KISTEP

2025

KISTEP R&D and BEYOND

K-R&D Initiative | AI-Driven Ecosystem | R&I Strategy | Multilateral Cooperation

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Editor's Message

The international order is being reshaped. A set of pressures is converging quickly: intensifying technological rivalry, more frequent climate-related disasters, and growing supply-chain instability as governments expand export controls. In response, major economies are stepping up efforts to secure technological sovereignty in strategic domains such as artificial intelligence, semiconductors, and quantum technologies. At the same time, they are strengthening international cooperation to achieve carbon neutrality and address the climate crisis. In this evolving environment, science and technology are no longer limited to industrial policy; they are central to diplomacy, national security, and economic security.

In the United States, the second Trump administration has advanced a protectionist trade agenda by imposing a 10 percent baseline tariff on nearly all imports. For selected trading partners, higher, country-specific reciprocal rates apply in place of the baseline. These measures aim to reduce trade deficits, protect domestic industries, and restructure strategic supply chains. They apply even to traditional allies, including the Republic of Korea, Japan, and the European Union. As a result, the multilateral trading system and existing frameworks for international cooperation are facing significant disruption. Countries are responding through a mix of negotiation and retaliation, while accelerating supply chain diversification and technological self-reliance—signaling a new phase of global trade tensions.

Against this backdrop, the strategic importance of science, technology, and innovation (STI)—along with international cooperation and science diplomacy—has become increasingly evident. Technological competition is increasingly inseparable from national security. In parallel, the shaping of global norms and standards has become a key determinant of national competitiveness. In this environment, proactive engagement in bilateral and multilateral cooperation—and in international rule-setting—is more critical than ever.

Beginning in 2025, KISTEP merged its two previously separate publications—KISTEP R&D and Beyond and Asian Research Policy—into a single integrated publication titled KISTEP R&D and Beyond. This transition reflects a strategic expansion from a research and development (R&D)-focused lens to a broader research and innovation (R&I) policy framework. It also aims to strengthen the publication's role as an open policy platform that bridges domestic and international STI policy dialogue.

The 2025 edition of the publication brings together a wide range of timely policy issues. It features key outcomes from major forums on transformative STI pathways toward sustainable growth and future industries, the results of the 2024 survey on the residency status of international students in science and engineering, and strategies for fostering AI-era innovation ecosystems. The volume also highlights major institutional achievements, including the election of Dr. Yujin Jeong as Vice Chair of the OECD Working Party of National Experts on Science and Technology Indicators (NESTI)—the first Korean to hold this role. It further notes government honors recognizing contributions to ICT and science and technology. In addition, it introduces KISTEP's efforts to strengthen domestic and international policy networks, such as the inaugural China Innovation Strategy Forum, a series of seminars on national strategic technologies, the Innopolis Forum, and participation in policy dialogues on establishing a Deputy Prime Minister for Science and Technology.

Notably, this year's edition introduces a new section featuring contributions from external experts. The section offers a focused examination of multilateral cooperation mechanisms and Korea's engagement in them. Organized around four thematic areas—OECD cooperation, multilateral export control regimes, climate-related multilateral frameworks, and ICT-focused multilateral cooperation—the section analyzes the structure and significance of these mechanisms. The section aims to inform Korea's efforts to expand multilateral engagement beyond bilateral cooperation and to develop a balanced and resilient global cooperation strategy.

This volume represents a key milestone in KISTEP's evolution from a research and development–centered institution into a comprehensive research and innovation policy think tank. At the same time, it positions the publication as an international policy platform capable of responding proactively to the rapidly changing global STI landscape. Through this publication, we hope that KISTEP will continue to deepen its policy insights and international linkages, while further strengthening its role in global STI policy discussions.

History

1993
MAY.
Reorganized CSTP and renamed it S&T Policy Institute (STEPI)

1999
FEB.
Establishment of KISTEP

2001
JUL.
Reorganized and strengthened planning function of KISTEP

2005
JAN.
Redirected KISTEP's main functions to national S&T planning, coordination and R&D evaluation

2007
NOV.
Establishment of Korea Institute of Human Resources Development in S&T (KIRD) affiliated with KISTEP

2009
FEB.
10th anniversary of KISTEP

2011
MAR.
KISTEP's affiliation was transferred to National Science & Technology Council (NSTC) from the Ministry of Education, Science and Technology

2013
MAR.
KISTEP's affiliation was transferred to the Ministry of Science and ICT from NSTC

2019
FEB.
20th anniversary of KISTEP

2020
JAN.
Relocation to Chungbuk Innovation City

2021
OCT.
KISTEP was designated as 'the Center for S&T Diplomacy Strategy'

2022
OCT.
The establishment of Office of Future Technology Strategy

2023
JAN.
KISTEP established 'Mission-oriented Strategy Roadmaps'

2024
MAR.
KISTEP designated as National Strategic Technology Policy Center

2025
OCT.
KISTEP established 'Global HRST Mapping for National Strategic Technologies'

Vision and Strategy

Vision

A global institute that contributes to economic growth and public welfare through strategic S&T planning and R&D evaluation

Mission

Improving the effectiveness of R&D investment through expertise in S&T policy planning and R&D evaluation

+

Contributing to the development of innovative growth engines by identifying future agendas and strategies

Strategy

- Identifying Future Agendas and Strategies for Enhancing National STI Capacity
- Advancing and Designing the Foundation of National R&D systems
- Creating Innovation Ecosystems by Fostering Innovative Growth Engines

4 Core Functions of KISTEP

National S&T Policy Planning and Future Strategies	Budget Allocation and Coordination of Government R&D Programs	Survey, Analysis, Evaluation and Performance Distribution of Government R&D Programs	Preliminary Feasibility Studies of Government R&D Programs

Key Achievements

2025
Established 'Global HRST Mapping for National Strategic Technologies'

2024
Established 'The 1st Basic Plan for National Strategic Technology Development (2024–2028)'

2023
Established 'Mission-oriented Strategy Roadmaps'

2022
Established 'The 5th Science and Technology Basic Plan'

2021
Designated as 'The Center for S&T Diplomacy Strategy'

2020
Established 'The 4th Government R&D Performance Evaluation Basic Plan'

2019
Established 'The 2nd Mid- to Long-term Government R&D Investment Strategy'

2018
Established 'The 4th Science and Technology Basic Plan'

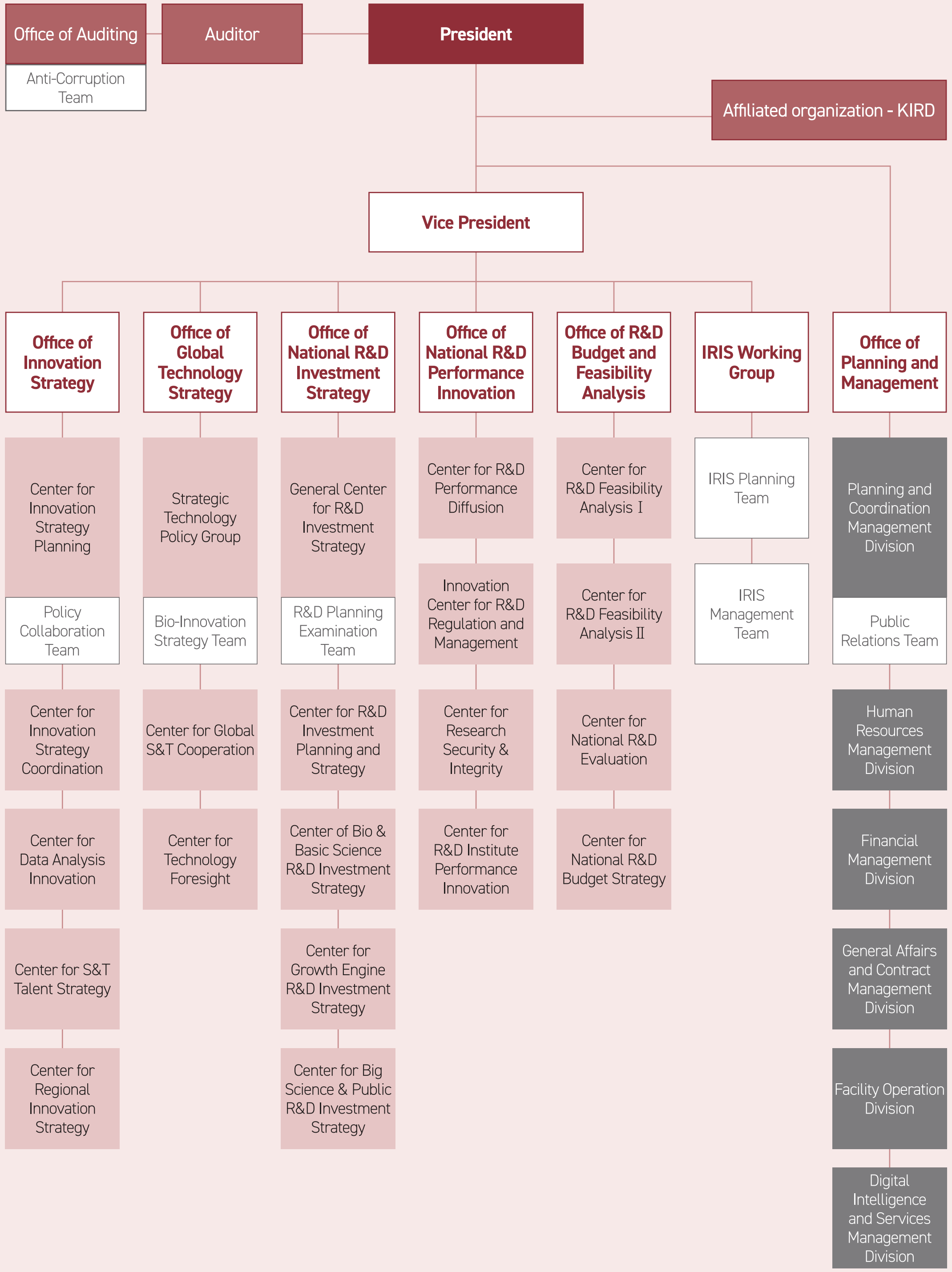
2017
Suggested 20 Policy Projects for STI of New Government

2016
Ranked 'Excellent' in Mission-oriented GRI Evaluation

2015
Announced KISTEP 10 S&T Policy Issues of 2015

2014
'The Road to Creative Economy' Forum in Celebration of KISTEP's 15th Anniversary

Organization



PART 1

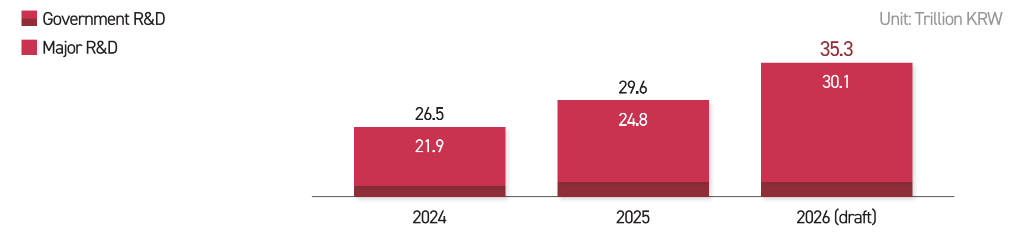
KISTEP Insight

KISTEP
R&D and
BEYOND

1 Lee Jae Myung Administration's K-R&D Initiative Draft Allocation and Adjustment of the 2026 National R&D Budget

Miyoung Hong, Director General, Office of R&D Budget and Feasibility Analysis /
Keunyoung Yun, Professional Manager, General Center for R&D Investment Strategy, KISTEP

On August 22, the Lee Jae-myung administration unveiled its "K-R&D Initiative" — the primary vehicle for its new R&D vision — and released the draft allocation and coordination plan for the 2026 national R&D budget. The proposed total budget for major R&D programs is KRW 30.1 trillion, up 21.4% from the previous year and a record high. To drive Technology-Driven Growth and Growth for All, funding will be concentrated in ten priority areas.



[Figure 1] Scale of the Draft 2026 Major R&D Budget compared to Previous Years

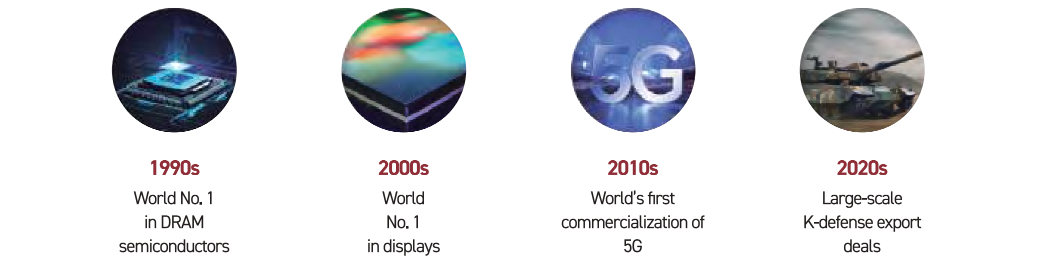
[Figure 2] Ten Priority Investment Areas for Major R&D

This article provides an overview of the draft allocation and adjustment plan for 2026, which was based on two key premises: the centrality of R&D as the key to "True Growth" (jinjja seongjang) and the need for a bold, pump-priming government investment to catalyze that growth.

1. The Overall Picture of the 2026 Major R&D Budget

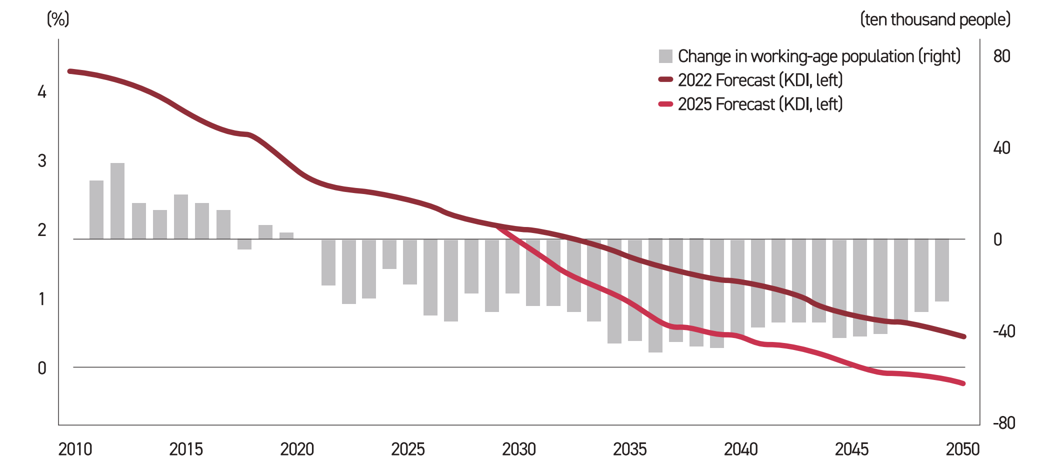
Through sustained investment in R&D, Korea has advanced science and technology, laying the groundwork for its mainstay industries — particularly in the manufacturing sector — and strengthening the foundation for rapid growth as an export and ICT powerhouse.

With the development of 4-Mbit DRAM in 1989, Korea emerged as a leader in semiconductors, while its achievement of the world's first commercialization of CDMA in 1994 established its ICT powerhouse status. Since then, Korea's technological prowess has continued to propel the country's industrial leaps forward, from displays to K-Defense (the Korean defense industry).



[Figure 3] Korea's Major Industrial and Technological Achievements by Decade

Today, however, Korea's potential growth rate is decelerating rapidly. This slowdown is widely viewed as a long-term structural problem stemming from declining productivity and insufficient development of new growth drivers. Domestically, Korea must overcome adverse conditions; internationally, it must contend with fierce competition as countries pour massive investments into advanced technologies to seize global leadership. Now more than ever, a pump-priming public investment in R&D is urgently needed to put growth on a sustainable footing by increasing the predictability of the R&D investment environment and restoring business confidence and willingness to invest in R&D.



* Source: KDI

[Figure 4] Trend in Korea's Potential Growth Rate

Accordingly, restoring the research ecosystem and reinvigorating the vigor of the private sector requires an entrepreneurial government — one that shoulders early-stage risk on behalf of the private sector and invests boldly in R&D.

Korea must now move toward "True Growth": sustained growth that, through structural reform and innovation, strengthens the economy's fundamentals and increases its growth potential, and tangible, broadly shared growth in which all citizens participate in innovation and value creation and share in the gains.

To that end, the government commits to making a decisive investment in R&D, to driving Technology-Driven Growth in partnership with the science and technology community, and to fully restoring the weakened research ecosystem — thereby delivering growth for all.

Based on a vision of achieving True growth that is grounded in science and technology, the 2026 major R&D budget is organized around ten priority investment areas for Technology-Driven Growth and Growth for All. To drive a major economic leap forward through Technology-Driven Growth, the plan prioritizes investments in AI, energy, strategic technologies, defense, and SMEs and startups.

First, to promote a sweeping economic and social transformation, the plan invests KRW 2.3 trillion in artificial intelligence (AI). It seeks to secure early leadership in technologies that could reshape the AI landscape, thereby strengthening independent AI capabilities. The focus includes realizing artificial general intelligence (AGI) capable of human-level reasoning, and securing the technologies that will become the foundation of lightweight, low-power AI that can transcend the limitations of frontier (large-scale) AI. To ensure AI can be optimized and applied across diverse real-world settings, the plan advances core technologies such as Physical AI and on-device AI, and secures technologies that strengthen AI reliability and safety, mitigating, and where possible eliminating, actual and potential risks such as bias, deepfakes, and cyberattacks.

Next, the plan builds the world's strongest "AI superhighway" for high-performance AI. To meet surging research demand, it supports access to high-performance GPUs (in collaboration with private cloud providers) and establishes a shared-use framework for distributed GPU resources. By developing high-performance network interconnects between large and small data centers and creating sector-specific micro data centers, it delivers a nationwide AI superhighway. It also lays the foundation for self-reliant AI services by developing core domestic cloud technologies for GPU resource sharing and management, and securing cloud technologies based on domestic NPUs and PIM.

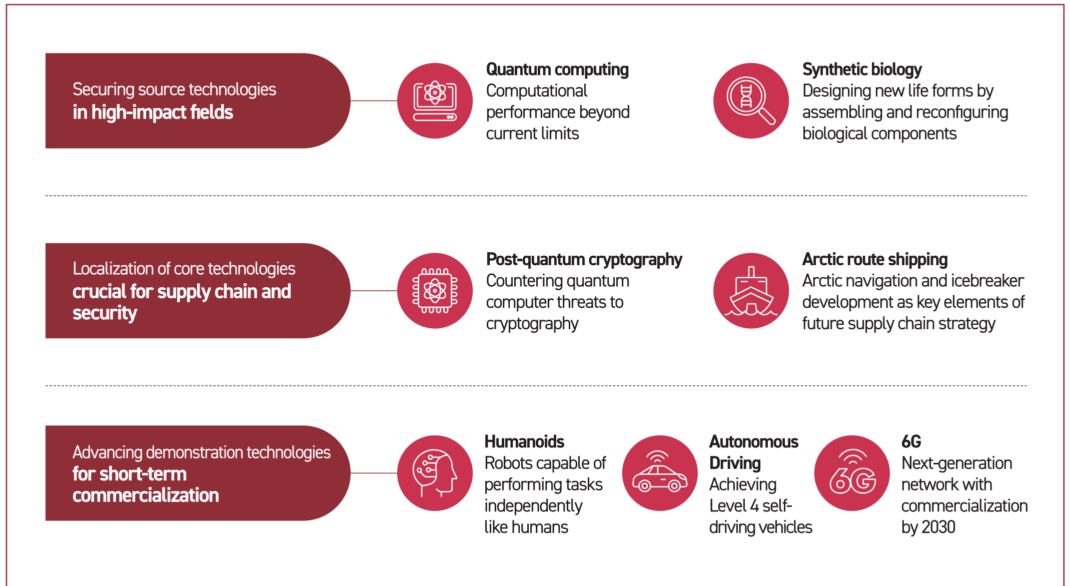
In addition, the plan integrates AI across research, industry, and the public sector to build an "AI-by-default society" that makes the best use of AI. It develops domain-specific AI models for individual research fields, and implements AI-enabled autonomous labs that leverage AI and robotics to accelerate scientific discovery. By embedding AI across all major industries — including manufacturing, biotech, and mobility — the plan will drive breakthroughs in productivity and the creation of new industries.

