KISTEP 10 Emerging Technologies in 2018
Realization of a People-centered Smart Society

Abstract

KISTEP's selection of 10 Emerging Technologies, the first of which was published in 2009, aims to identify emerging technologies from diverse viewpoints. Since 2013, KISTEP has identified emerging technologies with high social demand after selecting what it sees as the core issue of Korean society in the future. This year, "the realization of a people-centered smart society," which seeks to create new values through the medium of intelligent high technology, was selected as the core issue with significant ripple effects on our society over the next 10 years, based on which the KISTEP 10 Emerging Technologies in 2018 were selected through a comprehensive analysis of the roles and directions of development of science and technology. First, the domains which constitute the smart society were categorized into the five areas of residence/living, transportation, energy/resource, health, and food resources, and detailed issues were analyzed through a process that included a review of the relevant literature, analyses of social data, consultation with experts, and a survey of the general public. Several emerging technologies required to actualize products and services relevant to the issue were identified, which were then narrowed down to 20 candidate technologies. Finally, 10 emerging technologies were selected through an expert review based on the possibility of their realization within 10 years, their potential to respond to future issues, and their economic and technological impacts.

The ten selected emerging technologies are: ▶responsive housing technology ▶life log virtual assistant software technology ▶smart tattoo technology ▶soft robot technology ▶connected car technology ▶modular public transportation technology ▶wireless power transfer technology ▶smart farm technology ▶artificial intelligence security technology, and ▶mixed reality technology. Responsive housing technology allows the responsive and autonomous customization of lighting and flooring in accordance with the preference, emotions, and activities of the user. The technology is expected to address safety issues related to the increasing number of single-person and senior households, and provided user-oriented services exceeding those of IoT smart homes. Smart tattoos, which can be easily applied to the skin, allow the monitoring of blood glucose level or self-diagnosis

of cancer through changes in the color. A smart tattoo can also be used as a miniature wearable storage and control devices which can be used to load stored information such as voice files or play music, simply through scanning, which is already used in QR codes. Soft robots are robots built with soft and flexible materials, thus providing better flexibility and shock resistance than typical robots with a rigid structure. Due to such attributes, soft robots can be utilized in various circumstances which require physical interaction with humans, and are expected to evolve into "social bots," establishing communion with people, with Baymax of Big Hero 6 as an excellent example. KISTEP 10 Emerging Technologies of 2018 are of great significance in the sense that the selected technologies emphasize the roles of science & technology in resolving social issues caused by urban concentration, the prolonged low fertility rate, the intensification of population aging, and the continued increase of single-person households.

> ※ The views set out in the content of this publication are those of the author, and do not necessarily reflect the official opinion of KISTEP.

Ⅰ Overview

1. Overview

- The increased influence and rapid development of science and technology have led to higher expectations regarding the social roles of emerging technologies.

  - Technologies are not only considered the growth engine for new industries, but are also the means by which to address important issues faced by society, such as social stratification, low fertility and population aging, and climate change. In this light, national R&D programs to resolve social issues and public benefit programs are currently being conducted.

  - Strategic selection of core technologies is needed to support the effective utilization of limited resources, and in this regard, effective identification of core technologies based on a thorough assessment of societal changes and public needs is required.

- KISTEP has selected and announced 10 emerging technologies since 2009, and has incorporated the betterment of future Korea as a focal perspective since 2013.

  - KISTEP's selection process emphasizes the social role of technologies, by first selecting the major issues of future Korean society, and then selecting emerging technologies with both technological and economic impacts, and the capacity to address these issues.

  - The issues considered thus far include the aging of society, increasing safety hazards, increasing inequality, and the need to enhance quality of life and social trust.

- The role of science and technology in resolving social issues caused by urban concentration, prolonged trends of low fertility, aging society and continuous increase in single-person households needs to be emphasized.

● Comprehensive, sustainable and people-centered smart society was selected as the ideal image of future Korean society, and 10 consumer-oriented technologies which provide various services irrespective of gender, region or language were proposed as 10 emerging technologies in 2018.

2. Emerging Technologies Selection Process[1]

▣ The selection process consists of three stages of target issue selection, issue and needs analysis, and selection of emerging technologies.

Table 1. KISTEP Emerging Technologies Selection Process

Stages	Steps	Methods
Selection of Target Issue	Analysis of Domestic and International Literature and Issues ⇩	- Review and analysis of foresight reports and domestic emerging technology reports - Collection and analysis of major issues of Korea
	Candidate Pool of Target Issues ⇩	- Literature and issue analysis - Internal/external expert review
	Review and Selection of Issues ⇩	- Identifying and selecting priorities through expert survey and internal expert workshop
Issue and Needs Analysis	Analysis of Status Quo ⇩	- Analysis of domestic and international literature
	Selection of Field and Identification of Issues ⇩	- Survey and analysis of the relevant data - Expert review - Big data analysis of social media
	Identification of Future Needs ⇩	- Expert consultation - Mobile survey of the general public
Selection of Emerging Technologies	Identification of Candidate Technologies ⇩	- Utilizing multiple sources and internal DB - Matching analysis on scientific and technological response according to future needs.
	Selection of Emerging Technologies ⇩	- Internal researcher and expert review - Priority evaluation by technology
	In-depth Analysis of Emerging Technologies	- Research, industry and market trend analysis - Economic and social impact analysis

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[1] Detailed data on expert survey, social media big data analysis, mobile survey of the general public, and research/industry/market trend analyses for issue selection can be found at the KISTEP website (Study on KISTEP Emerging Technologies in 2018, available in Korean.)

