9	1.9	4.2	4.6	4.6	Korea 2031 Overseas 2031		Infrastructure Creation

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
216	Advanced Multidimensional Atmospheric Monitoring System for High-precision Environmental Analysis	3.9	3.1	1.8	4.2	4.9	4.2	Korea 2031 Overseas 2028		Infrastructure Creation
217	Optimal Power Configuration and Energy Management Technology for Vertiport Energy Supply	4.3	3.7	2.2	4.1	4.7	4.8	Korea 2030 Overseas 2029		Improve Regulation
218	Battery Material Optimization Technology Based on a Predictive Model for Battery Material Properties for Efficient Development of Next-generation Battery	4.5	3.5	2.2	4.5	4.5	4.5	Korea 2025 Overseas 2025		Increase in Research Fund
219	Cyber Physical System Reinforcement Technology to Improve Reliability of Energy Transactions on Future Neural Network System	4.4	3.3	2.8	4.2	4.3	4.5	Korea 2032 Overseas 2029		Infrastructure Creation
220	Global Disaster Prediction Modeling Technology to Strengthen Disaster Resilience	4.2	3.7	2.3	4.6	4.9	4.5	Korea 2034 Overseas 2031		Increase in Research Fund
221	Virtual Power Plant of Mobile Storage System and Electric Power Service Technology through V2X Technology	4.4	3.1	2.2	3.7	4.2	4.6	Korea 2029 Overseas 2029		Improve Regulation
222	Depolymerization-based Cyclic Production Technology	3.9	2.8	2.7	4.3	4.4	4.3	Korea 2030 Overseas 2029		Improve Regulation
223	Spent Nuclear Fuel Transmutation Technology	4.8	3.1	2.8	4.6	4.6	4.3	Korea 2030 Overseas 2028		Increase in Research Fund
224	Small Atomic Battery Technology Capable of Supplying Ultra-Long life Power	4.5	3.1	3.1	4.2	4.2	4.4	Korea 2034 Overseas 2028		Increase in Research Fund
225	Rapid and Safe Decontamination Technology for Extensive Radioactive Environmental Contamination	3.6	3.5	1.9	4.2	4.6	4.0	Korea 2033 Overseas 2029		Increase in Research Fund
226	Small and Medium-sized Modular Reactor Technology with Innovative Improvement in Economic Efficiency and Safety	4.3	3.0	2.6	4.5	4.2	4.6	Korea 2034 Overseas 2030		Increase in Research Fund

No.	Future Technology	Technological Criteria (5-point System)				Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts		Scientific	Public	Economic and Industrial			
227	Versatile Nuclear Power System to Achieve Carbon-neutral Electrification	4.3	3.0	2.3	4.5	4.5	4.5	4.5	Korea 2035 Overseas 2031		Increase in Research Fund
228	Future Nuclear Energy System For the Reduction of Volume and Toxicity of Spent Nuclear Fuel	4.3	3.6	3.0	4.4	4.2	4.1	4.1	Korea 2038 Overseas 2033		Increase in Research Fund
229	Sustainable Eco-friendly Gravity Energy Development Technology	3.6	3.2	2.0	3.2	4.1	3.9	3.9	Korea 2034 Overseas 2032		Infrastructure Creation
230	Magnetic Field Based Seismic Isolation System Development Technology for Complete Separation of Ground Motions	4.6	4.6	3.6	4.0	4.7	4.2	4.2	Korea 2038 Overseas 2026		Promoting Cooperation
231	Seawater Concentration Difference Battery Technology for Renewable Energy Power Storage	4.5	3.5	2.1	4.2	4.3	3.9	3.9	Korea 2034 Overseas 2030		Increase in Research Fund
232	Multi-Type Fuel Cell Complex Plant Technology	3.5	3.1	2.3	3.7	4.2	3.9	3.9	Korea 2030 Overseas 2030		Promoting Cooperation
233	Ammonia Utilization Technology for Building Hydrogen Energy Infrastructure	4.2	2.9	2.5	4.3	4.3	4.3	4.3	Korea 2030 Overseas 2029		Increase in Research Fund
234	High-capacity High-temperature Secondary Battery Technology for Long-term Power Storage	4.6	3.9	2.4	4.2	4.1	4.3	4.3	Korea 2034 Overseas 2030		Infrastructure Creation
235	High-Capacity Solid Oxide Fuel Cell Technology with Variable Output Power for Convergence and Hybrid Renewable Energy Generation	4.1	3.4	2.4	4.4	4.2	4.3	4.3	Korea 2033 Overseas 2031		Increase in Research Fund
236	Convergence and Hybrid High-temperature Solid Oxide Electrolysis (SOE) System that Produces Hydrogen and Aviation Fuel Using Renewable Energy (P2G)	4.6	3.5	2.5	4.7	4.7	4.5	4.5	Korea 2035 Overseas 2034		Promoting Cooperation
237	System for Providing Information on Harmful Effects on Humans in an Area or Place Based on the Degree of Pollution and Environmental Factors	4.3	3.3	2.2	4.3	4.8	4.1	4.1	Korea 2033 Overseas 2026		Increase in Research Fund

No.	Future Technology	Technological Criteria (5-point System)			Significance (5-point System)			Year Realized (Year)		Government Policy (Top Priority)
		Innovativeness	Uncertainty	Negative Impacts	Scientific	Public	Economic and Industrial			
238	System for Monitoring the Upper Layer Pollutant Distribution in a Local Area Using Solar Light as a Light Source	3.9	3.1	2.3	4.3	4.6	3.7	Korea 2030 Overseas 2028		Infrastructure Creation
239	Monitoring System Technology for Each Large-scale Point, Line, and Area Pollution Source with the Greatest Impact on National Air Quality	3.9	3.1	2.4	4.3	4.8	4.2	Korea 2031 Overseas 2028		Infrastructure Creation
240	New Integrated Carbon Cycle Observation, Simulation, and Diagnosis System with Ultra-high Resolution (within 1km)	3.9	3.0	2.1	4.1	4.4	3.8	Korea 2036 Overseas 2031		Infrastructure Creation
241	Earth System Modeling Technology with Urban-scale Processes in Resolution for Short- and Long-term Local Climate Change Forecast	4.2	3.7	2.2	4.5	4.6	4.2	Korea 2035 Overseas 2031		Infrastructure Creation

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