[Table 1] Draft Strategies for Embedding AI Across Key Industries

Manufacturing	Mobility	Bio	Agriculture & Fisheries	Culture & Content
Spread autonomous manufacturing by deploying industry-specific AI agents	Achieve Level 4 autonomous driving using end-to-end (E2E) AI and related technologies	Use AI convergence to transform the high-cost, high-risk process of new drug development	Promote the development and spread of data- and AI-based smart farming and aquaculture	Deploy K-content–specialized generative AI and transform cultural venues into AX spaces

Second, the plan invests KRW 2.6 trillion in a renewables-centered energy backbone. To meet RE100 commitments and accelerate the early demonstration and scaling-up of core technologies for next-generation flagship industries, it advances high-efficiency solar and utility-scale (very-large) wind to deliver a cost-effective transition to renewables. By upgrading AI-based energy-management systems (EMS) for real-time forecasting and dispatch, and developing core microgrid technologies and long-duration energy storage (LDES), the plan will build an intelligent, distributed "energy superhighway" that mitigates against grid variability.

In addition, the plan invests KRW 8.5 trillion in "commanding-lead" strategic technologies to cultivate advanced industries. Korea aims to secure early leadership in high-impact fields such as quantum computing and synthetic biology, while building domestic capabilities in technologies essential to supply chain resilience and national security, including Arctic shipping (the Northern Sea Route) and post-quantum cryptography. It also conducts near-term demonstrations of technologies poised for rapid commercialization, such as humanoid robots and autonomous driving.



[Figure 5] Cultivating advanced industries by securing commanding-lead strategic technologies

The plan invests KRW 3.9 trillion in defense science and technology to power K-Defense. It upgrades export-proven weapons systems like the K-9 self-propelled howitzer and the Cheongung-II missile to strengthen the export competitiveness of K-Defense. It also moves quickly to apply frontier technologies such as AI and quantum computing to defense, enabling a proactive response to the rapidly evolving future battlespace.

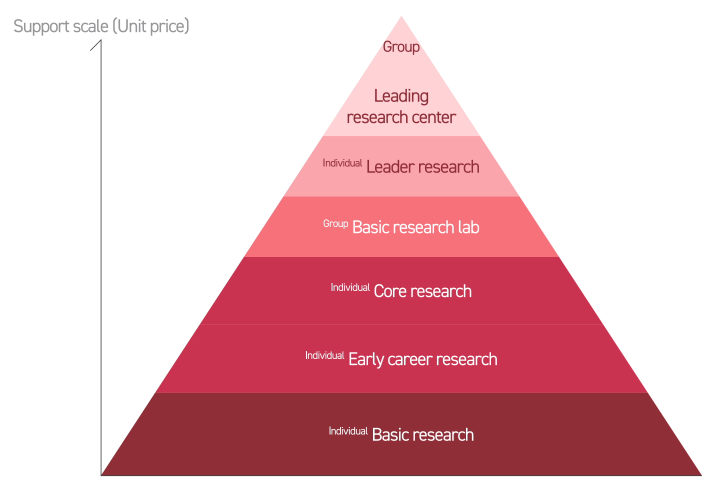
The plan invests KRW 3.4 trillion in SME and startup innovation to open new paths for growth. By providing decisive support to high-potential and market-validated firms, it will help them build a track record by linking innovation-oriented public procurement and purchasing to R&D outcomes.

[Table 2] R&D Support for SMEs and Startups

	SBIR-style Competitive Incubation – run by individual ministries	TIPS Private Investment-Linked – led by the Ministry of SMEs and Startups
Target companies	From a national perspective, firms with strong long-term spillover effects and growth potential, including early-stage projects at Technology Readiness Level (TRL) 3–4	From a private-sector perspective, firms with clear profitability and marketability, mainly projects at TRL 5–7 or above
Modality	Phase 1: technology verification → Phase 2: technology development → Phase 3: attraction of private investment; support limited to the top n percent selected through rigorous competition and screening	Phase 1: securing private investment → Phase 2: technology development
Key features	Government risk-sharing prevents promising technologies from being shelved and mitigates market failures arising from private risk aversion	Allocates resources by leveraging the market's own selection mechanisms; government support operates in line with the market's "invisible hand"

Beyond Technology-Driven Growth, the plan aims to deliver Growth for All — across basic science, talent, government-funded research institutes, regions, and even public safety — so that a weakened research ecosystem can be fully restored.

First, it invests KRW 3.4 trillion in basic science. To accelerate the recovery of the research ecosystem, the number of principal-investigator(PI)-driven basic research projects will be increased to more than 15,000, exceeding 2023 (pre-cut) levels. It restores a diverse portfolio of small grants (under KRW 100 million) for basic research so that both tenure-track and non-tenure-track faculty can fully exercise their expertise and creativity. To help researchers stay immersed in their work, it extends minimum project durations to create a more stable research environment. For early career research projects, the minimum duration has been extended from 1 year to 3 years (2+1), while for core research projects it has been extended from 3 years to 5 years (3+2).

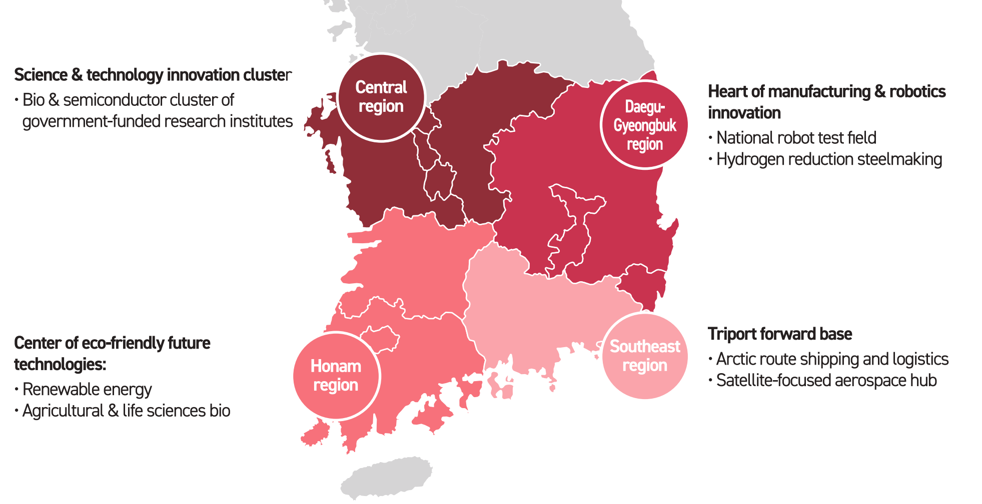


[Figure 6] Proposed reform of a demand-oriented basic research support system

The Korean government invests 1.3 trillion won to develop domestic STEM talent and attract outstanding researchers from overseas. Through generous, full-cycle support spanning from education to employment, specialists in key fields such as AI and biotechnology are trained. Centered on Korea's four Institutes of Science and Technology (KAIST, GIST, DGIST, and UNIST), the government has increased the annual salaries of outstanding postdoctoral researchers to around 90 million won under the InnoCORE initiative, and is expanding this standard to universities nationwide. It also strongly supports the "Brain to Korea" program, which is working rapidly to bring in top global talent in strategic technologies on exceptionally favorable terms. By offering a comprehensive package encompassing things like globally competitive salaries, stable research funding and settlement support, the government is creating an attractive environment that encourages overseas talents to put down roots and build their careers in Korea.

To enable government-funded science and technology research institutes to carry out their national missions, the government is investing 4 trillion won. It is phasing out the Project-Based System (PBS), which has effectively forced institutes to secure external projects simply to cover personnel costs, and refocusing research on mission-oriented programs to maximize impact. Every year through 2030, as government-commissioned projects are completed, their budgets are to be reallocated as institutional contributions and redesigned as large, mission-oriented projects (strategic research programs) tailored to each institute. The government is also introducing a new top-researcher incentive scheme that is directly linked to the research performance of these institutes, preventing the loss of outstanding talent and strengthening researchers' sense of pride.

The plan invests KRW 1.1 trillion in science and technology to boost regional economic vitality. It introduces the concept of "region-led(regionally autonomous) R&D," under which regions themselves identify and plan projects and develop technologies tailored to local strengths. It establishes a core pillar for balanced growth by jointly cultivating local talent, technology, and industry, and in particular, accelerates regional innovation through large-scale, AI-based demonstration projects linked to regionally strategic industries.



[Figure 7] Examples of region-specialized R&D reflecting local strengths and capabilities

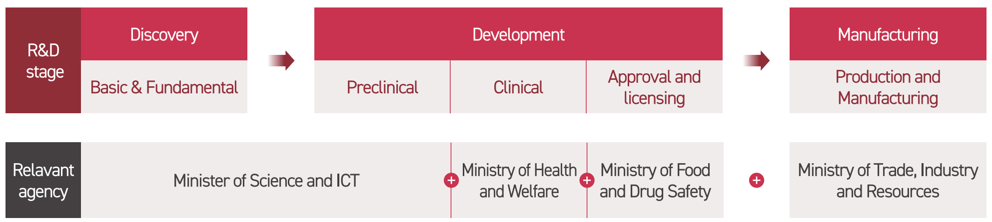
The plan invests KRW 2.4 trillion in disaster and public-safety response enabled by advanced technology. It addresses a wide range of hazards, including floods, industrial accidents, and crime, through technology convergence and cross-ministry collaboration. These efforts strengthen on-the-ground capabilities across the full cycle, from prevention and response to recovery.

[Table 3] Key Disaster- and Public-Safety R&D Investments

Natural disasters	Social disasters	Crime & accidents
Floods: predict inundation risk; enhance detention basins and related systems to reduce damage	Industrial accidents: use and analyze industrial-accident datasets; protect industrial workers	Digital crime: respond to deepfake videos, voice-phishing, and dark-web–enabled emerging crimes
Drought: nationwide monitoring of water supply and demand; optimize water-allocation operations	Suicide: identify and manage high-risk groups; tailored crisis interventions	Narcotics: use AI to investigate drug importation and distribution; identify new psychoactive substances
Earthquakes: big-data-based seismic-risk analysis; build real-time monitoring networks	Sinkholes: smart sensing for subsidence measurement; video analytics	Forensic science: crime-scene big data; AI-based pattern validation studies

2. Enhancing the Effectiveness of R&D Investment

Rather than simply increasing the size of the government's R&D budget for 2026, the government seeks to enhance the effectiveness of its R&D investments so that they lead to tangible results. To this end, it is first actively promoting collaboration among ministries to generate stronger synergies in research and development. It identifies and matches needs for inter-ministerial R&D cooperation along the entire chain from technology development through to utilization and diffusion, clearly defines the roles of each ministry to eliminate overlap and duplication, and organically links technology development, utilization and diffusion to expand the benefits of collaboration.



[Figure 8] Expanding Synergies through Inter-Ministerial Collaboration

In addition, the government is improving the effectiveness of R&D investment and management by restructuring and consolidating small-scale R&D programs into larger initiatives. It is revising the program and budget structure so that the fragmented projects that have resulted from preliminary feasibility studies and sunset provisions can be managed in an integrated manner, and is reorganizing them into larger, sector-specific R&D programs.

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- Plenary Session of the National Science and Technology Advisory Council(2025), 「Draft Allocation and Coordination Plan for the 2026 National R&D Budget」
- Plenary Session of the National Science and Technology Advisory Council(2025), 「Presentation Materials for the Draft Allocation and Coordination Plan for the 2026 National R&D Budget」

2 Key Takeaways and Significance of the "Science, Technology + Innovation Grand Transition Forum for Sustainable Growth and Future Industries"

Yeojin Jeong, Researcher, Center for Innovation Strategy Planning, KISTEP

1. Forum Overview: A Public Platform to Pivot Science, Technology & Innovation Policy

On May 29, 2025, the Korea Institute of Sc&T Evaluation and Planning (KISTEP) and the Korea Technology Innovation Society (KOTIS) co-hosted the Science, Technology & Innovation: Grand Transition Forum for Sustainable Growth and Future Industries at EL Tower in Seoul. The forum was convened to address structural challenges facing Korea—such as weakening industrial competitiveness and the low return on R&D—and to explore strategies for creating economic and social value and enabling sustainable growth through a transformation of science and technology (S&T) innovation policies.

Group Photo

Moving beyond an R&D-centric approach, the forum underscored the need to adopt an R&I strategy that integrates Research (R) and Innovation (I), focusing on the following main agenda items.

In the keynote, KISTEP President Taeseok Oh outlined a national science, technology × innovation strategy for future growth. Three policy talks followed on shifting the innovation investment system to respond to rapid industrial and technological change, revitalizing the startup ecosystem, and accelerating private sector innovation. Finally, a cross sector panel representing academia, policy, and industry discussed practical pathways to link policies and deliver implementation.

2. Main Discussions: Concrete Strategies to Execute S&T Innovation Policy

2.1 "Policy Directions for Science-and-Technology × Innovation to Drive Future Growth" — Keynote by Taeseok Oh, President of KISTEP

President Oh diagnosed Korea's structural growth limits, persistent low growth/productivity, and the so-called "Peak Korea" phenomenon. Citing international assessments (e.g., Nature, ITIF) and an innovation system skewed toward large firms, he pointed to structural reasons why technological outputs are not sufficiently translated into industrial and social value. Based on these analysis, he proposed the following four policy directions:

① Overhaul the R&D system: Redesign it from an output-driven model into an innovation-generating system closely linked to market and societal needs, featuring organic, iterative feedback loops among stakeholders.

② Strengthen the government's role as a venture investor: Move beyond a supplementary stance and pursue proactive, market-creating investments in high-uncertainty, high-risk areas.

Taeseok Oh, President of KISTEP

Byungheon Lee, Professor, KwangWoon University

③ Build an end-to-end support system for scaling up R&D outcomes: Integrate demand-driven technology selection, support for demonstration programs, and strategies for diffusion into the private-sector

④ Upgrade private-sector capabilities so firms can serve as the primary engines of technological innovation.

He concluded by calling for consistent, predictable mid- to long-term strategies; strategic R&D investments; the upgrading of the performance-management system oriented toward innovation and markets; and a shift to a mission-driven evaluation system to promote tangible, sustainable growth.

2.2 "Shifting the Innovation Investment System to Match Industrial and Technological Change" — Byungheon Lee, Professor, KwangWoon University

Professor Lee argued that, amid rapid structural change and shorter innovation cycles, fragmented grant schemes and rigid spending rules have reached their limits. In particular, he stressed the need to transition to a new innovation-investment system that fully takes into account the capabilities of the private sector—the core drive of innovation. He offers four key proposals:

① Diversify R&D support instruments (e.g., loan-based, reimbursement-based, competitive models) so projects can achieve the critical mass needed for commercialization.

② Shift government R&D grants for firms toward an upside-sharing model, minimizing public-sector investment risk while encouraging more active private-sector participation.

Yonggwan Lee, CEO, Bluepoint Partners

③ Create blended-finance R&D funds (equity + loans), such as a tentatively named "National Strategic Technology R&D Investment Fund," to fully launch loan-and-investment-based R&D programs.

④ Support venture capital (VC) firms and accelerators in establishing and operating R&D investment funds, and shift the implementation framework of government R&D grant programs so they are linked to private VC co-investment.

2.3 "Promoting Tech Startups and Scaleups for Greater Impact" — Yonggwan Lee, CEO, Bluepoint Partners

CEO Lee emphasized that deep-tech startups cannot generate meaningful outcomes based on technical excellence alone, underscoring the importance of a strategic, market-oriented approach to building successful ventures. In particular, he argued that startups can survive and grow only when they begin with a focus on solving a real market problem, rather than with the technology itself.

To that end, Lee stressed the need to establish a clear division of roles and a collaboration framework among technology, market, and management experts. Internally, he proposed that startups form a core technology team to turn technology into assets (IP); externally, they should organically connect with outside experts to accelerate market entry and expansion. He also highlighted the importance of management-efficiency strategies using AI and other enabling technologies.

Finally, citing Peter Thiel's remark that "Monopoly is the condition of every successful business," Lee reiterated that technology entrepreneurship should pursue game-changer strategies rather than head-to-head competition.

Wooseok Jang, Senior Research Fellow, Hyundai Research Institute

2.4 "Policy Directions to Catalyze Private-Sector Innovation" — Wooseok Jang, Senior Research Fellow, Hyundai Research Institute

Dr. Jang stressed that a structural shift in government policy is essential to enable private firms to engage in innovation more autonomously and on a self-sustaining basis. He noted that the current grant-based support scheme is weakly linked to outcomes, making the strengthening of performance-based incentives an urgent priority.

He proposed four directions for policy improvement:

① Shift to an outcomes-centered incentive system so that companies can voluntarily focus on generating results—for example, through tiered tax credit rates based on performance and additional incentives for firms that succeed.

② Reform the public procurement system so that it functions as a genuine lead customer and positions public procurement as a platform for creating demand for innovation.

③ Improve the regulatory environment that constrains firms' real-world demonstrations, removing obstacles to testing and validation.

④ Establish an incentive system that directly links private-sector innovation outcomes to policy mechanisms.

In closing, Dr. Jang emphasized that, to build a science-and-technology powerhouse, the government should act as an enabler—one that designs incentives that promote innovation. He also reiterated the need for a central coordinating "control tower" to clarify the division of roles among ministries and strengthen policy linkages.

2.5 Panel Discussion: Implementing Public–Private Policy Linkages

Following the presentations, the panel discussion focused on how to make public–private linkages in innovation policy effective in practice, with a wide range of views exchanged. Moderator Jeongdong Lee (Seoul National University) remarked that science and technology, like multiplication in arithmetic, yield far greater effects when combined with other fields, underscoring the need for an integrated R&I approach. As for the government's role, participants shared the view that, rather than providing a single "right answer," policy should create an environment that allows for experimentation and even failure.

Minsang Yoo, CSO of Autonomous A2Z, drew on his experience with an autonomous-driving startup to highlight institutional hurdles and policy gaps encountered during the demonstration phase. He noted that many technologies are sufficient, but still fail to enter the market because pilots are too difficult to implement, and argued that the government should put in place a clearer, more practically effective framework to support real-world demonstrations and test beds. He added that policy should fully accommodate private-sector pilots and risk-taking, and that government should support diverse experiments rather than providing a single "correct answer."

Byunggun Kim, Director of the Strategic Procurement Research Division at the Korea Institute of Procurement, pointed out that although Korea has introduced a pilot-purchase mechanism to procure R&D outputs directly, it does not function effectively in practice. In particular, public agencies still prioritize price and often feel burdened about buying new products. He called for structural changes so that technological value and innovativeness are properly reflected in evaluations.

Eunmi Jung, Research Fellow at the Korea Institute for Economics & Trade, cited examples form U.S. and other advanced-economies to emphasize the importance of manufacturing-centered S&T policy. Given Korea's technological capabilities and industrial structure, she cautioned that innovation policies that disregard the manufacturing base risk being ineffective. She went on to cite the standard economic production function, $y = f(L, K, T)$—commonly used to explain productivity growth—and emphasized that science and technology policy must likewise focus on people (L).

Hyunhwan Oh, Director General of KISTEP's Office of S&T Policy Planning, stressed that institutional approaches to addressing market problems should be more advanced in the early stages of technology development. He noted that, even during the planning stage—including for basic and foundational technologies—there needs to be deliberate consideration of how to reflect market demand and feedback. Given the ongoing reforms to government governance, he added that relevant laws and operational structures should be revised to provide solid institutional backing, ensuring this policy shift is codified and sustained.

Panel Discussion

In closing, as the panel moderator, Professor Lee identified two structural issues. First, the global competition to secure talent: as "innovation" takes the center stage on the policy agenda, he proposed that a strategy for the global talent race be treated as a core pillar and called for a macro-level, whole-of-nation approach. Second, policy integration: S&T innovation policy should move beyond fragmented, ministry-by-ministry approaches and be designed in an integrated way from a demand-side (user) perspective. To address these challenges, he expressed the view that an overarching, top-level governance framework is needed to steer and coordinate policy—such as appointing a Deputy Prime Minister for Science and Technology or establishing an integrated structure reporting directly to the President.

3. Significance of the Grand Transition Forum: Discussion on the Direction of Transition in STI Policy

The forum was significant as a venue to reflect on the limitations of R&D-centric science and technology (S&T) policy and to discuss the need for a research and innovation (R&I) policy system aimed at generating tangible innovation outcomes. Notably, it facilitated wide-ranging policy discussions on how to design transition pathways that move S&T beyond mere technology development and connect it with the market, society, and the economy, offering important implications for future policy.

(From left) Jeongdong Lee, Professor, Seoul National University; Byunggun Kim, Director, Korea Institute of Procurement

First, participants emphasized the importance of transitioning from supply-driven policy design to a demand-driven innovation system. Presenters and discussants alike agreed that, from the earliest stages of technology development, the government and policymakers should consider both market viability and demonstration feasibility, and that public procurement and other early-demand mechanisms should function as effective instruments to catalyze innovation. They also called for a structural re-examination of price-centered procurement models and institutional barriers to more effectively support technology commercialization.