Ⅱ Analysis of Future Needs

1. Selection of Target Issue

▣ Candidate pool of target issues* which are expected to be of great significance in the Korean society for the next 10 years were identified based on the results of emerging technologies DB analysis, literature review, and issue analysis

* ① Realization of a People-centered Smart Society, ② Response to the New Climate Regime for a Sustainable Society, ③ Response to Social Disasters for Public Safety, ④ Preparation for the 4th Industrial Revolution

Table 2. Definition and Current Trends of Candidate Issues

Candidate Issues	Definition and Current Trends	
Smart Society	(Definition)	A society that pursues the creation of new values including flexibility, creativity and humanism in daily life through the medium of advanced intelligent science and technology* * Open Network and Cooperation Technology, Artificial Intelligence (AI), IoT, etc.
	(Trends)	With the rapid spread of smartphones and social network services, the paradigm shift to a smart society has occurred, and the need for smart ideas which are consumer-oriented, rather than provider-oriented, has arisen.
Climate Change	(Definition)	Climate change can be classified into long-term trends (Global warming, etc), varying (El Niño, etc.), and discontinuous changes (average value experiences unexpected shift into another average value which remains), and causes anomalies in the climate such as a rise in temperature in polar regions, decline in glaciers, and a rise in sea level
	(Trends)	Frequent anomalies in the climate such as a rise in sea level, ocean acidification and glacier melting are expected to result in social disruption, change in lifestyles, and increased conflict.

Table 2. Definition and Current Trends of Candidate Issues

Candidate Issues	Definition and Current Trends
Social Disaster	(Definition) Damages caused by fire, collapse, explosion, traffic accident, environmental pollution, paralysis of infrastructure including energy, communication, finance, medicine and water supply, and spread of epidemics among the public and domestic animals (Trends) Man-made damages and disasters occur more frequently, and lack of control over epidemics results in a high number of casualties and economic turmoil. Also, infrastructures are faced with risks including cyberterror and private arms manufacturing.
4th Industrial Revolution	(Definition) Next-generation industrial revolution which leads to innovative changes based on the convergence of cutting-edge ICT such as AI, IoT, big data and mobile, with the economy and the society (Trends) While new technologies and extensive innovation emerging in the 4th Industrial Revolution are being dispersed rapidly and widely, the industrial revolution of the past is still ongoing

▣ Smart Society was selected as the target issue, based on KISTEP's internal/external expert survey and feedback on the importance of issues on future Korean society, economic and social impacts, and the possibility of addressing the issue through science and technology.

● Of the four candidate issues, Smart Society and the 4th Industrial Revolution showed relatively higher scores, with Smart Society being ranked higher in importance of issues on future Korean society and scientific & technological accessibility, and the 4th Industrial Revolution ranked higher in economic and social impacts.

● Based on the results of this assessment, "People-centered Smart Society" was selected as the target issue, to which contents related to the 4th Industrial Revolution were connected.

▣ The social paradigm is undergoing a rapid transition to the "Smart Society" due to the rapid penetration of smartphones and social network services in our daily lives, thus enhancing the importance and necessity of the establishment of a people-centered Smart Society.

● The Smart Society has been described in various publications as "a more advanced, people-centered future society that facilitates new creation and evolution in all aspects, and pursues new values and new shifts."

- People play the role of information creators, rather than consumers, and desire networking of open spaces, not limited spaces.

- The means of working is also shifting toward smart work, through which people work freely at home or other spaces. In terms of technology, the combination of analog and digital occurs freely, and mixture of wire line and wireless technology allows the production of new products and services.

● Contemporary society may be able to overcome income inequality or polarization with smart technology as the starting point of "the 4th Wave," a crucial period with a significance equivalent to the changes which took place during the 100 years of agrarian society.

- The decrease in the cost of technologies has led to the emergence of smart devices, allowing active social participation for people with disabilities or single elderly households, and public use of technologies allows for the resolution of social problems through cooperation.

▣ The Korean and Japanese governments have recognized the importance of the Smart Society, and are making a range of efforts in this area.

● In the 5th Science and Technology Basic Plan (2016-2020), the Japanese government emphasizes Smart Society as a part of its value creation measures in regard to the creation of future industry and social reform.

- The plan designates the fifth segment of mankind followed by hunting, agrarian, industrial, and information society as "Society 5.0."

- Society 5.0 pursues an environment in which people are provided various services irrespective of age, gender, origin or language, through the utilization of IT and robots in all aspects of society.

● The Korean government has established the "Intelligence Information Society 4th Industrial Revolution Medium- to Long-term Comprehensive Response Plan (2016.12.27)", and also included in its public pledge the realization of 4th Industrial Revolution platform and Smart Korea for the expansion of future growth engines.

- Intelligence Information Society is a society in which intelligent information technology, a mixture of data generated, collected and accumulated by advanced information and communication technology infrastructure (ICBM) and artificial intelligence (AI) is utilized universally in all aspects of the economy, society and everyday life, thereby creating and developing new values.

- In addition, the Presidential Committee on the 4th Industrial Revolution was founded to promote "Smart Korea," which includes projects such as Smart House, Smart Road, and Smart City, and to seek legal, institutional and political innovation and platform establishment to lead the 4th Industrial Revolution.

2. Issue and Needs Analysis

◇ Smart Society : A society that pursues the creation of new values including flexibility, creativity and humanism in daily life through the medium of advanced intelligent science and technology[*]
* Open Network and Cooperation Technology, Artificial Intelligence (AI), IoT, etc.

▣ The domains which constitute the smart society were categorized into the five areas of residence/living, transportation, energy/resource, health, and food resources.

● The categorization is generally used in governmental and administrative policies, and studies on social issues. "Technology and Innovation Futures (2017)" of the Government Office for Science of the United Kingdom also analyzes future society through the 5 categories of health, food, living, transport, and energy.

① Residence and Living

● Despite increasing needs for customized residential environments, Korea lacks customized residences that take into account the residential and living patterns of the individual, and is comparably lacking in amenities that support accessibility for the socially disadvantaged.

- Enhancement of mobility for the elderly and disabled is required for better accessibility to amenities.

- Propagation of customized UI technology is required for the development of assistance devices for those with impaired mobility, intelligent residential facilities and smart appliances.

● There has been an emergence of safety accidents of socially disadvantaged (elderly and disabled) in residential environments.

- The elderly and disabled are exposed to the risk of safety accidents due to their poor and deteriorated residential environments, resulting in a comparably higher incidence of accidents.

  ※ As of 2016, elderly households accounted for 25.8% of total households (average 1.31 elderly members in each household), and households of members with disabilities accounted for 6.7% of total households (average household size of 1.08 members) (Ministry of Land, Infrastructure and Transport, 2016).

- There is a need for accident management systems for the elderly due to the dramatic increase in the number of elderly and dementia patients.

  ※ The dementia population is estimated to have reached 612,000 by 2014 (9.6% dementia prevalence among those over 65), and is expected to reach 2.71 million (15% of all elderly) by 2050 (Ministry of Health and Welfare, 2015).

● There are increased psychological and safety concerns including loneliness due to the consistent increase in the number of single-person households.

② Transportation

● Traffic accidents and road casualty ratios are emerging as a serious social problem due to the rapid increase in the number of vehicles.

- Traffic accidents are caused by a range of factors including drivers, pedestrians, environment, and vehicles.

- The traffic accident rates of elderly drivers are on an increasing trend due to the aging of society.

● Despite the increase in the number of the "transportation vulnerable," the satisfaction with transportation in Korea remains low.

- While several solutions to enhance accessibility for the transportation vulnerable including door-to-door service and unmanned transportation are being implemented, there still remain technological and institutional limitations.

● Traffic congestion has continuously intensified due to urban concentration.

- Traffic congestion generally occurs in metropolitan areas which include Seoul and Incheon, resulting in higher cost.

- While the incidence of congestion is comparably low in rural and remote areas, such regions lack public transportation and other traffic-related facilities.

③ Energy and Resource

● There are increased demands related to new and environment-friendly sources of energy.

- Social debate on energy sources to replace coal (thermal) and nuclear power generation is becoming active due to concerns over environmental issues, including particulate matter and public safety.

- While various types of environment-friendly vehicles (hybrid, electric, hydrogen fuel, and plug-in hybrid) are being commercialized, Korea still experiences lack of infrastructure and institutional limitations.

● Increase in the number of the "energy poor"* due to intensified social polarization, rise in energy prices and increase in energy consumption per capita.

　* The government defines the "energy poor" as households which spend more than 10% of their household income on energy cost.

　- The majority of the energy poor reside in houses with low heating/cooling efficiency, and are vulnerable to severe cold and heat.

④ Health

● Higher average life expectancy results in stronger desire to live a healthy life.

　- However, as Korea has the highest elderly poverty rate of the OECD states, and many fear sickness after retirement, there are concerns that Korea may become a society of unstable longevity.

　　※ Only 32.5% of Koreans over 15 consider their health condition to be satisfactory (good or very good), which is considerably low compared to the OECD average of 69.6% (OECD, 2016).

　- There is high interest in customized medical treatment for systematic and convenient health care.

　　※ The paradigm of health and medical treatment has shifted from care provider/treatment-centered to consumer/medical care-centered, due to the aging of society and the development of ICT (Convergence Research Policy Center, 2017).

　　* Stages of paradigm shift: From 1.0 (Prevention of epidemics), to 2.0 (Extension of life expectancy through treatment), then 3.0 (Extension of life expectancy through disease prevention and health management).

● There is a general lack of health/medical resources (clinicians and clinical nurses).

　※ The number of clinicians (including Korean medicine doctors) in Korea is 2.2 per 1,000 population, which is 1.1 lower than the OECD average (3.3 clinicians), meaning that Korea is ranked as one of the lowest among the OECD states along with Mexico.

⑤ Food Resources

● Changes in life patterns and an increase in the number of single-person households have resulted in an increase in eating alone[2], causing nutritional imbalance and high sodium intake, and intensifying the quantitative and qualitative polarization of food.

● There is increased distrust and concern over food resources among the general public in Korea.

- Food-related safety accidents have been recurring in recent years.

   ※ Food safety accidents have been continuously taking place, including the insecticide egg crisis ('17), Norovirus outbreak ('17), adulteration of glass shards ('17), *Vibrio vulnificus* outbreak among fish and shellfish ('17), and cholera outbreak ('16) (Food Safety Portal).

- Additional safety-related issues are repeatedly being pointed out during the process of production, including genetically modified food, chemical fertilizers and insecticides, and microplastics.

3. Selection of Emerging Technologies

■ A candidate technology pool was formed through expert review after exploring potential candidate technologies using diverse research paths that reflect recent trends in technology development and social needs for new technologies.

● Using Emerging Technologies DB and domestic press data

- Selection of candidate technologies from the list of future technologies selected and announced by domestic and overseas institutions, and KISTEP's Future Technology DB.