Second, the forum emphasized the need to redefine the government's role—a shared recognition that it should act not as an "answer-giver," but as a coordinator and facilitator (enabler) that designs room for experimentation and institutional flexibility so that the private sector can experiment and fail. Accordingly, key policy tasks were proposed, including strengthening the government's strategic investment functions, designing end-to-end R&D system, and enhancing support systems for demonstration and scale-up.

Third, the importance of people—the workforce—emerged as a common theme. Because people are ultimately the principal agents of science, technology, and innovation, speakers emphasized the urgent need for strategic support for cross-disciplinary, field-ready talent that can connect technology to markets—moving beyond the mere training of research personnel. This, in turn, points to the need for more organic coordination among R&D, talent, employment, and education policies.

Finally, participants emphasized the importance of the government's role as an Integrator. To better connect science, technology, and innovation, there was broad agreement that market-oriented policy integration, leveraging policy instruments such as finance and investment, the creation of early markets, and improvements to the regulatory environment must function in an integrated, mutually reinforcing way. Some discussants expressed the view that a structural redesign within government is needed—for example, appointing a Deputy Prime Minister for Science and Technology—to enable the government to fulfull this role.

Next Steps for KISTEP. KISTEP plans to hold in-depth discussions on the issues raised at the forum, as well as on the additional innovation policy tasks identified there. It will continue efforts to support the implementation of the new administration's "Technology-Driven Growth" strategy—responding to changes in the global trade environment, fostering future strategic industries, and strengthening industrial and export competitiveness. To that end, KISTEP will need to progressively broaden its mandate beyond science and technology (S&T) policy to encompass the broader innovation policy domain.

3 Major Findings (Draft) of the 2024 Survey on the Domestic and Overseas Status of Science & Engineering (S&E) International Students

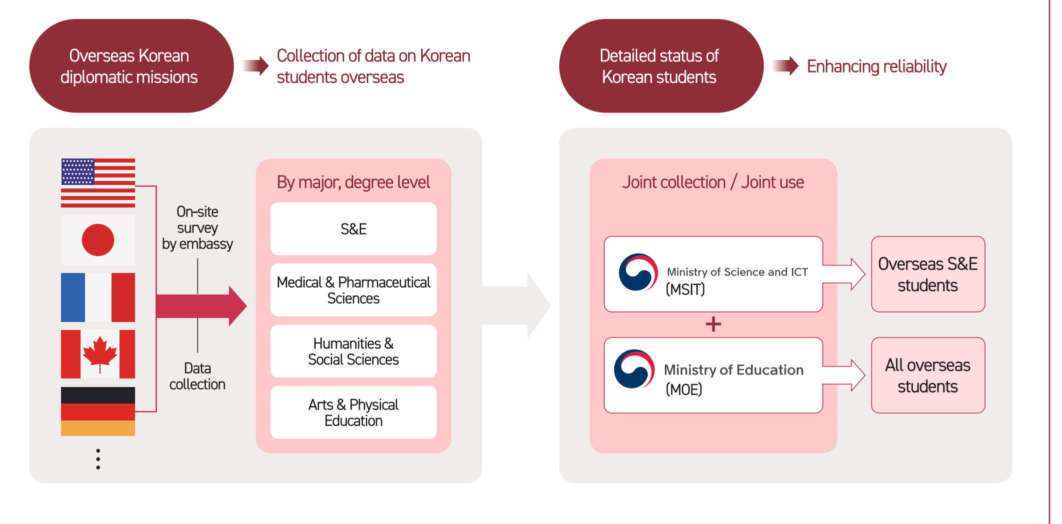
Soobin Park, Associate Research Fellow, Center for S&T Talent Strategy, KISTEP

1. Introduction

As the global competition to secure science and technology talent intensifies, Korea is facing a shrinking pool of human resources due to low birthrates and an aging population. This has heightened the need to attract outstanding foreign talent while also preventing the outflow of top domestic talent. Advanced countries, led by the United States, actively recruit international students and leverage them to advance their science and technology capacity. In the U.S., for example, more than half (56%) of international students major in S&E fields, making substantial contributions to the country's scientific and technological advancement. Consequently, S&E international students have significant strategic value as potential drivers of innovation.

Meanwhile, many Korean S&E students continue to pursue studies or relocate abroad in search of higher-quality education and research environments. Against this backdrop, it is essential to develop effective S&T human-resources policies based on an accurate understanding of where S&E students are located—both in Korea and overseas—to safeguard national competitiveness.

Pursuant to Article 7 of the Special Act on Support of Scientists and Engineers for Strengthening National Science and Technology Competitiveness, Korea conducted four rounds of surveys and analyses on the inflow and outflow (including the net balance and status) of S&E personnel between 2009 and 2019. In 2023, the overall survey and analysis framework was overhauled to enable more timely tracking of S&E mobility and to secure more reliable statistics. In particular, for the student survey, the previous approach—estimating the global number of Korean S&E students based on the S&E share (~30%) among Korean students in the United States—was replaced. Under the revised approach (proposal), the Ministry of Science and ICT (MSIT) and the Ministry of Education (MOE) jointly collect and utilize information on Korean students abroad using data provided by Korea's overseas missions.



[Figure 1] Joint system for collecting and using information on Korean students overseas

This article presents the key findings from the first student survey conducted after the system overhaul: the "2024 Survey (Draft) on the Domestic and Overseas Status of S&E International Students," which assesses the residence status of S&E students.

2. Key Findings

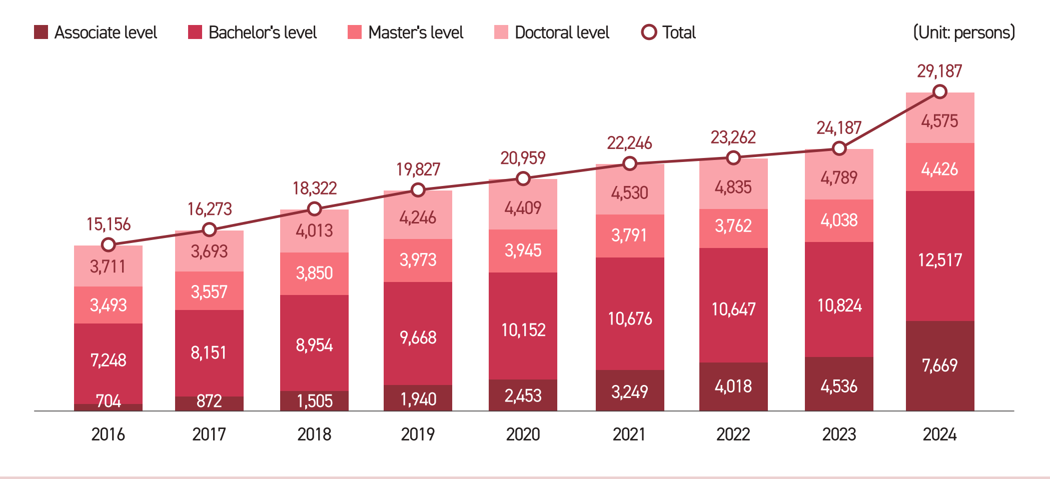
Survey population: S&E (natural sciences and engineering) international students enrolled in higher education institutions in Korea and abroad.

- Definitions and scope: S&E (natural sciences and engineering) international students at higher education institutions in Korea and abroad
- Definitions and scope
  - Source for Korea-based counts: Korean Educational Development Institute (KEDI), Basic Statistics of Higher Education Institutions (reference date each year: April 1)
  - Degree levels covered: Undergraduate (associate and bachelor's programs) and graduate (master's and doctoral programs)

    * Associate (colleges of technology and junior colleges), bachelor's (universities), master's/doctoral (general, professional, and specialized graduate schools).
  - For overseas counts: The most recent country-level data as of April 1 each year
  - Degree level and major classification are compiled from degree/major-level reports on Korean students submitted by each country's Korean overseas mission

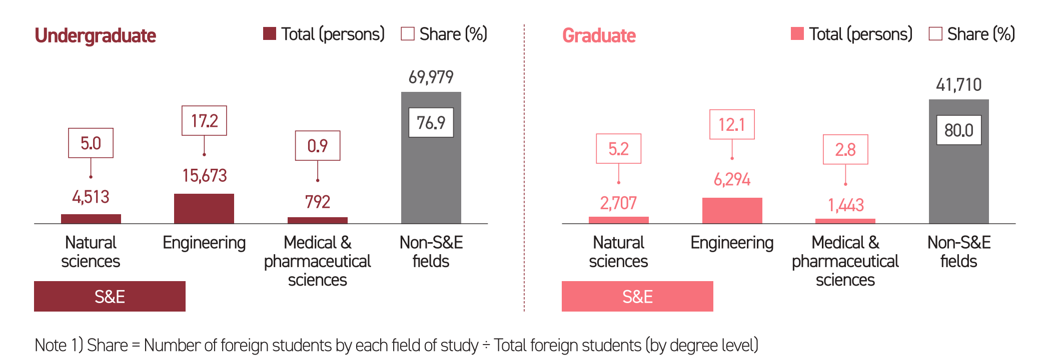
2.1 Status and characteristics of S&E foreign students in Korea

The number of S&E foreign students residing in Korea has steadily risen over the past nine years. As of 2024, there are 29,187 S&E foreign students in Korea—an increase of 5,000 (+20.7%) from the previous year. By degree level, associate programs recorded the largest increase, up 3,133 (+69.1%), followed by bachelor's programs (+1,693; +15.6%) and master's programs (+388; +9.6%). In contrast, doctoral students decreased by 214 (–4.5%), representing the only category to show a decline.



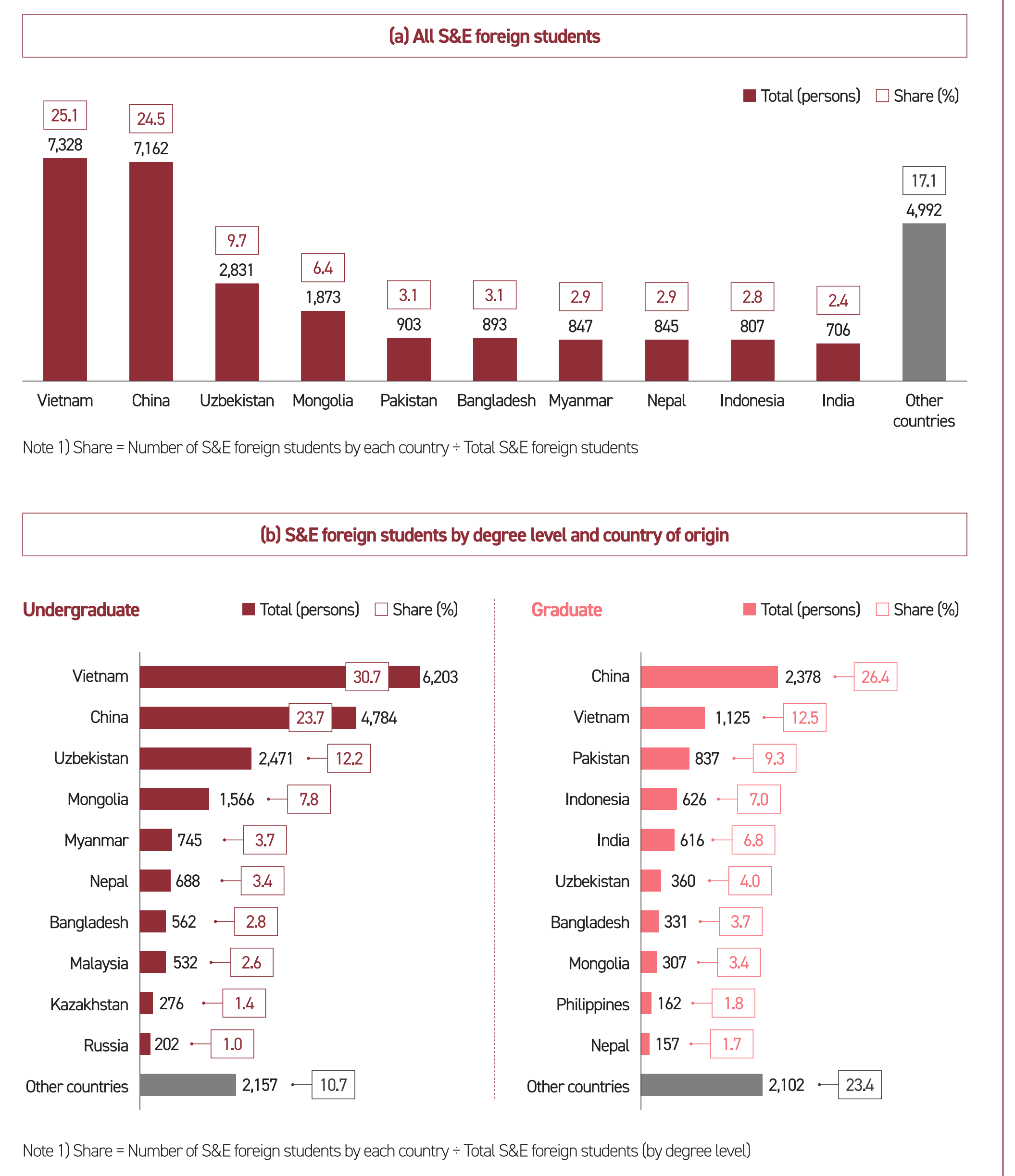
[Figure 2] S&E foreign students in Korea, 2016–2024

By degree level and field, undergraduate programs (associate + bachelor's) account for 20,186 students, exceeding the number in graduate programs (9,001), indicating a higher share at the undergraduate level. Within undergraduate programs, engineering (15,673) outnumbers natural sciences (4,513). The same pattern is observed at the graduate level, where engineering (6,294) exceeds natural sciences (2,707).



[Figure 3] S&E foreign students in Korea by degree level and field (2024)

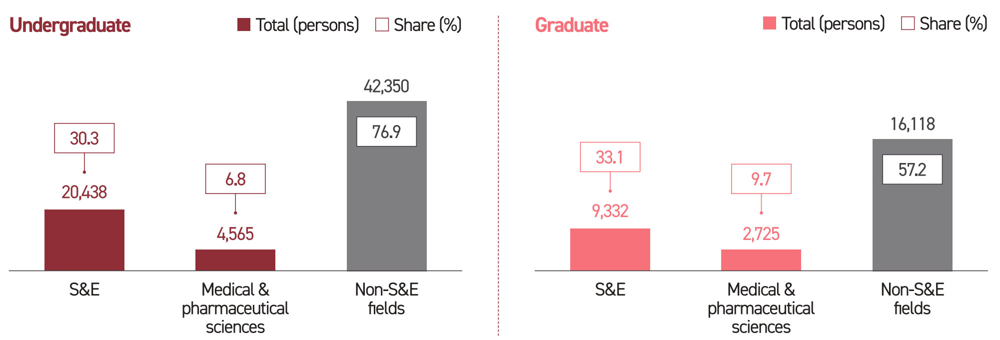
The top 10 countries of origin for S&E foreign students in Korea are all in Asia. Vietnam accounts for 25.1%, followed by China (24.5%), Uzbekistan (9.7%), and Mongolia (6.4%). Notably, students from Vietnam and China together comprise about half (49.6%) of all S&E foreign students. By degree level, Vietnam has the highest share at the undergraduate level (30.7%), whereas China leads at the graduate level (26.4%), ahead of Vietnam (12.5%).



[Figure 4] Top 10 countries of origin for S&E foreign students in Korea (2024)

2.2 Status and characteristics of Korean S&E students abroad

As of 2024, there are 29,770 Korean S&E students studying abroad. By degree level, 20,438 are enrolled in undergraduate programs and 9,332 in graduate programs, showing a larger number at the undergraduate level. However, as a share of all Korean international students, the S&E share is higher at the graduate level (33.1%) than at the undergraduate level (30.3%).

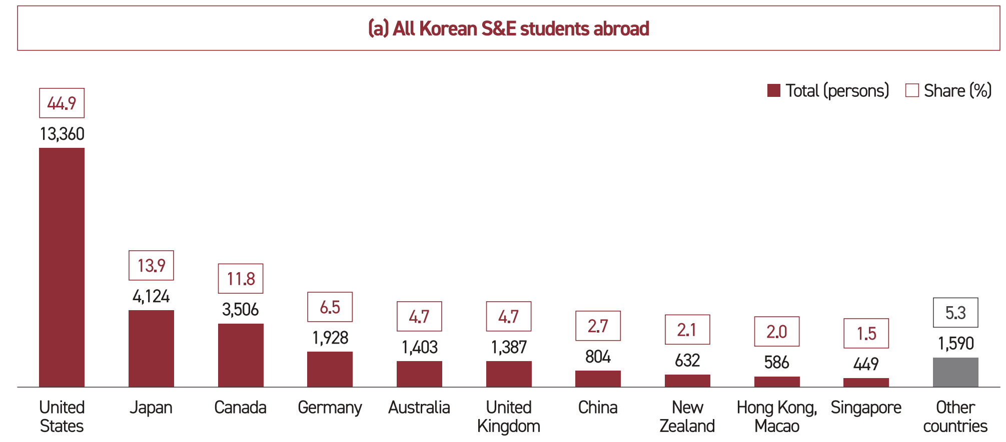


Note 1) Students in other majors or unclassified fields of study by each country are categorized as non-S&E.

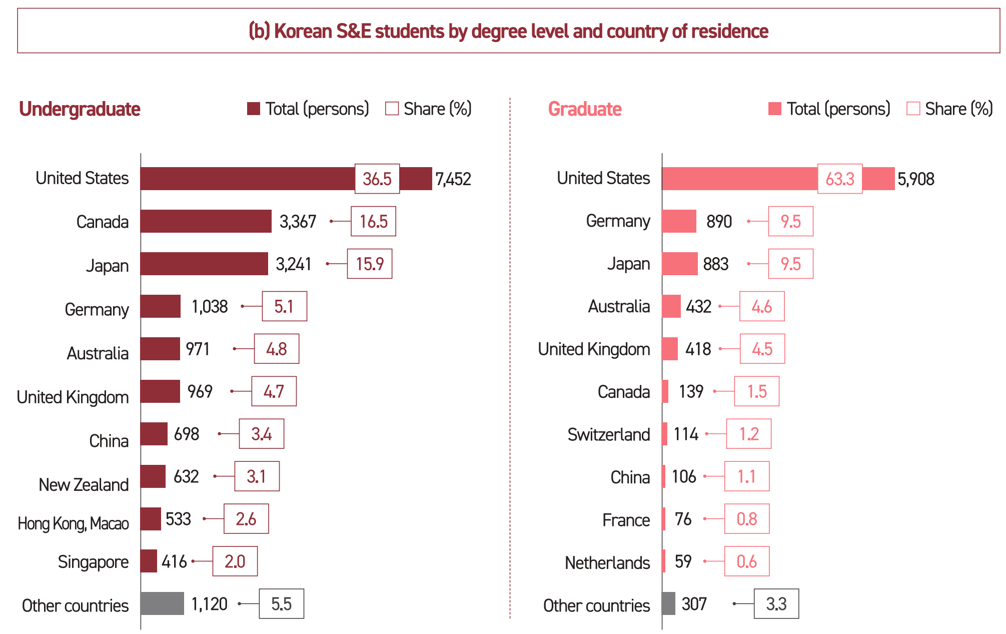
[Figure 5] Korean S&E students abroad by degree level and field (2024)

By country of residence, the United States holds the largest number of Korean S&E students—13,360 (44.9%)—followed by Japan (4,124; 13.9%) and Canada (3,506; 11.8%). Among the G7 countries (United States, Japan, Germany, United Kingdom, France, Italy, Canada), five—the United States, Japan, Germany, the United Kingdom, and Canada—rank among the top 10 countries hosting Korean S&E students. Together, these five countries account for 88.6% of all Korean S&E students abroad.

By degree level, the top three destinations for undergraduate students are the United States (36.5%), Canada (16.5%), and Japan (15.95%). At the graduate level, the United States (63.3%) overwhelmingly ranks first, followed by Germany (9.5%) and Japan (9.5%). In short, the United States is the primary destination for Korean S&E students at both undergraduate and graduate levels, with particularly strong preference at the master's and doctoral levels.



Note 1) Share = Number of Korean S&E students by each country ÷ Total overseas Korean S&E students



Note 1) Share = Number of overseas Korean S&E students by each country ÷ Total overseas Korean S&E students

2) The number of Korean S&E students in the United States, Canada, France, and New Zealand is estimated by combining data from overseas diplomatic missions and related sources.