- Analysis of future technology-related information from KISTEP News Clipping (domestic print/on-line press data DB, Nov. 2016 ~ Oct. 2017)

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2) National Institute of Korean Language Website (https://opendict.korean.go.kr)

● Proposal of new ideas from technological experts

  - Exploration of future technology to respond to the issues and needs of the smart society based on an expert review, in addition to reviewing candidate pool of future technologies

● Candidate pool of future technologies formed after reviewing the relevance with future needs*

  *Future needs identified through literature review, expert consultation, social media big data analysis, and public survey

Table 3. Issues, Needs, and Future Technologies by Field

Field	Detailed Issues	Future Needs	Future Technology
Residence and Living	Lack of customized residence and poor amenities accessibility*	Residential environment establishment system that reflects opinions of consumers (from the initial design stage)	− Voice security and interactive natural language UI technology − Intelligent walking aid technology − AI security technology − Soft Exosuit − Intelligent CCTV technology − AI-based crime and terror countermeasure system − Social robot/soft robot technology − Life-log virtual assistant software − Interactive augmented reality system − Mixed reality smart work system
		Designing and relocating customized residential facilities considering individual residential patterns	
		Developing UI and cultural content for the elderly	
		Assistance devices to enhance mobility of the elderly and disabled	
		Establishing friendly environment for childbirth and infant care	
	Emergence of safety accident issue in residential environment*	Protection and accident management system to prevent safety accidents in residential environment**	
		Securing safety of injury-prone spaces such as bathroom, restroom and veranda	
	Increased psychological and safety concerns of single-person households	Propagation of real-time monitoring technology in the area of neighborhood crime prevention and security	
		Development of entertainment products for the maintenance of joyful and happy biorhythm of single person households	
	Increased interest in amenities	Regular shipping of food and household items	
		Increased leisure time for individuals	
		Education in virtual settings and utilizing experience simulation	

* Addresses the needs of socially disadvantaged and vulnerable groups.
** Addresses the needs of the vulnerable and elderly.

Table 3. Issues, Needs, and Future Technologies by Field

Field	Detailed Issues	Future Needs	Future Technology
Transportation	Emergence of traffic accidents and road casualty ratios as a serious social problem	Commercialization of lighter and stronger vehicle frame	– Capsule-type autonomous vehicle to enhance the mobility of the transportation vulnerable – Driver emergency responsive vehicle-based safety control system – Safe driving system through brain-computer interface-based driving control – Autonomous origin-destination driving technology – Modular train – Hyperloop train system – Transportation infrastructure based on real-time weather and traffic conditions
		Dissemination of accident prediction and prevention technology	
		Driving assistance and safety technology for the elderly	
	Low level of installation rate of appropriate transportation amenities	Systemized door-to-door service	
		Provision of standards for the enhancement of protection and satisfaction of the transportation vulnerable	
		Unmanned vehicle signalling and central control system	
	Lack of transportation and facilities in rural areas	Strengthening of rural-urban transportation	
		Systemized database for traffic management in rural areas	
		Efficient allocation of transportation to resolve traffic congestion	
	Intensified traffic congestion in urban areas	Systemized database for traffic management in urban areas	
		Reorganizing urban planning and transportation infrastructure	
Energy and Resources	Increase in energy consumption	Consumer-oriented intelligent energy management	– Appliances with enhanced efficiency through demand-based autonomous control – IoE (Internet of Everything): internet network among devices – Micro grid – Wireless power transfer/ charging network – High efficiency, high output semiconductor power conversion device
		Enhancing fuel efficiency	
		Electrification of all home appliances (for ideal utilization of new renewable energy)	
		Enhancing energy efficiency in everyday life (cooling/heating and electric appliances)	
	High energy reliance on importation	Systematic energy production management	
		Commercialization of distributed generation technology (energy prosumer trade)	
	Increased needs on environment-friendly future energy	Developing highly efficient energy for stable supply	
		Environment-friendly low carbon fuel charging	
		Securing public consensus and receptiveness on new and renewable energy	
	Increase in energy poors	Developing low-cost, high-efficiency, easy-to-use energy	

Field	Detailed Issues	Future Needs	Future Technology
Health	Intensified health inequality due to intensified social inequality	Health care service for socially disadvantaged (disabled)	- Health management chatbot - Small-sized mobile imaging device - Wearable healthcare device - Digital biomarker - Transplantable real-time bio-information recognition and communication device - Cancer biomarker nano-chip blood diagnosis kit technology - Microbiome technology - Transplantable neural electrode - Neural signal-based personal verification technology for neuro-information security
		Enhanced accessibility to health care services	
		Developing affordable medical technology	
	High suicide rate	Establishing suicide prediction system	
	Negative cognizance of health	Real-time health check and diagnosis service	
	Stronger desire for healthy life due to higher average life expectancy	Technologies and products which slow aging (societal management of dementia)	
		Developing customized aid devices for the elderly	
		Customized precision medicine, prediction, prevention and diagnosis technology	
	Lack of resources (including clinicians and nurses)	Developing remote medical treatment service for efficient use of medical resources	
		Narrowing the medical resource gap of regions and individual hospitals	
Food Resources	Intensified nutrition inequality and food polarization	Nutritionally balanced convenient meal products for single-person households	- 3D printing food manufacturing technology - Individual genome/diet based customized risk assessment - Health condition-based risk assessment - ICT-integrated food shipping environment control - Prediction of zoonotic pathogen spread mechanism - Genetically modified leaven for heavy metal purification - Bio-degradable nano sensor - Smart farm
		Developing customized food to promote nutritional balance (based on one's health or diet)	
		Enhancing efficiency of food shipping	
	Increased distrust and concerns on food resources	Food poisoning and food resource-related (zoonotic) epidemic prediction model	
		Neutralization of pollutants and heavy metal discharge	
		Commercialization of people-friendly smart packaging	
		Securing GM food safety and producing eco-friendly food	
	Low self-sufficiency of food and grains	Developing products which can prevent or cure blight and insect damages	
		Developing disaster-tolerant and productive breeds	
		Developing high value-added genetic resources	

■ Of the candidate future technologies, 20 candidate technologies were selected based on an appropriateness evaluation.

● Evaluation was based on three criteria: concreteness, novelty, and possibility of realization.

Table 4. Criteria for Evaluation of Appropriateness as Emerging Technologies

Criterion	Evaluation Standards
Concreteness	• Excluded products and services from which no specific technology can be derived, notwithstanding the needs
Novelty	• Excluded products or services that can be produced or provided with the current level of technology, given sufficient capital and political or systemic support ※ Conducted analysis on advice of experts and related articles for each field
Technological and Social Realization Possibility	• Excluded technologies with significantly low possibility of realization within the next 10 years from a technological and/or social perspective ※ The assessment of the technology's realization possibility was based on contents such as expected time of realization or socioeconomic commercialization, as suggested in existing technology estimates including the contents of the 5th Science and Technology Foresight Study on 267 emerging technologies, or the review of specialists in each technological field

● A total of 20 candidate technologies were identified.

Table 5. 20 Candidate Technologies

Field	Candidate Technology	Field	Candidate Technology
Residential/ Living Environment	Responsive housing technology Chatbot technology Soft exosuit technology	Health	Smart tattoo technology Digital biomarker technology Smart implant technology
Transportation	Modular public transportation Connected car technology Hyperloop technology	Food Resources	3D food printing technology Nutrition/risk analysis technology Smart farm technology
Energy and Resources	Energy Internet of Things (E−IoT) Wireless power transfer technology Piezoelectric road	Common* (Convergence)	5G technology Life−log virtual assistant software technology Artificial intelligence security technology Soft robot technology Mixed reality technology

* Technologies relevant to multiple fields were categorized as common technologies

Ⅲ KISTEP 10 Emerging Technologies in 2018

■ A priority evaluation of 20 final candidate technologies selected through the appropriateness assessment was conducted by experts.

● The assessment was based on four criteria; possibility of realization within 10 years, capability to respond to future issues, economic impacts, and technological impacts.

Table 6. Evaluation Criteria for Selection of Emerging Technologies

Criterion	Standards
Possibility of realization within 10 years	The possibility of complete development and commercialization of technology, enabling practical use by the public in 10 years
Capability to respond to future issues	Expected scale of effectiveness from the realization of the technology in terms of resolution of key issues in the future
Economic impact	Potential of creating added value expected from the realization of the technology
Technological impact	Expected contribution to leading innovative development in the same or other fields of technology

● The evaluation was performed in two stages by KISTEP's researchers and technological experts from the relevant fields.

- Each of the 20 technologies was evaluated and given a score out of 5 on 4 different criteria, while assigning weight to each criteria.

  ※ Response certainty was also surveyed and reflected in the analysis of survey results

- The composite scores for each technology (maximum: 20) were calculated based on the weights of each of the four criteria.

■ KISTEP 10 Emerging Technologies were selected based on a priority evaluation of 20 candidates, and a expert/researcher review on the technological impact and responsiveness to future issues.

● Priority evaluation results were considered in conjunction with the technologies' strategic importance to the nation.

● Responsiveness of each technology to the social needs of each field was considered, and technologies corresponding to multiple needs were given priority.

Table 7. KISTEP 10 Emerging Technologies in 2018

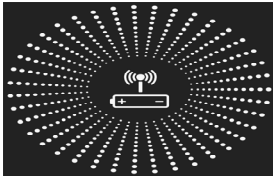| Technology	Details
Responsive Housing Technology	[Definition] Eco-friendly housing with spatial/functional/lighting variability to actively manage risks from outside and respond to user needs, using IoT-based intelligent flooring, active sensor and display technology [Application] User-customized housing in which lighting or flooring responds to the preferences, emotions and activities of users Resolves safety issues caused by the increase in the number of single-person households and elderly, while providing a more convenient residential environment to the users
Life-log Virtual Assistant Software Technology	[Definition] Intelligent Virtual Assistant software technology which accumulates knowledge and provides customized services by analyzing life-log data (daily lives, health conditions and behavioral patterns of the individual) [Application] Is being developed into a problem-solving agent which deals with various needs and provides solutions in reflection of one's life pattern, through convergence with AI, voice recognition, smart home, and autonomous vehicle
Smart Tattoo Technology	[Definition] Adhesive biometrics monitoring sensor (patch or tattoo type) involving a thin layer of electric circuit that includes sensors to monitor health condition and memory chips [Application] Enables convenient self-diagnosis without having to collect blood with color changing tatoos based on blood glucose level Can also be used as a wearable storage/control device through which the stored information can be loaded or music can be played by scanning the tattoo image

Technology	Details
Soft Robot Technology	[Definition] Robots manufactured with soft and flexible material, in contrast to traditional robots made with hard and rigid material [Application] Offers better flexibility and shock resistance compared to normal robots built with steel, and can be used in a more diverse environments which require physical interaction with humans
Connected Car Technology	[Definition] Future human-friendly vehicle infrastructure and mobility technology which allows vehicles to recognize the surrounding environment, minimize driver fatigue through autonomous control, and provide safe driving and connected services through the convergence of hi-tech sensors, information technology and intelligent control [Application] Enables real-time interactive communication with road network system, providing automatic collision alarm, speeding and safety alarm, ideal route navigation, and intelligent transportation systems (ITS)
Modular Public Transportation System	[Definition] Automatically assembled block-type transportation system operated based on smart technologies including IoT, remote control and autonomous driving [Application] Enables door-to-door transportation of the elderly, disabled and vulnerable Modules can be assembled or disassembled to assume the form of taxi (up to 3 passengers), van (up to 6) or bus (dozens)
Wireless Power Transfer Technology	[Definition] Technology which allows wireless power transfer to fixed/mobile devices in the same space using WiFi hotspot [Application] Enhances the usability of smart products and services by conveniently supplying power to mobile phones, home appliances, wearable devices and IoT sensors