3) For New Zealand, the total number of university and graduate students was provided; the figure is included in the undergraduate category.

[Figure 6] Top 10 countries hosting Korean S&E students abroad (2024)

3. Way Forward

The 2024 survey on the residence status of S&E students in Korea and abroad focuses on establishing baseline statistics—including scale, country of origin (for foreign students in Korea) and country of residence (for Korean students abroad), degree level, and field of study. In particular, the data on Korean S&E students abroad—jointly produced by the Ministry of Science and ICT (MSIT) and the Ministry of Education (MOE)—constitutes the only statistics that specify the number of Korean S&E students by country. It represents an important first step toward data-driven S&T human-resources policy.

Going forward, the survey should be conducted annually through continued collaboration between the Ministry of Science and ICT (MSIT) and the Ministry of Education (MOE), with joint collection, aggregation, and management of data from Korea's overseas diplomatic missions (embassies, consulates, and permanent missions). To ensure that the survey serves as a pillar of S&T talent policy rather than remaining a simple statistical exercise, more diverse and in-depth analyses are required.

For 2025, data on foreign S&E students in Korea will again be compiled from KEDI's Basic Statistics of Higher Education Institutions, and information on Korean S&E students abroad will be collected via overseas missions. In addition, a parallel survey will be carried out on the residence status of S&E workers. Specifically, the triennial "Survey on S&E Workforce (Institution)"—which covers the development, utilization, and treatment (working conditions) of S&E personnel—will be expanded by adding and linking a foreign-national module to survey foreign R&D personnel affiliated with companies, universities, and public research institutes in Korea. We will also examine methods for collecting information on Korean nationals employed overseas in major countries. Using indicators such as visa type and occupation, we plan to include Korean workers residing abroad in the survey.

By conducting multifaceted analyses on the residence status of domestic and overseas S&E students and workers, we aim to provide practical baseline data to support the formulation of S&T talent policies.

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4 Leading Strategies for an Innovation Ecosystem in the Age of AI(Autonomous Manufacturing, AI Semiconductors, AI Software, Humanoid Robots)

Compiled by: Deokyu Hwang, Research Fellow,
Center for R&D Investment Planning and Strategy, KISTEP

1. Four Transformative Pillars for Technology Leadership—from Autonomous Manufacturing to Humanoids

As countries embark on a global race to innovate with AI, the technology is no longer limited to a single field; it is now the key driver remaking industries across the board. The global AI market is projected to grow more than 19% annually and reach roughly ₩3.7 quadrillion by 2032, while the generative AI segment alone is expected to surpass $1.3 trillion within a decade.

AI is permeating nearly every sector—healthcare, finance, manufacturing, education, logistics, and entertainment—restructuring value chains end to end. Notably, autonomous manufacturing, AI semiconductors, AI software, and humanoid robots are emerging as core foundations for global supply chain stability, gains in labor productivity, and the realization of intelligent automation.

Korea is accelerating efforts to secure these strategic technologies. While AI adoption promises to significantly raise total factor productivity and GDP, only 6.3% of Korean companies currently use AI, indicating substantial room for improvement.

Against this backdrop, the 174th KISTEP Wednesday Forum explored "Leading Strategies for the Innovation Ecosystem in the Age of AI," focusing on the above four domains and discussing pathways for technology advancement and industrial ecosystem development.

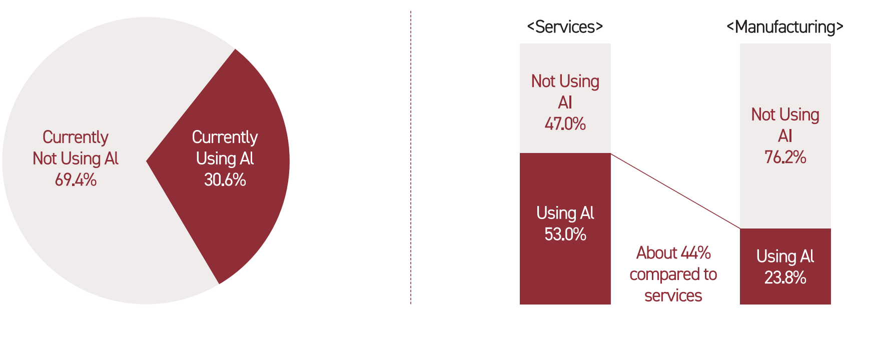
Overview of the 174th Wednesday Forum

- Date & Venue: March 26, 2025 (Wed), 14:00–15:40 / Online Broadcasting Studio, Korea ST Center
- Moderator: Seungsu Jun, Director General, Office of National R&D Coordination & Evaluation, KISTEP
- Speakers:
  - SungHo Cho, Director, Center for Growth Engine R&D Coordination, KISTEP
  - Kihyun Ahn, Executive Director, Korea Semiconductor Industry Association (KSIA)
  - Hyedong Jeong, Artificial Intelligence PM, IITP
  - Ikjae Kim, Director, KIST

2. Current Status & Key Issues

2.1 Autonomous Manufacturing

To strengthen its manufacturing competitiveness, Korea is advancing a national-level, large-scale rollout of smart factories through both R&D and non-R&D initiatives, while deploying solutions such as MES(Manufacturing Execution System) and ERP(Enterprise Resource Planning) across the manufacturing sector to accelerate digital transformation. With progress in digital twin technologies for physical processes, the groundwork is being laid to capture "digital manufacturing data" not just for single steps but for entire production flows. However, according to a survey on AI utilization by Korean firms, manufacturing's AI adoption rate (23.8%) lags well behind that of services (53%).



Source: ElecTimes(https://www.electimes.com/news/articleView.html?idxno=342289)

[Figure 1] Utilization Rate of AI Technologies

As digital transformation accelerates, AI is moving beyond basic automation to enable prediction, optimization, and autonomy. AI-centric smart manufacturing strategies—spanning productivity gains, cost reduction, safety enhancement, and customer responsiveness—are now essential to securing industrial competitiveness.

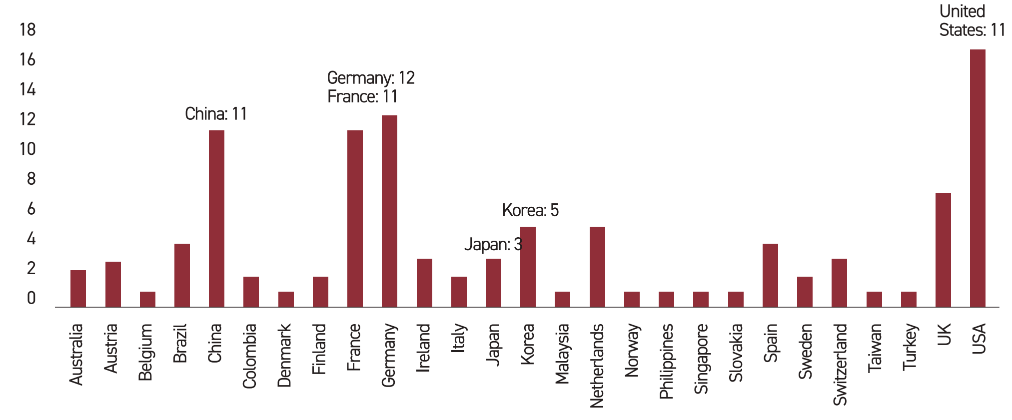
[Table 1] Why AI-Based Autonomous Smart Factories Are Needed

Core Area	Key Points
Process optimization & autonomous operations	Analyze IoT data to improve process efficiency; predictive maintenance to prevent equipment failures; collaborative smart-robot automation; optimize energy consumption
Real-time analytics & decision-making	High-speed cloud/edge analytics; instant anomaly detection and automated decisions; decision support for managers
Hyper-connected factory operations	Optimize SCM; automated ordering/inventory; synchronized global production
Customized manufacturing & customer-centric production	Demand-forecast-driven customization; enable mass customization; flexible production based on customer data
Cybersecurity & risk management	AI security to detect intrusions/hacking; real-time response to anomalies; integrated OT-IT security

In the manufacturing sector, the lack of standards around the collection of digital manufacturing data, security and regulatory issues at the data-use stage, and the absence of industry- and domain-specific AI foundation models for manufacturing are widely recognized as key obstacles to the widespread adoption and operational embedding of AI. Because firms are at different points in terms of timing and maturity, many continue to rely on automation-centric productivity strategies; as a result, the broad, on-the-ground adoption and diffusion of AI-driven manufacturing innovation are widely viewed as sluggish. To overcome these issues, we need an ecosystem-level collaboration framework to standardize and open manufacturing data, as well as clear security guidelines and calibrated regulatory streamlining for data use. In addition, policy and technical efforts are required to promote the development of manufacturing-specific AI foundation models tailored to industry- and domain-specific characteristics, thereby enabling a wide range of manufacturers to achieve practical and sustainable AI-based innovation.

To build an ecosystem in which AI adopters and AI suppliers can co-evolve, Korea should promote UAO (Open-source Autonomous Operations) AI manufacturing solutions based on open architectures. For two decades, open-source platforms in autonomous manufacturing have been advancing steadily, enabling developers and users to achieve faster, easier, and higher-quality outcomes. Traditional system integrators (SIs) have delivered site- or domain-specific solutions, but that approach is ill-suited as a generalizable strategy for broad, at-scale adoption and diffusion of AI manufacturing innovation.

For adopters, it is necessary to accelerate digital transformation on open architectures—rather than proprietary protocols—to reduce upfront costs, speed up on-site deployment, make interoperability and compatibility easier, and sustain innovation. UAO (Open-source Autonomous Operations)-based, AI-enabled autonomous-manufacturing systems can also support progress toward carbon neutrality by providing capabilities for real-time data collection to build carbon-emissions inventories, optimized resource utilization, energy-efficiency improvements, and emissions analysis. Around the world, leading, established system integrators (SIs)—such as Siemens (Germany), ABB (Switzerland), and Rockwell (U.S.)—are competing for market dominance. This is playing out as a contest between closed-platform, capital-rich incumbent market leaders and later entrants pursuing open strategies.



(Source: 174th Wednesday Forum presentations)

[Figure 2] Overview of UAO-Participating Institutions in Key Countries

2.2 AI Semiconductors [1]

AI progress depends on ultra-fast computation over massive datasets; AI system performance is ultimately determined by semiconductor performance and efficiency.

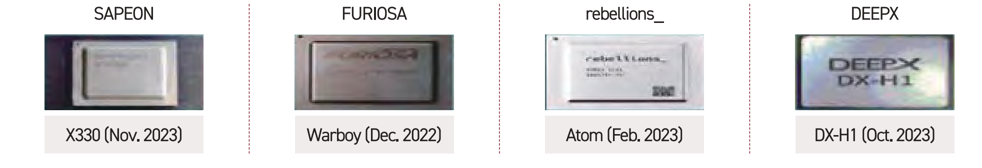
In the high-performance chip market that powers AI training and inference, U.S.-based NVIDIA leads in GPUs, Korea's SK hynix leads in HBM memory, and Taiwan's TSMC leads in advanced process technology — and they are locked in a fierce race for technological and market leadership.

1 Based on a talk by Ahn Ki-hyun, Executive Managing Director, Korea Semiconductor Industry Association

[Table 2] Major Countries and Companies in Semiconductors

Country	Key Companies	Role & Strengths
U.S.	NVIDIA	Dominant GPU share (e.g., A100, H100 for AI training); CUDA ecosystem lock-in advantage
	AMD	GPU challenger expanding AI inference portfolio
	Intel	CPU-based AI inference; pursuing AI-specific chips (e.g., Gaudi2)
Korea	SK hynix	Leads HBM3/HBM3E supply; key supplier to NVIDIA and others
	Samsung Electronics	Advancing HBM and in-house AI chips; researching memory-logic integration
Taiwan	TSMC	Exclusive provider of 3nm-and-below leading-edge process nodes; critical partner to global fabless leaders (NVIDIA, AMD)
China	SMIC, Huawei	Developing domestic AI chips; growth constrained by U.S. export controls yet building alternative ecosystems

While NVIDIA dominates the GPU market—the core of AI chips—the HBM memory segment that these GPUs rely on has SK hynix, Samsung, Micron (U.S.), and China's CXMT vying for leadership, and fierce competition over the medium to long term appears to be inevitable. South Korea is world-class in HBM memory technology, but GPU/NPU design remains in a nascent stage. Its advanced-packaging capabilities—the linchpin of overall AI-chip maturity—lag those of top global players, underscoring the need for strategic reinforcement to ensure balanced technological development. The country also has strong potential to expand its cloud-AI ecosystem by launching high-performance, low-power AI chips and partnering with system-software and cloud-service firms. For example, KT Cloud is building a full AI stack with Rebellions (hardware) and Moreh (software).



(Source: 174th Wednesday Forum presentations)

[Figure 3] Overview of Cloud AI Chip Development by Korean Companies

In terms of market size and growth, non-memory (system) semiconductors and foundry have the strongest prospects, while automotive and power semiconductors are gaining momentum with the rise of EVs and AI. Non-memory (logic) semiconductors and foundry are core segments with both large market size and high growth, offering strong long-term investment value as AI adoption and digital transformation accelerate. Automotive and power semiconductors are smaller today, but are drawing attention as structural growth areas with the expansion of EVs and autonomous driving. Memory semiconductors are a traditional stronghold for Korea, but the segment faces intensifying competition and is highly cycle-sensitive. Display driver ICs are seeing relatively stable growth, but the risk from China-led low-price competition warrants caution.

[Table 3] Semiconductor Market Size and Growth Rates

Segment	2024 Market Size	CAGR	Source
Memory (DRAM & NAND Flash)	~$161.6B	~8.87%(2025~2033)	Global Market Statistics
Non-memory (System)	~$570B	~8–10%	Fortune Business Insights
Foundry (Contract Mfg.)	~$136.3B	~9.1%(2025~2034)	Global Market Insights
InsightsPower(incl. SiC/GaN)	~$5.407B	~4.93%(2025~2030)	Mordor Intelligence
Automotive	~$6.93B	~11%(2024~2032)	Global Market Insights
Display Driver IC(DDI)	~$4.23B	~8.2%(2024~2030)	Semiconductor Insight

With the expansion of cloud-based, hyperscale generative AI services, data-center efficiency and lower power consumption are becoming increasingly important. Meanwhile, on-device AI is emerging as a key driver of growth not only in established mainstay industries such as smartphones and automobiles, but also in emerging sectors, including robotics, video surveillance (CCTV), and wearables. To respond to the rapid expansion of cloud-based, hyperscale generative-AI services, the hardware/software ecosystem that enables high-efficiency, low-power data-center operations needs to be strengthened. Secure core capabilities early across upstream and downstream industries and aggressively target nascent domestic and overseas markets to lay the foundation for growth. On-device AI is expected to act as a key driver of growth in mainstay industries (smartphones, automobiles, robotics) and to accelerate the expansion of emerging sectors (robotics, CCTV, wearables).

Improvements in AI-chip performance can no longer be achieved by single-chip advances alone; advanced packaging is emerging as both a complement and a central driver. To break through performance limits and achieve sustained technological progress, advanced packaging has shifted from a mere auxiliary technique to a core strategic capability and is expected to play a decisive role in high-performance application domains—including AI, high-performance computing (HPC), automotive/mobility, and data centers. In particular, 3D integration, chiplet-based architectures, and high-bandwidth interconnects are becoming key determinants of AI performance, underscoring the urgent need for focused investment and ecosystem development at both the industry and policy levels.

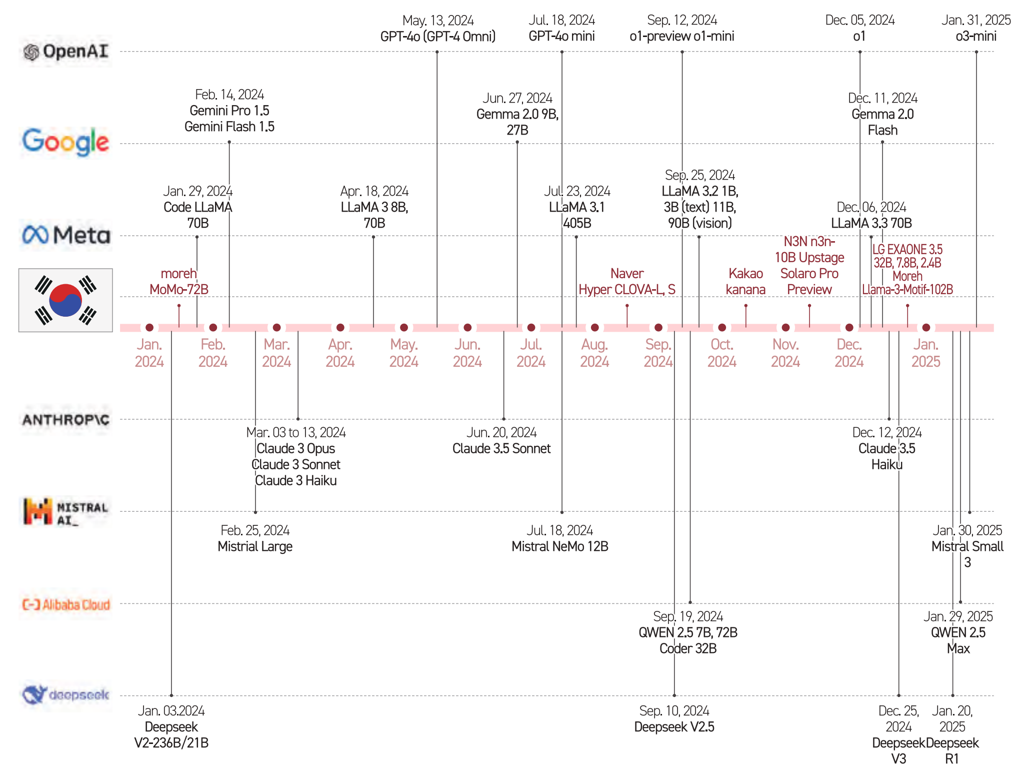
2.3 AI Software [2]

Recently, AI systems such as ChatGPT have demonstrated strong performance not only on single tasks but also on complex, multi-step tasks, reaching and even surpassing human-level performance in certain domains. Moving beyond the single-interaction paradigm of Artificial Narrow Intelligence (ANI), the field is rapidly evolving toward "Agentic AI," which autonomously solves problems through sophisticated reasoning and iterative planning, and "Innovative AI," which exhibits human-like autonomy and creativity while exploring unknown problem spaces. Taken together, this marks a shift beyond AI as a mere tool toward autonomous systems that define their own problems and devise and execute optimal strategies even under complex conditions. Ultimately, this trajectory points to the feasibility of Artificial General Intelligence (AGI)—systems that, without human instruction, autonomously carry out the full plan–reason–execute–adapt cycle aligned with high-level objectives.

Major economies—including the United States and China—continue to invest in AI R&D; as a result, the global AI technology gap is steadily widening. The United States has secured an integrated lead across the full stack—cloud, models, and compute infrastructure—anchored by firms such as NVIDIA, AWS, and OpenAI. China, despite sanctions and export controls, is strengthening a localization/self-reliance strategy and focusing on homegrown AI-chip development (e.g., Baidu's Kunlun), while new possibilities such as DeepSeek are also emerging.