Table 7. KISTEP 10 Emerging Technologies in 2018

Technology	Details
Smart Farm Technology	**[Definition]** Technology which controls the entire process of agriculture, livestock and fisheries industries in an intelligent manner and enhances productivity, efficiency and stability based on information and communication technology **[Application]** Resolves safety issues in the entire process of food production, distribution and consumption, and contributes to alleviating the qualitative and quantitative polarization of food resources through enhancement of productivity and efficiency
Artificial Intelligence Security Technology	**[Definition]** Technology for AI-level security system which discovers weak points or blocks attacks through automatic collection and analysis of data, or for monitoring of AI itself **[Application]** Applies AI technology in responds to risks of unfair use or malfunctioning of AI and accident prevention, detecting security risks
Mixed Reality Technology	**[Definition]** Technology which interacts with users through real-time combination of virtual information such as computer graphics, sound, haptic information and smell with objects of actual environment **[Application]** Can be used in various aspects of life, including smart work (resolves difficulties caused by compatibility of work and household burdens to provide a more flexible working environment), smart home schooling, and leisure activities of mobility impaired

◩ The economic and social impacts likely to occur following the adoption of the 10 Emerging technologies were analyzed, focusing on the individuals and the industries that the implementation of each technology will affect.

Table 8. Social and Economic Impacts of 10 Emerging Technologies

Technology		Impacts
Responsive Housing Technology	Social Impacts	• Consumer-oriented variable space realization technology which expands freely based on the life cycle of the resident, is expected to enhance livelihood convenience. • Responsive floorings and smart furnitures can aid the mobility of users including the disabled and the elderly, enhancing spatial stability and psychological stability of the resident. • The technology will actualize healthier surroundings and enhances quality of life through technologies such as indoor air quality improvement, anthrophilic lighting, and smart glass panel (for freer space use and fire resistance).
	Economic Impacts	• The domestic smart home market exceeded KRW 10 trillion in 2015. Based on an average annual growth rate of over 20%, the market is expected to reach KRW 21 trillion in 2019. • The size of the smart home market accessible for global service providers was USD 24 billion (KRW 26 trillion) in 2015. With an average annual growth rate of 24.2%, the market is expected to reach USD 71 billion (KRW 76 trillion) in 2020.
Life-log Virtual Assistant Software Technology	Social Impacts	• Virtual AI assistants will play the role of an old family doctor or friend in interacting with the user based on life-log data, and is expected to show great performance when applied in the field of health management service for the vulnerable, such as dementia care. • Information on user behavior accumulated through the life-log (digital biomarker) will be linked to intelligent virtual assistant, allowing for wider use in the health care industry, such as lifestyle coaching. • Also, with a life-log based intelligent assistant performing miscellaneous works in every aspect of business including finance, security, communication, sports and entertainment, the quality of life of the public is expected to improve.
	Economic Impacts	• Global market in 2014 was USD 15.7 billion, and is expected to reach USD 790.9 billion in 2021. The domestic market is estimated to grow from KRW 87.4 billion to KRW 1.902 trillion in 2021. • The digital health care market which includes digital biomarkers is valued at USD 196.3 billion in 2017. With an average annual growth rate of 13.4%, the market is expected to reach USD 535.6 billion in 2025.

Table 8. Social and Economic Impacts of 10 Emerging Technologies

Technology	Impacts	
Connected Car Technology	Social Impacts	• The technology can be used in the realization of autonomous mobility, which allows advanced connection of self-driving vehicles, drones, and robots on the network. • Connected Automated Vehicles (CAV) allow a dramatic reduction of traffic congestion, and significantly alleviate driver workload, reducing driver fatigue, a key stress factor. • Greater pedestrian convenience and a reduction in traffic accidents, supporting the establishment of a safer environment.
	Economic Impacts	• The size of the industries spinning off from autonomous vehicles is expected to reach KRW 74 trillion* in 2030. *Economic impact of KRW 37.7 trillion when converted to the economic scale of Korea
Modular Public Transportation System	Social Impacts	• The technology enables the realization of door-to-door services for the elderly, disabled and disadvantaged (pods-on-demand), and guarantees freedom of mobility of the public by resolving urban traffic issues through traffic control based on modular technology. • The technology will resolve pollution and traffic capacity issues caused by urban concentration, with individual ownership of virtual transportation evolving into shared ownership.
	Economic Impacts	• Positive impacts are expected to occur in the aspects of welfare for the transportation vulnerable, regional development, and effective transportation infrastructure.
Wireless Power Transfer Technology	Social Impacts	• Intelligent charging is enabled through wireless power hotspot installation, solving various issues such as battery replacement and disposal, and wiring in homes or offices. • The technology will support the simultaneous charging of multiple devices and provide spatial freedom, leading to facilitation of a wider use of IoT, wearable devices and smart devices, and contributing to the development of new products.
	Economic Impacts	• The size of the domestic and overseas wireless power transfer technology market is estimated to reach KRW 1.9 billion and KRW 19.1 billion in 2022, respectively, with an average annual growth rate of 17.9%.