2 Based on a talk by Jeong Hye-dong, AI PM, IITP

The Current State of AI Trends in LLM Technology Announcements (2024-)



(Source: 174th Wednesday Forum presentation materials)

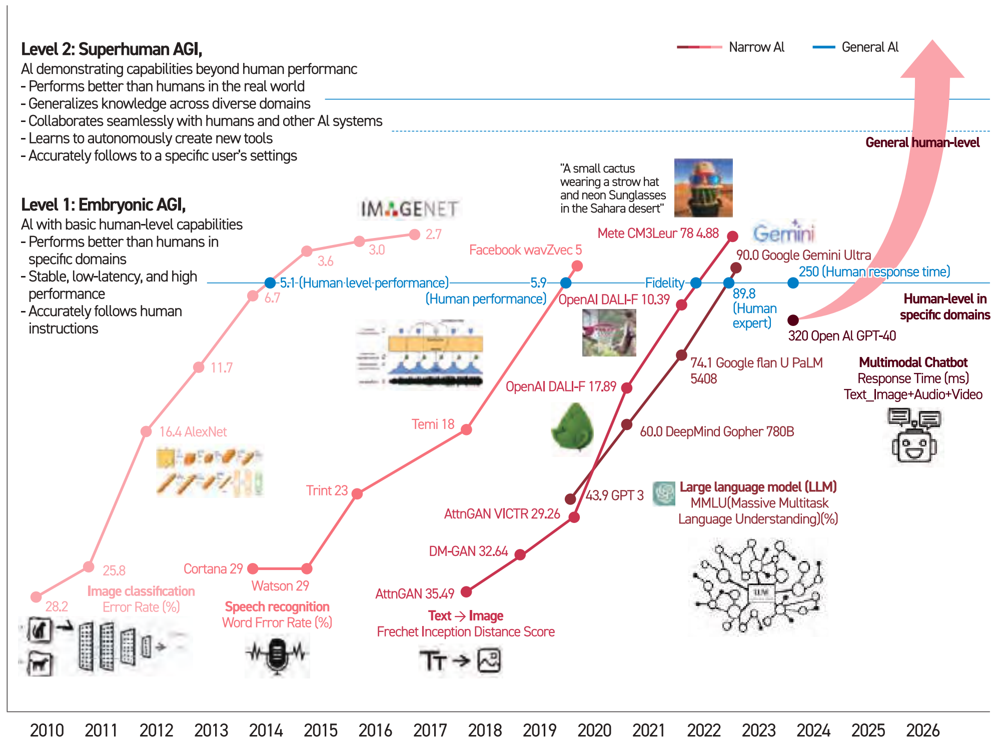
[Figure 4] The Current State of AI

Both the United States and China are building AI industrial ecosystems at the national level—rather than around any single company. Yet, under widely observed scaling laws, model performance increases in proportion to model size, training-data volume, and compute—albeit nonlinearly (typically following a power law)—so massive compute and datasets remain indispensable. South Korean players—Moreh, Upstage, N3N, and LG AI Research—have taken first place on Hugging Face's Open LLM Leaderboard, drawing global attention in the LLM arena. They also show strong competitiveness in both on-device (edge) AI and global LLMs, and have posted excellent results on KMMLU (Korean Massive Multi-task Language Understanding)[3].

3 KMMLU (Korean Massive Multi-task Language Understanding): A test set designed to evaluate an AI model's general knowledge and language comprehension through a variety of Korean-language questions. It is used to compare the Korean-language performance of various models, including OpenAI's GPT series, HyperCLOVA, and KoAlpaca

KMMLU is a Korean-language benchmark that evaluates a model's general knowledge and language understanding across diverse domains; it is used to compare the Korean performance of models such as OpenAI's GPT series, HyperCLOVA, and KoAlpaca. The country is not focused solely on ultra-large models; it also maintains strong competitiveness in on-device (edge) AI and industry-specific optimization.

While LLM-centric AI has surged thanks to the relative ease of collecting text data, the real world is multimodal—far beyond what text alone can capture—so R&D must reflect that reality. Because text data are easy to obtain, today's AI has advanced rapidly around LLMs—especially ultra-large LLMs—but a text-centric approach has inherent limits given that the real world includes images, video, audio, and touch. For AI to understand complex real-world situations and operate in physical environments, multimodal data processing and a grounded understanding of the physical world are essential; accordingly, "Physical AI" is emerging as a core next-generation technology. Understanding and acting in the physical world remains an open challenge; representative examples include Prof. Fei-Fei Li's founding of World Labs and Jensen Huang's emphasis on Physical AI at CES 2025.



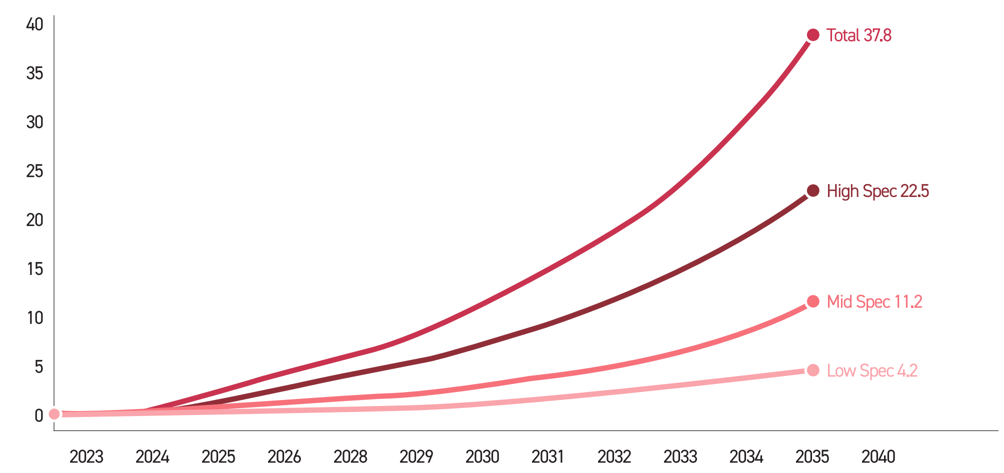
(Source: 174th Wednesday Forum presentation materials)

[Figure 5] AI's Evolution and Current State

2.4 Humanoid Robots

Humanoid robots are emerging as a key response to labor shortages caused by a declining working-age population. Expectations for commercialization and mass production are rising. Yet despite this, their development in South Korea has stagnated, fueling a growing sense of urgency. Aging demographics and low birth rates are creating severe labor shortages in core sectors such as manufacturing and logistics. As a remedy, humanoid robots—capable of boosting productivity, efficiency, and safety through automation—are drawing increasing attention. Major players in the U.S. and China—including Tesla, Figure AI, and Agility Robotics in the U.S., and Unitree, Fourier Intelligence, and Xiaomi in China—are unveiling humanoid robots with new capabilities and leading the push toward commercialization. In South Korea, humanoid-robot R&D remains fragmented, with a handful of labs, companies, and universities pursuing small, independent projects, characterized by an emphasis on prior-generation robots. As a result, a technology gap persists relative to global frontrunners.

Against this backdrop, humanoid robots that combine AI and robotics are entering the commercialization phase across manufacturing, logistics, and services. Goldman Sachs projects that the humanoid-robot market will grow to approximately $16.99 billion by 2028 (₩ KRW 22 trillion) and $37.8 billion by 2035 (₩ KRW 50 trillion).

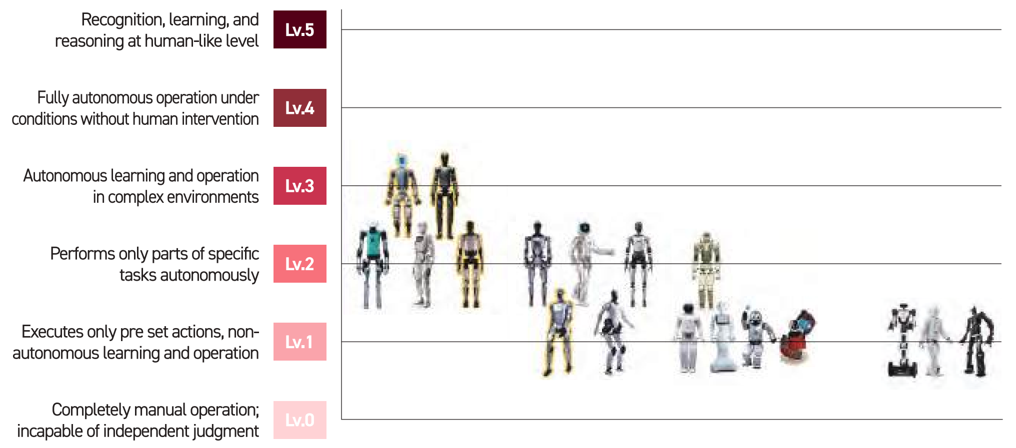


(Source: Goldman Sachs (2024))

[Figure 6] Humanoid-robot market outlook

Major countries, including the United States and China, are making early, aggressive investments to secure technology leadership and first-mover advantages. Recent advances from Tesla's Optimus, Figure AI, Sanctuary AI, Apptronik, and Agility Robotics are intensifying global competition. In South Korea, the humanoid-robot market remains in a nascent stage. It is expected to evolve from a focus on mobile robots toward humanoid robots, and leading companies—Samsung, Hyundai Motor Group, LG, Doosan Robotics, and Hanwha Robotics—are entering the market.

Note: South Korea's technology gap relative to the United States is approximately 2.5 years in service-robot technologies and approximately 3 years in disaster-response/extreme-environment exploration and smart-manufacturing robotics.



(Source: 174th "Wednesday Forum" presentation materials)

[Figure 7] Global humanoid-robot technology levels

As AI-powered humanoid robotics advances rapidly, the related applications are expanding quickly across both industrial and everyday settings. Progress in vision-language-action (VLA) models is greatly enhancing robots' ability to perceive their environment, act autonomously, and interact with humans. Major corporations are making strategic investments to secure leadership in the global market. The fusion of AI and robotics technologies has dramatically improved humanoid robots' perception, reasoning, and action capabilities. Advances in natural language processing (NLP), computer vision, and reinforcement learning (RL) are enabling more natural and human-like interactions. In addition, the integration of large-scale AI models (LLMs) with robotic control technologies (locomotion) is strengthening robots' ability to perform complex physical tasks.

That said, numerous issues remain that require improvement—securing the safety and reliability of humanoid robots, reducing dependence on expensive core components and software sourced from overseas, addressing privacy and ethical concerns, and expanding social acceptance alongside still-insufficient legal and ethical guidelines. Because humanoid robots interact closely with people, securing physical safety and technical reliability is essential. As operational errors or malfunctions could cause harm to people and property, advanced testing and certification frameworks are required. Most core components—such as sensors, actuators, and high-performance control chips—and AI-based software are sourced from abroad, creating supply-chain risks and technological dependence. Domestic production and independent technology development are required to mitigate these vulnerabilities.

Humanoid robots collect and process personal data through various sensors, including cameras and microphones, which can heighten ethical concerns such as privacy violations and fears of a surveillance society. Tailored regulations and technical safeguards that reflect personal-information protection laws and AI ethics standards are required. It is necessary to address social resistance and anxiety about robots sharing everyday spaces with humans. There is an urgent need to establish legal liability for robot use, incident-response protocols in the event of accidents, and standards for ethical deployment.

3. Implications and Recommendations

3.1 Autonomous Manufacturing

To quickly strengthen national manufacturing competitiveness, there is an urgent need to establish a "One-Team" technology development and utilization strategy—grounded in interoperability and inter-compatibility—that enables customized AI-driven manufacturing innovation within a common platform. As technologies for collaborative and service robots have advanced and a wider variety of products has come to market, there are now more solutions that can be readily applied on the shop floor than in the past. However, platform heterogeneity across industries, domains, and functions has become a bottleneck to rapid, seamless deployment and diffusion. To address this, foundational strategies should be established from the R&D stage, accounting for technology, industry dynamics, standards, and policies for deployment and diffusion.

Because there are practical difficulties with data sharing and use when it comes to applying AI in manufacturing settings, institutional support is needed to overcome these. With respect to data sharing, it is necessary to build a data-utilization framework that prevents data leakage while promoting autonomous use, taking Germany's public–private "Catena-X" model—widely regarded as a successful example—as a reference.

3.2 AI Semiconductors

While South Korea is world-class in memory semiconductors, it is still generally regarded as being at an early stage in system (logic) semiconductors—particularly AI chips. In system-semiconductor areas such as GPU and MPU (microprocessor unit) development, insufficient software capabilities and weak collaboration frameworks are frequently cited as core challenges. Accordingly, much closer integration between the software and semiconductor industries has become an urgent priority, making national-level support and strategic investment essential.

To preserve South Korea's commanding lead in HBM (high-bandwidth memory), sustained technological advancement and pre-competitive (early-stage) R&D are essential. In parallel, this effort must be accompanied by government-led strategic investment and infrastructure support to strengthen the manufacturing base for AI chips—specifically, leading-edge (advanced-node) process technologies and advanced packaging capabilities.

Advanced packaging remains a nascent segment with a relatively weak domestic base; bold investment and the cultivation of specialized talent are needed to secure capabilities. In particular, proactive R&D in materials, parts, and equipment (MPE) is critical to achieving self-reliance in packaging technologies. AI-chip technology development should be pursued through a co-development framework with downstream customers, advancing demand-driven innovation. At the manufacturing stage, an industrial ecosystem that enables seamless collaboration between semiconductor manufacturers and materials, parts, and equipment (MPE) suppliers needs to be built. To that end, strategic public–private collaboration and supportive policy measures are essential.

3.3 AI Software

AI technologies, including large language models (LLMs), need to move beyond text and into the physical world; to that end, securing diverse data modalities and developing new training methods are both critical. Especially if the goal is AGI (artificial general intelligence), rather than simply throwing more resources at the problem, it is essential to formulate efficient strategies and secure multimodal datasets—and to pursue an innovation agenda that enables these aims.

Because AGI goes beyond mere technical progress and is directly tied to national technological primacy, strategic goal-setting at the national level is required.

AGI—defined as AI with human-level or greater intelligence—must be designated a top-priority national strategy essential to national survival and competitiveness. This calls for large-scale government-led strategic investment, ambitious public–private collaboration models, and the establishment of a public–private resource-sharing framework to secure high-performance infrastructure (data and compute). In addition, real-world application of AI requires research that goes beyond text to integrate sensors, vision, robotics, and other inputs; a government-led multimodal AI research hub and the expansion of demonstration projects are needed.

3.4 Humanoid Robots

To accelerate technology development and diffusion, it is essential to establish an enabling environment in which robots can interact naturally with people across industry and in everyday life. To that end, close collaboration should begin at the earliest stages of developing core components—such as semiconductors—and a demand-driven R&D strategy is needed to bridge the gap between industry and research.

To shift to an AI-driven robotics strategy, advanced robot-control systems and manufacturing-based real-world demonstration capacity are essential. This requires an integrated, whole-of-government strategy. For a software-centric shift, efforts must go beyond basic robot control, and leverage Vision-Language Models (VLMs), Vision-Language-Action (VLA) models, and Large Language Models (LLMs) to build a robot foundation model—either through in-house LLM development or by integrating with global, open-source LLMs. By leveraging its strong manufacturing base, South Korea can gain a competitive edge in the real-world demonstration phase. Converting major production lines at relevant firms into humanoid-robot demonstration testbeds would help generate real-world evidence of adoption and productivity gains on the factory floor. To realize this strategy, the relevant ministries need to collaborate to establish a comprehensive technology roadmap that integrates robotics, AI, semiconductors, and telecommunications, and to designate "AI humanoid robots" as a next-generation national strategic industry. They also need to pursue sustained medium- to long-term investments, and implement industry-nurturing policies.

PART 2

External Opinion

KISTEP R&D and BEYOND

1 An Overview of APEC Regional Cooperation in Digital and Artificial Intelligence (AI) Policies

Sangyirl Nam, Research Fellow Emeritus, KISDI

1. Introduction: Expectations and Uncertainties of Digital and Artificial Intelligence-Driven Transformation

The rapid and extensive deployment of digital transformation (DX) and artificial intelligence-driven transformation (AIX) is reshaping our industries, economic activities, and all aspects of daily lives. These changes stemming from new technologies bring expectations of potential opportunities through innovation, but also raise challenges and concerns such as cybersecurity; the need to establish digital and artificial intelligence governance that is people-centered, inclusive, and trustworthy; and the need to respond to increasing uncertainties. From an economic perspective, however, the key considerations must be balanced between costs and benefits regarding the development of emerging digital technologies. That is, the costs involved in the process—such as the substantial investment required for their development and utilization, and uncertainties—and the potential benefits that can be gained as a result, such as opportunities for innovation. However, the latter is often emphasized more than the former, which is also a common phenomenon during periods of technological transition.

Meanwhile, humankind faces global challenges including climate change, natural disasters, environmental degradation, public health threats, demographic changes (aging populations and low birth rates), and widening socio-economic disparities, etc. Accordingly, the need for multilateral and regional cooperation to address global challenges is higher than ever, and such cooperation can leverage innovation utilizing emerging digital technologies, particularly artificial intelligence (AI). Given the Asia-Pacific region's unique dynamism and the diversity of its subregions and consisting countries, it is imperative to strengthen cooperation by identifying current issues, common interests, priorities, and sharing policy experiences and best practices.

Against this background, this paper is to overview the trends and implications of discussions on policy cooperation in digital and artificial intelligence in the Asia-Pacific region, focusing on the activities of APEC and the Telecommunications and Information Working Group (TELWG).

2. Policy Cooperation on Digital and AI-Driven Transformation in the Asia-Pacific Region

Recent advances in digital transformation and AI-driven transformation should be understood not simply as matters of software or technology, but as comprehensive systemic phenomena. In other words, to pursue digital transformation and AI-driven transformation, it is necessary to build a comprehensive ecosystem encompassing infrastructure (networks, computing resources, etc.), technology, industry, research and development (R&D) foundations, digital data, human capacity, a trustworthy environment, and a supportive regulatory framework, etc. Major countries are indeed establishing comprehensive national AI promotion strategies and strengthening their implementation. For example, Korea announced its "National Strategy of Artificial Intelligence-Toward an AI World Leader Beyond IT" in December 2019 (refer to Government of the Republic of Korea (2019)). This national strategy was jointly developed with all ministries, including the Ministry of Science and ICT (MSIT), and set nine strategies and one hundred detailed measures across three major AI fields, targeting implementation by 2030. Subsequently, Korea presented a new vision, "Leap to the Top Three in AI through the AI Grand Transformation (AX) (2022)," aiming to solidify the existing strategy, and reorganized and enhanced related government organizations (refer to [Box 1] and Ministry of Science and ICT (2025)).

[Box 1] Key Points of Korea's National Strategy of Artificial Intelligence (December 2019) and related government reorganization

(1) Creating an AI innovation ecosystem for global leadership	- Enhancing AI infrastructure, including data and computing resources - Securing a competitive edge in AI technology, semiconductor industry, and R&D - Establishing a supportive regulatory framework - Creating an innovative ecosystem by globalizing AI startups
(2) Maximizing AI utilization	- Cultivating AI experts - Establishing AI education programs for everyone - Spreading AI technology across all industrial sectors - Establishing a next-generation intelligent government
(3) Realizing people-centered AI	- Establishing a safety net for an inclusive labor market - Preventing the negative impacts of AI - Establishing an AI ethics framework

(Source: Government of the Republic of Korea (2019), "National Strategy of Artificial Intelligence- Toward AI World Leader Beyond IT," GPRN 11-1721000-000393-01)

At the same time, in line with changes to the government organization related to AI policy, the position of Senior Secretary for Science and Technology in the Presidential Secretariat was changed in June 2025 into the Senior Secretary for AI Future Planning, with an expanded scope of responsibility that includes AI and future planning in June 2025. In addition, theThe Ministry of Science and ICT will be elevated to a deputy prime minister-level ministry to oversee science, technology, and artificial intelligence (AI) policy. The existing AI policy division (Director-General for AI-Based Policy), previously at the bureau level, will be expanded and reinforced to become the Office of Artificial Intelligence Policy (under which the following offices will be established: Director-General for AI Policy Planning, Director-General for AI Infrastructure Policy, and eight divisions covering overall and specialized areas). Furthermore, with the launch of the Ministerial Meeting on Science, Technology, and Artificial Intelligence as a collaborative platform for planning and sharing national agendas related to these areas, cross-ministerial policy leadership is expected to be further strengthened.

(Source: Ministry of Science and ICT press release, "Launch of Deputy Prime Minister System Overseeing Science, Technology, and AI," announced on September 30, 2025)

In Asia-Pacific cooperation, sharing relevant information and policy experiences is crucial, along with stakeholder participation. That is, to promote innovation and effectively address global challenges, it is essential to build a trustworthy and people-centered digital and artificial intelligence technology ecosystem. Ultimately, this must lead to inclusive DX and AIX that enables all stakeholders and people in the Asia-Pacific region to participate, adapt, and reap the benefits. For example, in terms of government policy, this includes forwardlooking and guiding roles, particularly concerning resource allocation and investment; participation through the creativity and entrepreneurship of the private corporate sector; and the cultivation of digital and AI capacities for individuals' adaptation and utilization. Furthermore, it is crucial to perform and share analyses and outlooks regarding the current status, progress trends, and use cases related to DX and AIX advancement, along with policy instruments, policy experiences, and assessments, to foster collaboration.

2.1 Overview of APEC

The Asia-Pacific Economic Cooperation (APEC) was launched in 1989 by major Pacific Rim countries with the vision of "Building an Asia-Pacific Community," aiming to ultimately establish an Asia-Pacific Community through trade and investment liberalization and facilitation (TILF). During this period, the global trade environment was under the post-World War II multilateral trade system. The Uruguay Round (September 1986–April 1994), the eighth major trade liberalization negotiation under the General Agreement on Tariffs and Trade (GATT), was struggling to make progress toward a conclusion. Regionalism was spreading, with preferential and exclusive regional trade agreements (RTAs) or free trade agreements (FTAs) being established among some regions or a few countries. In this situation, APEC promoted economic and technical cooperation (ECOTECH) among its diverse member economies while pursuing trade and investment liberalization and facilitation through voluntary, non-binding, and consensus-building principles. It advocated open regionalism, declaring its intention of sharing such achievements with non-member economies as well. Furthermore, while APEC is an intergovernmental policy forum, it recognizes the role of business activities in regional integration. Consequently, it has established the APEC Business Advisory Council (ABAC, 1995) and promotes dialogue with the APEC Economic Leaders, emphasizing business cooperation. Through these activities, APEC consistently pursues its ultimate vision of building an Asia-Pacific community.

Korea played a leading role in launching APEC alongside Australia and others, and in 1991 brought about the simultaneous accession to APEC of China, Hong Kong, and Chinese Taipei. APEC operated as a Senior Official-Level and Ministerial-Level Dialogue from 1989 to 1992. Since 1993, it has held the annual APEC Economic Leaders' Meetings (AELMs), presenting a vision through strategic discussions on Asia-Pacific and global issues. For example, at the 1994 APEC Summit (Bogor, Indonesia), it supported the successful launch of the WTO multilateral trading system and established the Bogor Goals, seeking to achieve trade and investment liberalization and openness by 2010 for developed economies and by 2020 for developing economies. Furthermore, at the 2020 AELM (held by Malaysia via videoconference due to the spread of the COVID-19 Pandemic), APEC assessed its progress, including a final review toward achieving the Bogor Goals, and announced a new vision for building an open, dynamic, resilient, and peaceful Asia-Pacific Community by 2040 (APEC Putrajaya Vision 2040) (refer to APEC (2020)-2).

As an economic cooperation body, APEC maintains a minimal administrative secretariat in Singapore. The 21 member economies take turns serving as the host economy as well as the Chair of the AELM for a one-year term, during which time they are responsible for setting the theme and priorities for that year. APEC operates through a discussion process that progresses through sectoral working group meetings (and sectoral ministerial meetings), senior officials' meetings, joint ministerial meetings (foreign affairs and trade), and the AELM, as well as over 30 diverse sectoral working groups/fora and 19 specialized APEC centers. The outcomes of discussions and agreements are compiled and manifested in the adoption of the APEC Economic Leaders' Declaration each year. The directions from the leaders are then disseminated downward for implementation and further discussion, creating a bi-directional cycle. Korea served as the chair of AELM in 2005 and 2025, hosting the AELMs in Busan and Gyeongju, respectively (refer to APEC (2025)-1).

Currently, APEC encompasses 21 member economies along the Pacific Rim, effectively including the world's major economies outside Europe. The 21 APEC member economies are Korea (Republic of), Japan, China, Chinese Taipei, Hong Kong, the Philippines, Brunei, Indonesia, Singapore, Malaysia, Thailand, Vietnam, Australia, New Zealand, Papua New Guinea, Canada, the United States, Mexico, Peru, Chile, and the Russian Federation. Since simultaneously admitting the three Chinas—China, Chinese Taipei, and Hong Kong—APEC has used the term "member economies" instead of "member countries," and as a rule, does not use national flags and the terms "country" or "nation."

2.2 Activities of the APEC Telecommunications and Information Working Group (TELWG)

APEC's cooperation in ICT and the digital economy is centered around the Telecommunications and Information Working Group (TELWG), established in 1990, and the Telecommunications and Information Ministerial Meeting (TELMIN). The primary objectives of the APEC TELWG include the development of information and communications infrastructure and services in the Asia-Pacific region, fostering cooperation in information sharing, and facilitating the development of effective ICT policies and regulations. The TELWG also aims to further promote socio-economic development through the effective use of ICT and to promote a safe and reliable ICT environment. In more specific terms, the TELWG aims to ensure that everyone in the Asia-Pacific region has affordable access to ICT and the Internet, recognizing that broadband connectivity is an essential element, and ultimately strives to build the Asia-Pacific Information Society (APIS). In addition, as an intergovernmental policy forum, APEC operates primarily by sharing policy experiences and information, such as best practices and regulatory policy updates, among government ministries and ICT regulatory agencies. APEC has three operational groups for specific sectors: the ICT Development and Policy Steering Group (DPSG), the ICT Security and Trust Steering Group (STSG), and the ICT Conformity Assessment and Interoperability Steering Group (CISG) (refer to APEC (2025)-2).

TELWG establishes a Strategic Action Plan every five years and pursues cooperation through discussions and the implementation of related projects based on this plan. The current TELWG Strategic Action Plan 2021-2025 prioritizes responding to the rapid advancement of new digital technologies in the ICT sector, including artificial intelligence (AI), 5G, big data, and the Internet of Things (IoT). Furthermore, based on the experience of responding to the COVID-19 Pandemic, it is emphasized that capacity building is crucial to ensure Internet connectivity for everyone in the Asia-Pacific region and enable them to benefit from the Internet and the digital economy. More specifically, it identifies four priority areas: (1) ICT infrastructure and connectivity, (2) Reliable, secure, and resilient ICT, (3) ICT policies and regulations enabling innovation, economic integration, and inclusiveness, and (4) ICT and application cooperation, including contributions to the sustainability of the digital economy through the implementation of the APEC Internet and Digital Economy Roadmap (AIDER) adopted in 2017 (refer to APEC TELWG (2020)).

Discussions and cooperation in the TELWG are primarily conducted through proposed projects (APEC projects). In its early stage, TELWG projects, classified by theme, were focused on building telecommunications infrastructure, interoperability, and improving accessibility. Since around 2017 with the adoption of the AIDER, the trend has shifted significantly toward government policy, regulation, measurement and innovation of the digital economy, fostering digital ecosystems, and related cooperation. APEC also places a significant emphasis on cross-fora collaboration with relevant APEC fora. Regarding e-commerce, APEC established the Electronic Commerce Steering Group (ECSG) in 1998, recognizing the leading role of private enterprises and industry sectors. In 2017, APEC adopted the APEC Internet and Digital Economy Roadmap (AIDER) and restructured the ECSG into the Digital Economy Steering Group (DESG) as a forum overseeing AIDER implementation. The DESG, together with TELWG, was primarily tasked with implementing AIDER. Accordingly, TELWG and DESG hold two meetings annually: the DESG-TELWG Joint Meeting for AIDER implementation and the Public-Private Partnership Dialogue involving the private sector.

The APEC Mutual Recognition Arrangement for Conformity Assessment of Telecommunications Equipment (TEL MRA) is one of TELWG's key cooperative achievements. This is a way for APEC member economies to conclude bilateral agreements, based on a framework for the Mutual Recognition Arrangement for Conformity Assessment of Telecommunications Equipment (MRA-CA or MRA Phase 1, 1998) and the Mutual Recognition Arrangement for Equivalence of Technical Requirements (MRA-ETR or MRA Phase 2, 2010). As of September 2024, 15 out of 21 current APEC member economies participate in the TEL MRA, except China, Papua New Guinea, Peru, the Philippines, Russia, and Thailand. For MRA Phase 1, 62 arrangements have been concluded among the 15 member economies; for MRA Phase 2, 18 arrangements have been concluded among 8 member economies. These arrangements are currently valid and utilized (refer to APEC (2025)-3).

2.3 APEC Policy Cooperation on the Digital Economy and AI

Discussions on the digital economy and AI policy cooperation can be observed across a few periods through APEC's annual themes, priority initiatives, and Leaders' Declarations.

First, the period from APEC's inception in 1989 through 1996 was the phase of establishing the overall framework for APEC's advancement. During this period, the following major advances occurred: the 1993 Seattle Leaders' Declaration (Blake Island, Seattle, USA) agreed to deepen the spirit of community based on a shared vision of stability, security, and prosperity; the 1994 Bogor Declaration (Bogor, Indonesia) established the Bogor Goals for trade and investment liberalization; the 1995 Osaka Action Agenda (OAA; Osaka, Japan) declared entry into the implementation phase through three pillars (trade and investment liberalization, facilitation, and economic and technical cooperation); and the 1996 Manila Action Plan for APEC (MAPA; Manila, the Philippines) specified implementation measures through Collective Action Plans (CAPs) and Individual Action Plans (IAPs) for each sector. During this period, TELWG was launched in 1990, and the First Telecommunications Ministers' Meeting (TELMIN 1) was held in Seoul in 1995, at which the Seoul Declaration for the Asia Pacific Information Infrastructure was adopted to promote cooperation in building the Asia Pacific Information Infrastructure (APII) (refer to APEC (1995)).

Second, the period from 1997 to 2007 represented the phase of comprehensive discussions and cooperation on electronic commerce. During this period, comprehensive attention was drawn to trade, innovation, creativity, protection of intellectual property rights (IPR), and ICT cooperation, based on changes in emerging technologies involving various concepts such as the new economy, the knowledge-based economy and society, and the digital economy, stemming from electronic commerce.

Third, the period from 2008 to 2016 was marked by more concrete discussions on prosperity and cooperation through the digital economy. Emphases were given to promoting ICT utilization and innovation, addressing e-commerce-related standards compliance and technical barriers to trade (TBT), strengthening intellectual property rights protection, supporting an environment of accessibility, openness, interoperability, reliability, and security for ICT as a key means to promote Asia-Pacific integration, and cooperation to realize the potential of economic growth based on the digital economy and innovation.

Fourth, the period from 2017 to the present is a time of cooperation in digital transformation (DX) and AI-driven transformation (AIX). This period is also an era of cooperation in utilizing potential opportunities and addressing global challenges, considering the systemic characteristics of DX and AIX and their extensive and rapid progress. Key achievements during this period include the adoption of the APEC Internet and Digital Economy Roadmap (AIDER) in 2017, which emphasizes eleven key focus areas (KFAs) for promoting the Internet and digital economy, and contributes to achieving the 2030 Sustainable Development Goals (SDGs); and adopting cooperative initiatives for leveraging and innovating emerging digital technologies to address global challenges such as climate change, demographic shifts, and the COVID-19 Pandemic public health crisis (refer to [Box 2], APEC (2017), and APEC (2020)-1).

[Box 2] APEC Internet and Digital Economy Roadmap (AIDER), 11 Key Focus Areas (KFAs)

1. Developing digital infrastructure
2. Promoting interoperability
3. Achieving universal broadband access
4. Developing a framework for holistic government policies for the Internet and digital economy
5. Promoting and cooperating on regulatory coherence for the Internet and digital economy
6. Promoting the adoption of innovation and enabling technologies and services
7. Promoting trust and security in ICT utilization
8. Promoting the free flow of information and data while respecting applicable domestic laws and regulations
9. Improving measurement standards for the Internet and digital economy
10. Enhancing the inclusiveness of the Internet and digital economy
11. Promoting e-commerce and enhancing cooperation on digital trade

(Source: APEC (2017). "APEC Internet and Digital Economy Roadmap," 2017/ Agenda Item: 3. https://www.apec.org/docs/default-source/groups/ecsg/17_csom_006.pdf

In practice, APEC has established and pursued progressive shared goals for development and cooperation around ICT and the digital economy among its member economies. Key aspects of this effort include the following.

First, at the First Telecommunications and Information Ministerial Meeting (TELMIN 1; Seoul, Korea) in 1995, APEC agreed to strengthen cooperation for the development and improvement of information and communications infrastructure in the Asia-Pacific region through the Seoul Declaration for the Asia-Pacific Information Infrastructure (APII), and to thereby make the information and communications sector a model area for achieving the Bogor Goals (1994).

At the 2000 AELM (Brunei), the Brunei Goals were set with the goal of achieving universal Internet access in the Asia-Pacific region by 2010, and it was decided to triple regional Internet access by 2005 to achieve the goals.

At the 7th Telecommunications and Information Ministerial Meeting (TELMIN 7; Bangkok, Thailand) in 2008, noting that the Brunei goal of tripling Internet access within the Asia-Pacific region had been achieved, it pledged further to achieve universal access to broadband by 2015.

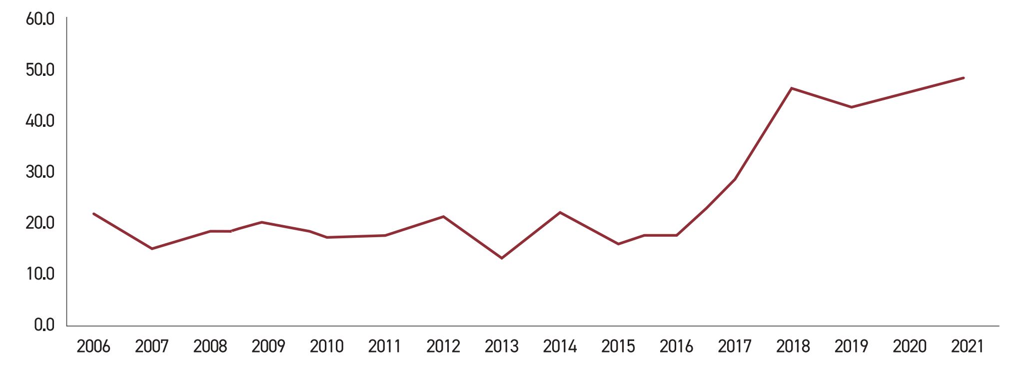
At the 8th Telecommunications and Information Ministerial Meeting (TELMIN 8; Okinawa, Japan) in 2010, the ambitious goal was set of achieving access to next-generation high-speed broadband by 2020 to support the growth of the knowledge-based economy in the Asia-Pacific region.

The 2017 AELM focused on the importance of promoting the Internet and digital economy, and welcomed the adoption of the APEC Internet and Digital Economy Roadmap (AIDER). The Telecommunications and Information Working Group is taking the lead in drafting this roadmap, as well as in its subsequent implementation.

At the 2020 AELM (held by Malaysia via videoconference due to the spread of the COVID-19 Pandemic), the Bogor Goals—achieving trade and investment liberalization and openness by 2010 for developed economies and by 2020 for developing economies—were succeeded by the APEC Putrajaya Vision 2040: to build an open, dynamic, resilient, and peaceful Asia-Pacific Community by 2040 for the prosperity of all people and future generations in the Asia-Pacific region. The new vision places a particular emphasis on the role of the digital economy, new technologies, and innovation, encompassing: (1) A free, open, fair, non-discriminatory, transparent, and predictable trade and investment environment; (2) Participation in an inclusive economy through the digital economy and technology; (3) Innovation and inclusive sustainability for the recovery from the COVID-19 Pandemic; and (4) Increased stakeholder participation, including the private sector, regional and international organizations.

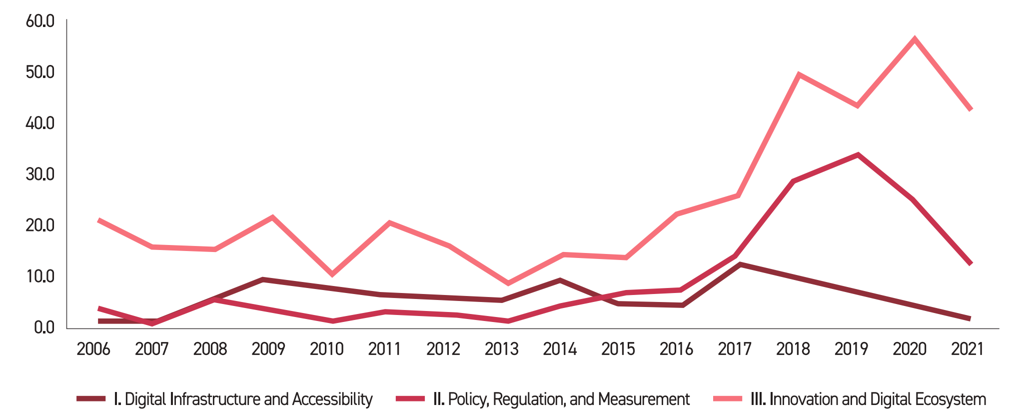
In addition, to address the global challenges posed by the spread of the COVID-19 Pandemic in 2020, the Telecommunications and Information Working Group swiftly adopted the "APEC TEL Initiative on Global Challenges Utilizing ICT: COVID-19 Pandemic and Beyond," demonstrating its commitment to relevant cooperation.

Meanwhile, an examination of trends in APEC cooperation projects reveals that around the time of the adoption of the 2017 APEC Internet and Digital Economy Roadmap, the proportion of APEC projects that include the key terms of the eleven Key Focus Areas (KFAs) of the roadmap has significantly increased across all APEC fora. Furthermore, a shift has emerged in the composition of sub-categories with the advancement of digital convergence and digital transformation, around the time of the adoption of the 2017 APEC Internet and Digital Economy Roadmap. That is, compared to Group 1 (ICT and Digital Infrastructure and Accessibility), the proportion of cooperative projects related to Group 2 (Government Policy, Regulation, and Measurement) and Group 3 (Innovation and Digital Ecosystem) has increased significantly (refer to [Figure 1] and [Figure 2])



Source: Prepared by the author based on data from the APEC project database

[Figure 1] Share of Projects Including Key Terms from the APEC Internet and Digital Economy Roadmap (2006–November 2021, %)



Source: Prepared by the author based on data from the APEC project database

[Figure 2] Number of projects related to the APEC Internet and Digital Economy Roadmap by key term classification (2006–November 2021, %)

2.4 Discussions on Cooperation at APEC 2025

In 2025, as the host economy of APEC, Korea played a leading role in cooperation related to DX and AIX. Korea hosted the first-ever APEC Digital and AI Ministerial Meeting, replacing the Telecommunications and Information Ministerial Meeting (TELMIN) which had not been held in the past decade (since 2015). This meeting discussed relevant cooperation under the theme "Digital and AI Transformation Toward Prosperity and Sustainable Growth for All," and was structured into three sessions: (1) Innovation, (2) Connectivity, and (3) Safety.

The Ministerial Statement on AI and Digital Cooperation, which outlines a shared vision, includes key elements such as promoting future-oriented innovation, fostering human capacity across society and industry, and encouraging investment to build a robust AI infrastructure.

The key elements were adopted as the APEC AI Initiative (2026-2030), a major outcome of the 2025 APEC Economic Leaders' Meeting (refer to [Box 3] and APEC (2025)-4).

The APEC AI Initiative includes three strategic objectives and associated priority cooperation activities: (1) Advancing successful AI transformation within the APEC region, (2) Building AI capabilities at all levels, and (3) Fostering an investment ecosystem for sound AI infrastructure development. Progress on its implementation will be reviewed annually at the DESG-TELWG joint meeting, with a final review scheduled for 2030. This initiative has particular significance as it encompasses APEC member economies with diverse perspectives, laying the groundwork for AI policy cooperation within the Asia-Pacific region and toward building consensus.

[Box 3] Strategic Goals and Key Collaborative Activities of the APEC AI Initiative (2026-2030)

(1) Progress toward a successful AI transition within the APEC region
- Voluntary review
- Cooperation among stakeholders
- Policy exchange
- Safe and reliable transition

(2) AI capacity building at all levels
- Public sector capacity
- Private sector capacity
- Worker capacity
- Consumer capacity and trust
- Regional cooperation on capacity building

(3) Nurturing an investment ecosystem for robust AI infrastructure
- Public policy
- Private sector
- Cooperation on investment

(Source: https://www.apec.org/meeting-papers/leaders-declarations/2025/2025-apec-leaders—gyeongju-declaration/apec-artificial-intelligence-(ai)-initiative-(2026-2030)

3. Strengthening Policy Cooperation on Digital and AI in APEC

To enhance policy cooperation on digital and AI in the Asia-Pacific region, above all, priority areas and approaches for cooperation should be explored, considering the diversity and shared interests of APEC member economies. Key areas of interest set as primary goals by most member economies include building ICT and digital infrastructure, digital inclusion and bridging the digital divide, human capacity building, and creating employment and innovation. These can become fundamental priorities for cooperation. Cyber trust and security, facilitating data mobility, and spectrum allocation and management are key enablers supporting these major goals and should also be given high priority for cooperation. In addition, areas in which progress may face challenges include the Mutual Recognition Arrangement for Conformity Assessment of Telecommunications Equipment (MRA-CA), cooperation on standards, and collaboration on digital technologies (e.g., technology choice, Open RAN, technological hegemony competition), which require ongoing discussion and cooperation. Beyond these, horizontal issues across APEC (e.g., addressing socio-economic disparity, SMEs, women, and global challenges) could become new priority areas for discussion and cooperation on efficient solutions leveraging digital technologies.

Given the conditions within APEC and the Asia-Pacific region, the following points should be considered for strengthening cooperation.

First, realistic expectations are needed, including discussions and progressive goal-setting for cooperation that aligns with APEC's characteristics. As a regional cooperative body, APEC pursues voluntary participation and non-binding implementation centered on comprehensive intergovernmental policy cooperation. For this reason, sharing best policy practices and information serves as the primary method of cooperation. Recognizing the important role that business activities play in regional integration, APEC also focuses on facilitating business within the region ("APEC means business").