Technology	Impacts	
Smart Tattoo Technology	Social Impacts	• The technology is expected to dramatically improve the effectiveness of treatment by enabling treatment to be based on analysis of daily life data such as blood glucose level, ECG and body fat level, collected through biomaterial monitoring or bioelectronic drug delivery devices, or customizing treatment which delivers drug accurately to the target area. • The technology can also be used in emergencies of single elderly households or solo travellers, and in self-monitoring, diagnosis and prevention of disease, allowing for a more precise remote medical service, leading to a shift in the medical paradigm from treatment-oriented to prevention-oriented.
	Economic Impacts	• The bioelectronics market is expected to grow from USD 25 billion to USD 51 billion by 2023
Soft Robot Technology	Social Impacts	• Soft medical robots will be able to enter digestive tracts or organs and conduct diagnosis or treatment, which was considered impossible for preexisting hard robots, contributing to a healthier public. • Soft body-based guard robots and disaster response robots perform tasks previously considered impossible without morphology, such as guard duty in complex terrain, context awareness at scene of collapse or fire, or lifesaving missions, allowing for a dramatic reduction of social maintenance cost. • Soft hand-based domestic robots which can handle home or office objects with a diverse range of shapes and characteristics can provide pragmatic support in housework including dishwashing, organizing, cooking, and laundry, improving quality of life.
	Economic Impacts	• The size of the domestic and international soft exosuit technology market is expected to reach KRW 13.4 billion and KRW 133.8 billion, respectively, by 2022, and is estimated to show 10% annual growth.
Smart Farm Technology	Social Impacts	• Allows monitoring of the entire pipeline from cultivation/breeding, production, distribution and consumption, contributing to food safety and a stable food supply. • Eco-friendly and high-quality agricultural goods may lead to an improvement in the diet of the public through enhanced food safety and environment and ecosystem management.
	Economic Impacts	• The size of the domestic and international smart farm technology market is expected to reach KRW 7 trillion and KRW 225 trillion, respectively, by 2022, and is estimated to show 13.3% annual growth.

Table 8. Social and Economic Impacts of 10 Emerging Technologies

Technology	Impacts	
Artificial Intelligence Security Technology	Social Impacts	• Enhanced security through AI leads to risk-free use of universal services • Expansion of fields of cooperation is expected once security risks diminish and a reliable system is established.
	Economic Impacts	• The global AI security market is expected to reach USD 10 billion (KRW 11. 3 trillion) by 2023 through average annual growth of 19% from 2017 to 2023.
Mixed Reality Technology	Social Impacts	• Fair provision of information and services to all regions and strata can contribute to reducing social and economic gaps • Generalization of virtual travel/leisure, shopping, remote education and medical services, and telecommuting provides benefits that were previously unavailable due to physical, economic and social limitations, enhancing the quality of life of individuals and establishing a sustainable business environment.
	Economic Impacts	• In 2015, the size of mixed reality (MR) market reached USD 662 million.

[Source] KISTEP (2018), Study on the Selection of KISTEP Emerging Technologies in 2018.

Ⅳ Conclusions and Implications

▣ KISTEP 10 Emerging Technologies were selected with the goal of constructing a desirable future society, which distinguishes this list from other selections of emerging technologies in Korea.

  ● The selection of emerging technologies in Korea is performed mostly by public institutions, and focuses on technologies that are more likely to have bigger economic and social effects. However, KISTEP 10 Emerging Technologies is the only assessment that presents a balanced reflection of the ability to cope with the needs of our future society, and the economic and social impacts.

    ※ Each institution selectively applies different topics in the area of economy, technology, and society (national ideals) in the selection of emerging technologies. In particular, topics on the economy and the industry represent a higher proportion.

  ● KISTEP 10 Emerging Technologies is significant in that the changes of the future are forecast based on a different issue every year. The perspectives and methods are adjusted and newly developed accordingly to select emerging technologies, which contributes to enhancing diversity and advancing the research methodology.

▣ Through the selection process, KISTEP 10 Emerging Technologies in 2018 showed the following characteristics.

  ● Four candidate issues* were identified which may emerge as key issues in the future Korean society in the next 10 years, and "people-centered smart society" was selected based on the assessments of experts on the criteria of significance, economic and social impact, and the possibility of addressing the issues through science and technology.

    * ① Realization of a People-centered Smart Society, ② Response to the New Climate Regime for Sustainable Society, ③ Response to Social Disasters for Public Safety, ④ Preparation for the 4th Industrial Revolution

- Five categories of residence/living, transportation, energy/resources, health, and food resources were determined, which were then used to analyze the current status of Korean society based on relevant studies.

- Surveys of the general public were conducted regarding the issues and future needs to identify the most important needs of people.

- More precise implications were identified through the utilization of more than one million pieces of news data, which were then reflected in the issue analysis.

- In the process of identifying emerging technologies, future technologies announced through the media were analyzed and used to identify technologies which reflect social needs in Korea.

- A quantitative analysis was conducted including marketability index in parallel with a review of the existing literature to provide vast data and enhance applicability.

- KISTEP provides a new direction for the role of science & technology in building a desirable future for Korea.

  - The study emphasizes the role of science and technology in resolving social issues resulting from urban concentration, the extended low birth rate, and the continuous increase in the number of single-person households.

  - The study proposes people-centered technology which allows the provision of various services irrespective of one's gender, origin and language.

  - The study provides analysis results including the applicability and future image of emerging technologies, domestic and international research and policy trends by technology, and social and economic impacts, to enhance the data applicability of S&T-related researchers, policy-makers and decision-makers.