Second, considering APEC's discussion and cooperation framework, procedural linkages must be strengthened. A cyclical, bi-directional framework involving both bottom-up and top-down approaches should be considered, including from APEC's sectoral fora (and sectoral ministerial meetings), senior officials' meetings, joint ministerial meetings (foreign affairs and trade), and all the way to the AELMs, alongside the role of high-level (sectoral ministerial-level) meetings. The Telecommunications and Information Ministerial Meeting (TELMIN) was held approximately every 2-3 years, a total of 10 times between 1995 and 2015. After a 10-year absence, it returned in 2025 as the Digital and AI Ministers' Meeting. Sectoral ministerial meetings serve as a crucial link connecting working group meetings and the AELMs. For instance, compared to sectors in which ministerial meetings are held annually (such as Finance, SMEWG, Trade, WEF, etc.), sectors without such meetings inevitably deal with weaker momentum in securing budget and personnel allocation priorities, as well as a weaker link for reflecting their agendas at the AELMs. If there are material and time constraints that make it difficult to hold high-level meetings more frequently or annually, virtual or hybrid (online and in-person) meetings should be actively considered. This approach can reduce material burdens and allow a greater focus to be placed on identifying and discussing cooperation agendas, boosting momentum.

Third, given the systemic nature of digital and AI issues, cooperation must be strengthened through joint meetings with relevant APEC fora and the promotion of joint projects. Considering the objectives and priority areas of the TELWG, potential candidates for priority cooperation fora include: the Digital Economy Steering Group (DESG), the Small and Medium Enterprises Working Group (SMEWG), the Business Mobility Group, the Sub-Committee on Standards and Conformance (SCSC), the APEC Business Advisory Council (ABAC), the Intellectual Property Experts Group (IPEG), the Human Resources Development Working Group (HRDWG), the Policy Partnership on Science, Technology and Innovation (PPSTI), and the Policy Partnership on Women and the Economy (PPWE), etc.

Fourth, considering the dynamism, creativity, and innovative role of the private industrial sectors, it is necessary to increase their participation in APEC discussions for cooperation. This could be achieved by regularizing public-private partnership (PPP) dialogues, or by facilitating the participation of stakeholder groups (e.g., ABAC, APNIC (Asia Pacific Network Information Center), ICC (International Chamber of Commerce), ISOC (Internet Society), and PECC (Pacific Economic Cooperation Council)). For this purpose, it is necessary to identify key issues and cooperation needs within the Asia-Pacific business sector and explore objectives and methods for collaboration. Furthermore, related initiatives could be pursued, such as conducting relevant analyses (e.g., economic impact assessments) and statistical analysis and measurement for evidence-based policy development and cooperation. Efforts can also be pursued to develop specialized agreement documents that will serve as the basis for ICT and digital economy cooperation (e.g., AIDER (2017), APEC Framework for Securing the Digital Economy (2019), APEC TEL Initiative on Global Challenges (2020)), and to establish or expand funds for project support (e.g., the Digital Innovation Fund).

Fifth, it is necessary to utilize and link existing initiatives related to Asia-Pacific regional cooperation (including Specialized APEC Centers). Various existing projects within APEC and the Asia-Pacific region should be linked and utilized, while avoiding duplication. Additionally, discussions and strengthened linkages are required regarding cooperation in the digital economy and AI sectors within frameworks such as Korea-ASEAN, PECC, G20, OECD, and IPEF (Indo-Pacific Economic Framework).

4. Summary and Implications: Cooperation to Address the Uncertainties and Build Trust

Based on the discussions thus far, the following implications can be outlined around enhancing digital and AI policy cooperation within APEC and the Asia-Pacific region going forward.

First, the Asia-Pacific region, and more specifically APEC, is facing opportunities and global challenges arising from digital transformation and the emerging AI-driven transformation. In this context, governments within the Asia-Pacific region, APEC member economies, and businesses must strengthen their cooperation to reduce the related uncertainties, build trust through dialogue, and share best practices on relevant information and policies for the pursuit of common interests. Above all, it is essential to build trust in APEC's dynamism and the value of open regionalism, as well as to define roles and expectations that align with APEC's unique characteristics. Sharing diverse perspectives and policy experiences provides a sound foundation for cooperation. In this regard, I would like to propose establishing an APEC Policy and Data Repository on DX and AIX at the Asia-Pacific or APEC level.

Second, expectations and cooperation must be based on the characteristics of the Asia-Pacific region and APEC, including its dynamism and diversity. In particular, APEC primarily shares policy experiences and establishes comprehensive common goals, seeking non-binding cooperation, capacity building, and horizontal and vertical dialogue and cooperation among various forums. Key areas of focus and issues for APEC include trade and investment liberalization, economic and technical cooperation, leveraging opportunities from digital transformation and AI-based transformation, responding to global challenges, and achieving people-centered, inclusive prosperity. However, diverse opinions have recently emerged among some member economies regarding issues such as climate change, inclusiveness, disparities, and gender equality. The most important priority must be enhancing mutual understanding and building people-centered trust at the Asia-Pacific and APEC levels. Greater cooperation is required to jointly respond to the structural changes, global challenges, and increasing uncertainties we face. Technology and institutions must exist and be utilized for people's prosperity. I would like to propose working together to avoid creating unnecessary institutional and artificial barriers that undermine Asia-Pacific cooperation, without any legitimate objectives of public policy.

Third, to effectively address the current global challenges, a comprehensive and systematic approach is required, in addition to cooperation in utilizing digital and emerging AI technologies. For example, within APEC, this involves horizontal cooperation among various sectoral fora, innovation utilizing digital and AI technologies, and vertically, strengthening continuous momentum through a bottom-up and top-down approach involving from Working Groups (Sectoral Ministerial Meetings), Senior Officials' Meetings, Joint Ministerial Meetings, and all the way to the APEC Economic Leaders' Meetings. In this regard, it is worth noting the four cooperation measures proposed in the “APEC TEL Initiative on Global Challenges Utilizing ICT: COVID-19 Pandemic and Beyond (2020)” drafted and adopted during my chairmanship of the TELWG. These include: (1) Sharing information and best policy practices, (2) Enhancing APEC's external cooperation and cooperation within the Asia-Pacific region, (3) Increasing the utilization of emerging digital technologies to meet global challenges, and (4) Building on the experience of utilizing emerging digital technologies during the COVID-19 response to strengthen preparedness for future global challenges.

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2 Current Status of Multilateral Cooperation in Export Control and Korea's Cooperation Strategy

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1. Overview

The concept of export controls originated from the need to block the outflow of weapons and strategic items to enemy states during World War I (1914–1918) and World War II (1939–1945) and the Cold War era.

Export controls in the traditional sense began with wartime economic controls restricting trade, investment, and financial transactions with enemy states during wartime; one prominent example is the U.S. Trading with the Enemy Act (TWEA) of 1917, during World War I. During World War II and the early Cold War era, the primary purpose of export controls was security-centered items control to prevent the export of traditional munitions such as weapons and ammunition, as well as certain strategic items, to hostile nations.

One example, COCOM (Coordinating Committee for Multilateral Export Controls), launched in 1949, was a system in which the U.S., NATO allies, Japan, and Australia jointly controlled exports to prevent strategic items from reaching the communist bloc countries, including the Soviet Union and China. Since trade itself was limited at the time due to bloc separation, it was possible to comprehensively decouple a relatively wide range of items.

However, with the dissolution of the Soviet Union in 1991 and the end of the Cold War, COCOM was disbanded in 1994, and functional multilateral export control regimes were established: the Wassenaar Arrangement (hereinafter "WA", conventional arms control), the Missile Technology Control Regime (hereinafter "MTCR", missile technology control), the Australia Group (hereinafter "AG", chemical and biological weapons control), and the Nuclear Suppliers Group (hereinafter "NSG", nuclear weapons control).

In other words, the international export control system can be broadly divided into four areas covering nuclear weapons, chemical and biological weapons, missiles, conventional weapons, and dual-use items used for the development and manufacturing of such weapons; it continuously updates control lists and operating guidelines through member consensus and shares information on denials of export licenses among members to preemptively block transactions of related items aimed to circumvent controls. Items and technologies subject to control by each regime are determined through agreement procedures among member states.

Korea systematically ensures its compliance with the relevant international norms, joining the NSG in 1995, the AG and WA in 1996, and the MTCR in 2001.

2. Items and Technologies Subject to Control

As of 2025, the number of items agreed upon as control targets in international export control regimes is approximately 1,800, most of which are civil-military dual-use items (about 80%), and the main items Korea exports include semiconductor chips, semiconductor manufacturing equipment, secondary cells, machine tools, carbon fibers, valves, and encryption equipment. Recently, emerging technologies such as quantum computers, AI chips, 3D printers, cryogenic refrigerators, amplifiers, and isotopes for quantum computers have been added to the control list, indicating that export controls on advanced technologies are becoming full-scale.

[Table 1] International Export Control Regimes and Domestic Status (as of 2025)

Regime Name	Field	Established (Korea Joined)	Member States	Licensing Authority
Wassenaar Arrangement (WA)	Conventional Weapons	1996 (1996)	42 countries	Dual-use → MOTIE / Military → DAPA
Australia Group (AG)	Chemical/ Biological Weapons	1985 (1996)	43 countries	MOTIE
Missile Technology Control Regime (MTCR)	Missiles	1987 (2001)	35 countries	
Nuclear Suppliers Group (NSG)	Nuclear Weapons	1978 (1995)	48 countries	Dual-use → MOTIE / Nuclear-exclusive → NSSC

[Table 2] Domestic Status of Strategic Items by Technology Field Based on the Foreign Trade Act (as of 2025)

Category			Major Items/Technologies
Annex 2	Category 1	Materials, Chemicals, Microorganisms & Toxins	Carbon fiber, maraging steel, nickel alloys, precursors, pathogens, etc.
Dual-Use Items	Category 2	Materials Processing	Machine tools, dimensional inspection machines, centrifuges, 3D printers, etc.
	Category 3	Electronics	Integrated circuits for communications, AI chips, etching equipment, lithography equipment, cryogenic refrigerators, amplifiers, EUV masks, etc.
	Category 4	Computers	Supercomputers, quantum computers, etc.
	Category 5	Telecommunications and Information Security	Routers, optical fibers, jamming devices, encryption equipment, etc.
	Category 6	Sensors and Lasers	GPS, high-speed cameras, optical sensors, high-power lasers, etc.
	Category 7	Navigation and Avionics	Accelerometers, gyroscopes, satellite navigation systems, etc.
	Category 8	Marine	Submersibles, underwater robots, underwater cameras, etc.
	Category 9	Aerospace and Propulsion	Gas turbine engines, launch vehicles, space vehicles, etc.
	Category 10	Nuclear	Nuclear reactors, fuel rods, steam generators, valves, pressure gauges, etc.
	Subtotal		-
Annex 3	Military Items	Military Items	Rifles, ammunition, bombs, tanks, armored vehicles, naval vessels, fighter jets, etc.

In addition, even for exports of non-strategic items (general goods) that have a high possibility of being diverted for weapons manufacturing or development, a catch-all license equivalent to an export license is required.

Notably, following the Russia-Ukraine war in 2022, general industrial items (1,402 items in 2024) such as ships, passenger cars, general machinery, and electronic components have been designated as items subject to catch-all controls to coordinate sanctions against Russia and Belarus. In addition, 25 items, including vibration test equipment and stainless steel pipes, are designated as items subject to catch-all controls for Iran, Syria, and Pakistan.

3. Characteristics by International Export Control Regime

Details of the international export control regimes mentioned above, classified by regime, are as follows.

3.1 WA Regime

The WA regime was established in 1996 to succeed COCOM, which was responsible for export controls against the communist bloc during the Cold War, to control conventional weapons and dual-use items that can be used to manufacture or develop them. Member states aim to contribute to world peace and regional security by preventing the illegal accumulation of related items and technologies through strengthening transparency and responsibility in transactions of conventional weapons exported from their countries abroad and dual-use items and technologies that can be diverted for their manufacture and development.

After the end of World War II, the Coordinating Committee for Multilateral Export Controls (COCOM) was established in 1949, centered on member states of the North Atlantic Treaty Organization (NATO), to prevent the transfer of advanced Western technologies to the communist bloc. Subsequently, as the Cold War era ended in the early 1990s, it was recognized that the existing system could no longer serve as the basis for export controls, and the need to introduce a new regime to replace it arose. Accordingly, at the High Level Meeting (HLM) held in The Hague, Netherlands, on November 16, 1993, the 17 member states dissolved COCOM and established a temporary multilateral control regime named the "New Forum." This decision was reaffirmed at the High Level Meeting (HLM) held in Wassenaar, Netherlands, from March 29–30, 1994, and COCOM was dissolved on March 31, 1994. The member states established three working groups with the goal of launching a new regime as soon as possible; Group 1 was responsible for developing the objectives, principles, and procedures of the new regime, Group 2 for developing the list of controlled items and technologies, and Group 3 for overall administrative duties. Russia, the Czech Republic, Hungary, Poland, and Slovakia participated as member states in the High Level Meeting (HLM) held in Wassenaar, Netherlands, from September 11–12, 1995, and the meeting urged the working groups to expedite their tasks. Finally, the WA agreement was concluded at the High Level Meeting (HLM) held in Wassenaar, Netherlands, on December 19, 1995, and member states released a Final Declaration announcing the establishment of the WA at the Peace Palace in The Hague, Netherlands. The Final Declaration included an agreement to establish a secretariat in Vienna, Austria, and to form a Preparatory Committee for the inaugural plenary meeting.

Final Declaration

1. Representatives of Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States met in Wassenaar, the Netherlands, on December 18 and 19, 1995.
2. The representatives agreed to establish "The Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies."
3. The representatives agreed to establish the Initial Elements of the Wassenaar Arrangement and to submit them to their respective governments for approval.
4. The representatives also agreed to form a Preparatory Committee for the Plenary scheduled for January 1996.
5. The representatives agreed to locate the Secretariat of the Wassenaar Arrangement in Vienna, Austria. The first Plenary is scheduled to be held on April 2 and 3, 1996.

[Figure 1] WA Final Declaration (December 19, 1995)

The inaugural Plenary was held in Vienna, Austria, from April 2–3, 1996, and Argentina and Romania, along with Korea, were included as additional founding members. The inaugural Plenary did not reach a final agreement on the agenda items, and the meeting was adjourned to allow time for resolving issues.

The next Plenary was held from July 11–12, 1996, and involved a total of 33 founding member states (Argentina, Australia, Austria, Belgium, Bulgaria, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Republic of Korea, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom, and the United States), including new members Bulgaria and Ukraine; at this meeting, the final consensus on the Initial Elements contained in the WA Basic Documents was adopted. It was decided that the new control lists and information exchange would be implemented starting November 1, 1996.

The Plenary is held at least once a year, with the chairmanship rotating annually as stipulated in the Initial Elements, and meetings are held in accordance with the guidelines. In the founding year of 1996, the second WA Plenary was held from December 12–13, 1996, and since then it has generally been held once a year. As of December 2025, the following 42 member states are participating in the Wassenaar Arrangement.

[Table 3] Status of Wassenaar Arrangement (WA) Member States(As of Dec. 2025)

No.	Country Name	Accession Year
1	Argentina	1996
2	Australia	
3	Austria	
4	Belgium	
5	Bulgaria	
6	Canada	
7	Czech Republic	
8	Denmark	
9	Finland	
10	France	
11	Germany	
12	Greece	
13	Hungary	
14	Ireland	
15	Italy	
16	Japan	
17	Luxembourg	
18	Netherlands	
19	New Zealand	
20	Norway	
21	Poland	
22	Portugal	1996
23	Republic of Korea	
24	Romania	
25	Russia	
26	Slovakia	
27	Spain	
28	Sweden	
29	Switzerland	
30	Turkey	
31	Ukraine	
32	United Kingdom	
33	United States	
34	Slovenia	2004
35	Croatia	2005
36	Estonia	
37	Latvia	
38	Lithuania	
39	Malta	
40	South Africa	2006
41	Mexico	2012
42	India	2017

The purpose of the establishment of the Wassenaar Arrangement (WA) was first declared in the Initial Elements at the inaugural Plenary held July 11–12, 1996, and was specially amended at the Plenary held December 6–7, 2001. The purposes of its establishment, as declared in the Initial Elements, are as follows.

1. The Wassenaar Arrangement has been established in order to contribute to regional and international security and stability, by promoting transparency and greater responsibility in transfers of conventional arms and dual-use goods and technologies, thus preventing destabilizing accumulations. Participating States will seek, through their national policies, to ensure that transfers of these items do not contribute to the development or enhancement of military capabilities which undermine these goals, and are not diverted to support such capabilities.

2. This Arrangement will complement and reinforce, without duplication, the existing control regimes for weapons of mass destruction and their delivery systems, as well as other international groups promoting transparency and greater responsibility, by focusing on the threats to international and regional peace and security which may arise from transfers of armaments and sensitive dual-use goods and technologies where the risks are judged to be the greatest.

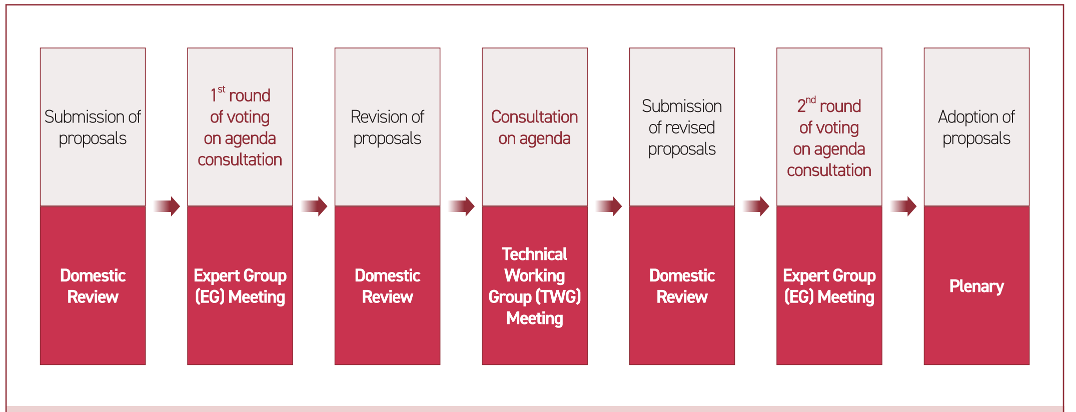
3. This Arrangement is also intended to enhance cooperation to prevent the acquisition of armaments and sensitive dual-use items for military end-uses, if the behavior of a state is, or becomes, a cause for serious concern to the Participating States.

4. This Arrangement is not directed against any state or group of states and will not impede bona fide civil transactions, nor will it interfere with the rights of states to acquire legitimate means with which to defend themselves pursuant to Article 51 of the Charter of the United Nations.

5. In accordance with the above, Participating States will continue to prevent the acquisition of conventional arms and dual-use goods and technologies by terrorist groups and organisations, as well as by individual terrorists. Such efforts are an integral part of the global fight against terrorism.

The WA controls dual-use items across industries, in addition to military items, on a limited basis using technical parameters and thresholds, while actively permitting bona fide civil transactions. It also observes a kind of "foreign availability" practice whereby control standards are relaxed if a non-member state acquires specific technology, and there is no "no undercut" obligation to respect other members' denial decisions, which is a characteristic distinct from the three regimes controlling Weapons of Mass Destruction (WMD) and related dual-use items: NSG, AG, and MTCR.

Currently, there are 42 member states in the WA, and China and Taiwan are not members. Member states have continuously strived to prevent countries of concern or terrorist organizations from acquiring conventional weapons and related dual-use items and technologies, and have endeavored in particular to ensure that the development of advanced weapons and industrial technologies is not diverted in ways that may undermine international peace and regional security by revising the list of controlled items and technologies annually. However, following Japan's export restrictions on Korean semiconductors in 2019 and the intensification of US-China technological hegemony competition in 2022, as well as Russia's subsequent invasion of Ukraine, a limitation of the regime has been revealed, in that the sole opposition of a specific country can prevent existing regulations from being amended at all. This can be evaluated as a kind of inflection point in the history of export control, and various attempts to overcome the problems of this regime are continuing, centered on the United States and others.