References

- Business Opportunity Supporting System (http://boss.kisti.re.kr/, Korea Institute of Science and Technology Information)
- Cabinet Office of Japan (2016), 「The 5th Science and Technology Basic Plan」.
- Chae, Min-young and Kim, Seung-in (2017), "A Study on the Role of Social Robot in Aspect of User Experiences—Focus on Single-person Households", 「Journal of Digital Convergence」, 15(2), pp.295~300.
- Convergence Research Policy Center (2017), 「Research Trend on Genome-based Precision Medicine」.
- Electronic Times (2017), "Korea Approaches through Welfare vs Japan Develops as Industry", Nov. 9th.
- Forbes (2017), 「The Top 10 Technology Trends To Watch: 2018 To 2020」.
- Gartner (2018), 「Top 10 Strategic Technology Trends」.
- Hwang, Jong-sung (2016), "Paradigms of the Intelligent Society : Analysis and Policy Implications", 「Informatization Policy Journal」, 23(2), pp.3~18.
- IEEE (2017), 「Top Technology Trends」.
- KB Research (2017), 「2017 Korea Single Person Household Report」.
- Kim, Chang-soo and Park, Gyung-shik (2016), "Policy Trends and Implications for the Establishment of a Sound Smart Society – Focusing on Discussions at International Conferences such as ITU", 「Information, Communication and Broadcasting Policy」, 28(11).
- Kim, Gu (2016), 『Smart Society & Community : Convergence of Humanist Community and Smart Information Technology』, Dae Young Co.
- Kim, Moon-jo (2013), "Smart Society, a New Challenge in the History of Civilization", 「Horizon of Knowledge」, 14.
- Kim, Sung-tae (2010), 「Foresight on Paradigm Shift in Smart Generation and ICT Strategy」, National Information Society Agency.
- Kim, Sung-tae (2013), 『Information Policy and e-Government in Smart Society』, Bupmunsa Co.
- Kim, Young-han and Kim, Ji-hoon (2011), 『Business Model War』, Heritage.
- Korea Energy Economics Institute (2017), 「Statistics on Energy Supply and Demand」.

- Korea Health Promotion Institute (2016), 「Report on Regional Public Health Vulnerability by Cities and Provinces」.
- Korea Institute for Health and Social Affairs (2015), 「Directions of the Establishment of the 4th Comprehensive Public Health Enhancement Plan」, Ministry of Health and Welfare.
- Korea Research Institute of Bioscience & Biotechnology (2016), "10 Emerging ICT Convergence Biohealth Technologies", 「BioINsay」.
- Korean Intellectual Property Office (2013), 「Future Food Technologies Discovered from Big Data」.
- KT Economic Management Research Institute (2015), 「The Three Agents of Change in Smart Generation: Mobile-Intelligence-Social」.
- KT Economic Management Research Institute (2017), 「Global Trends on Energy Prosumer and Implications to the Domestic Market」.
- Lee, Ga-won et al. (2014), "Smart Cloud Service Integration Platform for Big Data Service in Smart Society", 「2014 Korea Computer Congress Journal」.
- McKinsey Global Institute (2014), 「Disruptive technologies: Advances that will transform life, business, and the global economy」.
- Ministry of Culture, Sports and Tourism (2016), 「2016 Survey on National Leisure Activity」.
- Ministry of Environment (2015), 「Third Master Plan for Eco-friendly Vehicle Development and Distribution (2016-2020)」.
- Ministry of Health and Welfare (2015), 「The 3rd Basic Plan for Aging Society and Population (2016-2020)」.
- Ministry of Health and Welfare (2015), 「The 3rd National Dementia Plan (2016-2020)」.
- Ministry of Land, Infrastructure and Transport (2016), 「2016 Survey on Residential Status」.
- Ministry of Land, Infrastructure and Transport (2017), 「2016 Survey on Mobility Convenience of Transportation Vulnerable」.
- Ministry of SMEs and Startups (2017), 「Comprehensive Technological Roadmap for SMEs」.
- MIT (2017), 「Breakthrough Technologies」.
- MIT Media Lab City Science Group (http://cities.media.mit.edu/about/cities)
- Myung, Seung-hwan (2015), 『Smart e-Government Theory』, Yulgok Books Co.

- Nam, Gil-hyun (2012), "IT Trends, Threats on Information Protection and Countermeasures in Smart Society", 「Journal of Information Protection Society」, 22(8), p.41~53
- National Information Society Agency (2011), "Analysis on New National Informatization Strategy for the Actualization of Smart Society; Finland", 「IT&SOCIETY」, 30.
- National Information Society Agency (2016), "Hypersmart Society Strategy and AI Policies of Japan", 「NIA Special Report」.
- National Information Society Agency (2017), "10 Technology Trends of e-Government", 「D.gov Edge」.
- National Intelligence Council of the United States of America (2017), 『Global Trends 2035』.
- National Police Agency (2017), 「Traffic Accident Statistics」.
- OECD (2016), 「Health Statistics 2016」.
- Park, Sang-pil (2017), "Need for the Application of Interactive Smart Technology and Service in Active Reflection of the Lives of Local Residents", 「Busan Development Forum」, 164, p.54~65
- Park, Youngsook and Glenn, Jerome (2016), 『State of the Future UN, 2050』, Kyobo Books Co.
- Relevant Ministries of the Republic of Korea (2017), 「Intelligence Information Society 4th Industrial Revolution Medium- to Long-term Comprehensive Response Plan」.
- Rural Development Administration (2016), 「Survey on Rural Well-being」.
- Schwab, Klaus (2016), 『Klaus Schwab's the 4th Industrial Revolution』, Saerowoon Hyunjae Co.
- Statistics Korea (2015), 「National Census」.
- UK Government Office for Science (2017), 「Technology and Innovation Futures 2017」.
- UN Population Division (2014), 「World Urbanization Report Revision Highlights」.
- UN (2015), 「Sustainable Development Goals」.
- WEF (2017), 「The Global Risks Report 2017」.
- WEF (2017), 「The list of Emerging Technologies」.

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