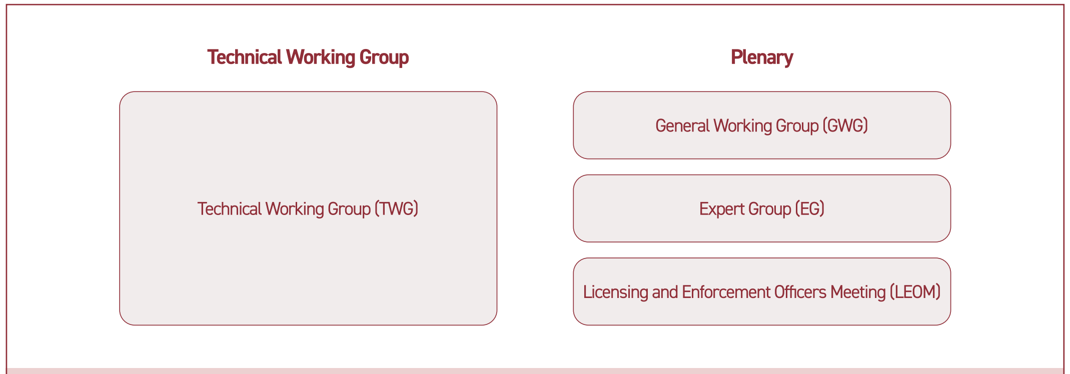
[Figure 2] Basic Procedure for WA Agenda Response

The WA consists of the Expert Group (EG) Meeting, the Technical Working Group (TWG) Meeting, the Licensing and Enforcement Officers Meeting (LEOM), the General Working Group (GWG) Meeting, and the Plenary; the EG Meeting is held twice a year (April, September) to review members' proposals on revising the control lists and determine whether to adopt them based on consensus. The TWG Meeting is held once a year (June) to discuss in depth, in a free format, issues that became controversial in the EG Meeting. The Licensing and Enforcement Officers Meeting (LEOM) is held once a year (June), at which presentations and opinion sharing take place on the topics of license review, enforcement, outreach, licensing exceptions, license review procedures, classification of strategic items, IT systems, catch-all controls, end-user management, and post-shipment verification. The GWG Meeting is held twice per year (May, October) to share the latest country-specific trends and exchange information related to controls, licensing, and enforcement. The Plenary meets once a year to finalize agreements from each sub-meeting and decide on other operational matters; it performs tasks such as updating best practices related to controls, licensing, and enforcement, discussing new member admissions, revising control lists, and reporting and approving the budget and business plan for the following year.

WA member states must maintain an effective export control system based on their technological development level and experience, and reflect the control lists agreed upon in the regime in their national laws. Through the exchange and review of information among member states, they can develop common elements of understanding regarding the risks associated with the transfer of arms and dual-use items and the scope of their national export control policies in response to these risks.

Specific information exchange requirements of the WA include semi-annual notifications of arms transfers. Arms subject to notification include items within the seven categories registered as conventional arms at the UN. Member states must also report notifications of transfers or denials of transfers of certain controlled items. Notifications of denials can alert member states to avoid transfer activities contrary to the purposes of the Wassenaar Arrangement. Information exchanged through the Wassenaar Arrangement may include various information relevant to the purposes of the Wassenaar Arrangement intended to alert individual member states.

Representatives of member states hold regular meetings at the Secretariat located in Vienna, Austria. Decisions within this regime are made based on the principle of consensus. The Wassenaar Arrangement is open on a global basis and non-discriminatory to adherents that comply with the agreed standards. A state wishing to join this regime must be ① a producer or exporter of arms or industrial equipment, and ② capable of implementing effective export control systems through appropriate policies while faithfully implementing international non-proliferation regimes and treaties.



[Figure 3] Composition of WA Meetings

The WA has two pillars: one related to arms and the other related to dual-use items. Both pillars have control lists and possess different guidelines regarding controls, information exchange, and review.

The WA Dual-Use List is divided into three item categories according to sensitivity: the Basic List, the Sensitive List, and the Very Sensitive List. In addition, dual-use items have nine categories: Materials, Materials Processing, Electronics, Computers, Telecommunications and Information Security, Sensors and Lasers, Navigation and Avionics, Marine, and Aerospace and Propulsion.

The WA Munitions List was originally composed of ① tanks, ② armored combat vehicles, ③ large-caliber artillery systems, ④ combat aircraft, ⑤ attack helicopters, ⑥ warships, and ⑦ missiles or missile systems, following the categories of the UN Register of Conventional Arms (UNRCA); however, it was decided at the 2003 Plenary to include small arms and light weapons, and currently consists of 22 items capable of manufacturing 8 types of weapons.

[Table 4] Wassenaar Arrangement (WA) Control List

Classification		Item
Dual-Use	Category 1 Special Materials and Related Equipment	Metal alloys such as aluminum pipes and titanium tubes, tungsten powder, aluminum powder, carbon fiber, etc.
List	Category 2 Materials Processing	Bearings, CNC lathes, milling machines, grinding machines, electrical discharge machines, dimensional inspection machines, robots, flow forming machines, etc.
	Category 3 Electronics	Special integrated circuits, semiconductor equipment, secondary batteries, signal analyzers, network analyzers, frequency changers, etc.
	Category 4 Computers	Supercomputers, quantum computers, optical fibers, wireless direction finders, jamming devices, intrusion detection systems, etc.
	Category 5 Part 1 Telecommunications	Telecommunications equipment, wireless video receiving equipment, switching equipment, etc.
	Category 5 Part 2 Information Security	Information security equipment, network equipment, servers, etc.
	Category 6 Sensors and Lasers	Bathymeters, acoustic transceivers, seismic survey equipment, optical sensors, thermal imaging cameras, radar systems, etc.
	Category 7 Navigation and Avionics	Accelerometers, satellite navigation systems, inertial systems, gyroscopes, vibration equipment, navigation equipment, etc.
	Category 8 Marine	Submersibles, surface vessels, underwater cameras, underwater robots, underwater observation systems, propulsion propellers, pump jets, etc.
	Category 9 Aerospace and Propulsion	Gas turbine engines, turbo engines, vibration test equipment, rocket engines, unmanned aerial vehicles, space launch vehicles, satellites, etc.
	Sensitive List	Designated for key elements among dual-use items which are directly related to the development, production, use, or enhancement of advanced conventional military capabilities

WA member states determine the scope of cooperation in domestic control policies among members by exchanging information with each other; exchanged information may include any agenda item, such as issues to which an individual member state wishes to call other states' attention or matters outside an individual member's decision-making authority. In addition, information exchange includes general information, which is information regarding risks associated with the transfer of conventional arms and dual-use goods and technologies to determine the scope of control policies among member states; major items included here relate to acquisition activities, export control policies, and suspected development projects. Regarding dual-use goods and technologies, non-member states are notified regarding decisions of denial when the denial decision is consistent with the objectives of the Arrangement; for dual-use goods and technologies (Tier 1), member states announce all denial records related to non-member states (aggregated twice a year).

Also, for sensitive items (Tier 2) and very sensitive items (included in Tier 2), member states announce all denial records on a case-by-case basis as stipulated by the Arrangement. This announcement is made in a timely manner, within 30 days (maximum 60 days) from the date of denial. In addition, member states must aggregate and announce licenses or transfers for sensitive items in accordance with the Arrangement twice a year.

Regarding information exchange in the arms sector, member states agreed to announce delivery records every six months. Furthermore, WA member states should endeavor to apply the following 'Best Practices Guidelines and Procedures' to their national export control decision-making processes.

- "Elements for Objective Analysis and Advice Concerning Potentially Demobilizing Accumulations of Conventional Weapons" adopted at the 1998 Plenary
- "Statement of Understanding on Intangible Transfers of Software and Technology" adopted at the 2001 Plenary
- "Best Practices Guidelines for Exports of Small Arms and Light Weapons (SALW)" adopted at the 2002 Plenary
- "Elements for Export Controls of Man-Portable Air Defense Systems (MANPADS)" adopted at the 2003 Plenary
- "Statement of Understanding on Control of Non-Listed Dual-Use Items" adopted at the 2003 Plenary

3.2 NSG Regime

The absence of an international nuclear export control regime on the 'peaceful use of nuclear energy' has long been raised as an issue of export control. Accordingly, following U.S. President Eisenhower's speech at the 8th UN General Assembly in 1953, negotiations for the creation of the International Atomic Energy Agency (IAEA) began with the interest of several countries, and the IAEA was formally established in 1957. With the establishment of the IAEA, only the proliferation of nuclear technology and nuclear material for peaceful purposes was permitted, and to accomplish this, implementation of agreements on safeguards and assurances by nuclear item exporters and importers was required. States that signed the Nuclear Non-Proliferation Treaty (NPT)[1], which entered into force in 1970, agreed not to provide (a) source or special fissionable material or (b) equipment or material especially designed or prepared for the processing, use, or production of special fissionable material, to any non-nuclear-weapon state unless it was subject to IAEA safeguards. In other words, it demanded the application of safeguards and export controls as a means of ensuring nuclear non-proliferation. However, the NPT did not define the specific details of nuclear materials or equipment and materials, which made it difficult to select items subject to export control. As a result, some parties to the NPT formed the NPT Exporters Committee based on Article III, Paragraph 2 of the NPT in 1971 to clarify this issue, which came to be called the Zangger Committee (ZC) after its first chairman, Professor Claude Zangger of Switzerland. Subsequently, in 1974, the Zangger Committee defined control items related to the processing, use, or production of nuclear material based on the IAEA Statute, etc., which came to be called the Trigger List[2]. In May 1974, India succeeded in its first nuclear test in Rajasthan, claiming it was for peaceful purposes. The nuclear weapons test by India once again increased concerns about nuclear proliferation, leading to a close examination of export management of nuclear items by nuclear suppliers. Along with this examination, the first meeting was held in London in 1975, and by 1977, the 'London Club' (which later became the Nuclear Suppliers Group (NSG)), a group of major nuclear suppliers at the time, was formed. During this period, the London Club discussed ways to strengthen nuclear-related export controls and subsequently published the "London Guidelines" (which later became NSG Part I), guidelines on nuclear transfers. In early 1976, the seven initial participating countries of the Nuclear Suppliers Group (US, USSR, UK, France, Germany, Japan, Canada) agreed to the first "Guidelines on Nuclear Transfers," including criteria for export control and physical protection of nuclear-related sensitive items, and reached an agreement through further discussions with eight countries that joined later (Belgium, Czechoslovakia, Germany, Italy, Netherlands, Poland, Sweden, Switzerland). Subsequently, this content was published as IAEA document INFCIRC/254 in January 1978, including not only the Trigger List of the Zangger Committee but also control requirements for IAEA safeguards and re-transfers regarding the production and peaceful use of heavy water. Meanwhile, the nuclear-exclusive items defined by the Zangger Committee were modified and supplemented for about 13 years after 1977 and were published as IAEA document INFCIRC/209/Rev 1 in late 1990, containing definitions and details of nuclear-exclusive items. After publishing the relevant guidelines in 1978, the Nuclear Suppliers Group, an extension of the London Club, entered a period of inactivity without holding a single meeting from 1978 to 1990 after its establishment, as its necessity was diluted by criticism that it was an exclusive cartel and functionally overlapped with the Zangger Committee and COCOM[3]. However, during the inactive period, many countries began nuclear power generation and developed the capability to produce nuclear material and equipment, which meant that the number of NSG participating countries increased from 15 in 1978 to 27 in 1990. Meanwhile, the Gulf War, which began with Iraq's invasion of Kuwait on August 2, 1990, involved a multinational force of 34 countries, including the U.S., the U.K., and France, deployed against Iraq. Due to the Gulf War, Iraq imported large-scale materials, equipment, and technology, materials which

1 Nuclear Non-Proliferation Treaty (NPT): An international treaty that prohibits non-nuclear-weapon states from possessing nuclear weapons or nuclear-weapon states from transferring them to non-nuclear-weapon states.

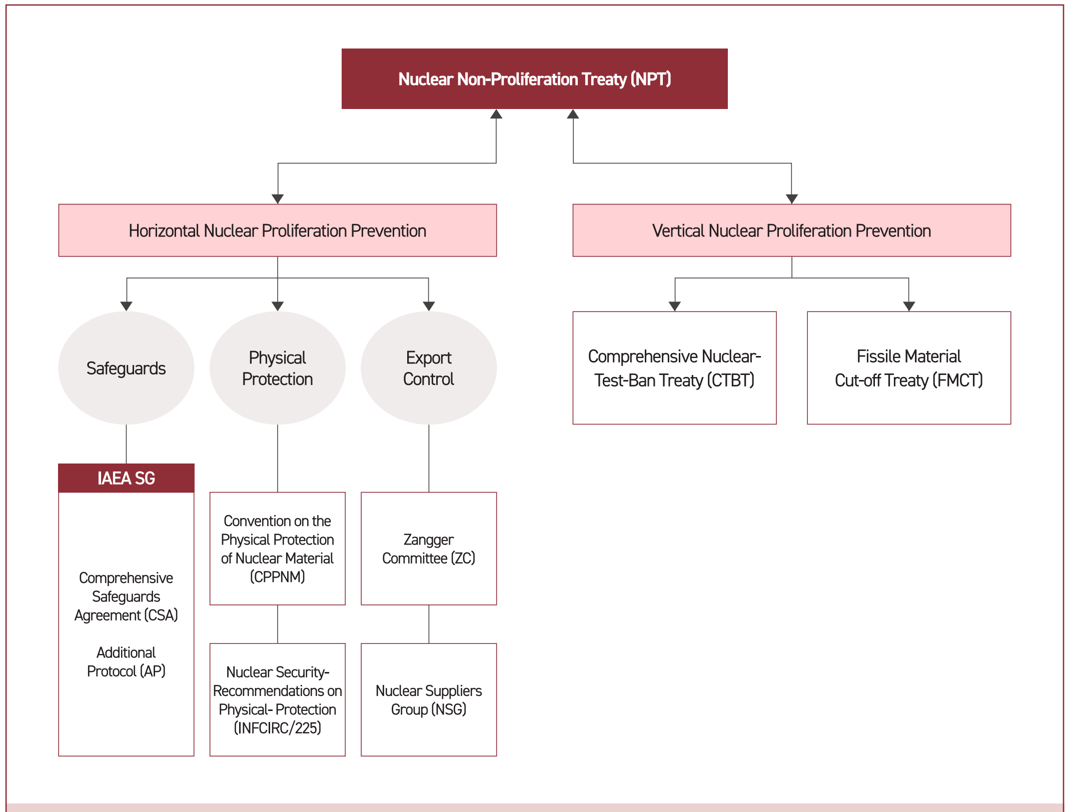
2 Refer to original text for nuclear-exclusive items, http://zanggercommittee.org/publications

3 Coordinating Committee for Multilateral Export Controls (COCOM): Enforced economic sanctions against communist countries by the Western bloc for the first five years of the Cold War after the end of World War II. After the collapse of the Soviet Union, the role of COCOM diminished, and its functions were suspended as of March 31, 1994.

could indirectly contribute to the development of nuclear weapons. These materials were procured through various methods, including concealment of end-users, transshipment through third countries, and secret procurement; when the scale of Iraq's nuclear development program was revealed after the First Gulf War, the need for fundamental control and blocking of nuclear development resulting from war was raised in earnest. Subsequently, after 13 years of inactivity, the Nuclear Suppliers Group recalled the cooperative spirit of the Nuclear Suppliers Group and the unified action and sense of purpose regarding export controls through a meeting held in The Hague in March 1991. Afterwards, the Nuclear Suppliers Group added guidelines and items controlling the export of nuclear-related dual-use materials, equipment, and technology to the existing export control items limited to nuclear items, and required IAEA full-scope safeguards for these items as well. This agenda was officially adopted by 27 member states at the Plenary held in Warsaw a year later. These guidelines specify that suppliers shall not transfer items included in the guidelines when they are to be used for nuclear explosive activities or unsafeguarded nuclear fuel cycle activities, or when there is a risk of such use or diversion; subsequently, the guidelines and item list were published through the IAEA as INFCIRC/254/REV 1/Part 2, new guidelines for dual-use items. In 1993, IAEA safeguards for all nuclear activities were applied in accordance with the new guidelines of the Nuclear Suppliers Group. Subsequently, in 1994, the guidelines for dual-use items of the Nuclear Suppliers Group were expanded. In 2002, the Nuclear Suppliers Group announced its recommendation that greater efforts be made to control and block terrorists in response to the 9/11 attacks, and subsequently in 2004 agreed to adopt the so-called "catch-all control" to block access by foreign companies suspected of participating in nuclear weapons development programs for items not included in the guidelines. Currently, the international nuclear non-proliferation regime aims to prevent horizontal and vertical nuclear proliferation with the Nuclear Non-Proliferation Treaty (NPT) as a main pillar. To prevent vertical nuclear proliferation, in addition to the NPT, the Comprehensive Nuclear-Test-Ban Treaty (CTBT)[4] and the Fissile Material Cut-off Treaty (FMCT)[5] have been implemented, while safeguards, physical protection, and export controls are in place as means to prevent horizontal nuclear proliferation. Safeguards to prevent horizontal nuclear proliferation are being applied under the leadership of the IAEA together with Comprehensive Safeguards Agreements (CSA) and the Additional Protocol (AP), and physical protection is carried out based on the Convention on Physical Protection of Nuclear Material (CPPNM) and INFCIRC/225, the IAEA's physical protection recommendations.

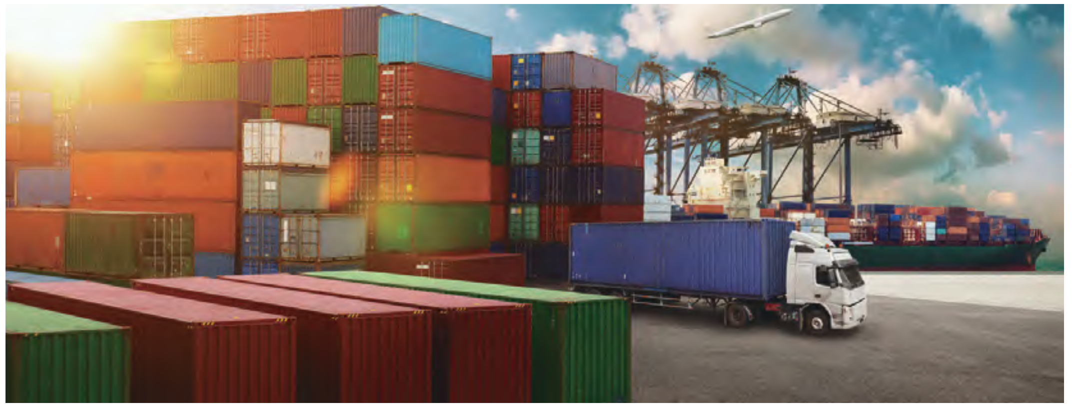
4 Comprehensive Nuclear-Test-Ban Treaty (CTBT): An international nuclear non-proliferation treaty that bans all types of nuclear tests in all environments, including the atmosphere, outer space, underwater, and underground. Adopted by the UN General Assembly in 1996, it has been ratified by 36 of the 44 Annex 2 states (whose ratification is required for its entry into force); as of 2021, it has not yet entered into force.

5 Fissile Material Cut-off Treaty (FMCT): A treaty proposed by U.S. President Clinton in 1993 to ban the production of plutonium and uranium for nuclear weapons or nuclear explosive devices. As of 2021, negotiations are underway on specific details for the progress of the FMCT.



[Figure 4] Structure of Nuclear Non-Proliferatio Treaty (NPT)

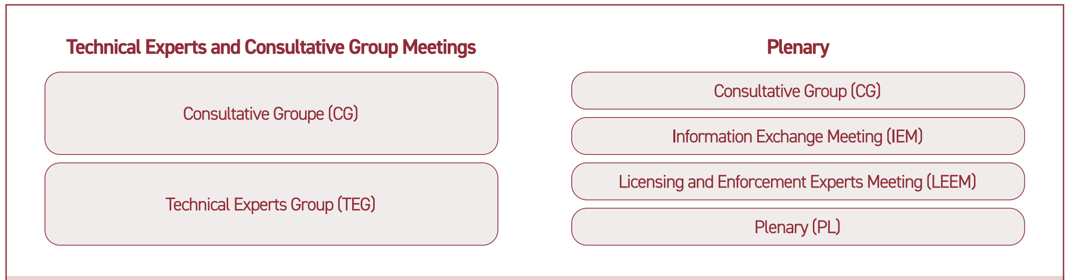
Meanwhile, in the area of export controls, nuclear-exclusive and dual-use items and technologies are controlled under the leadership of the Zangger Committee and the Nuclear Suppliers Group, and import and export controls are applied in close cooperation with the IAEA. As of 2021, 48 countries participate in the Nuclear Suppliers Group, and its role as a mediator and export control tool is emphasized in various areas such as the spread of multilateral trade networks, the increasing role of non-state actors in illicit procurement and nuclear weapons proliferation, opportunistic export policies of suppliers, and international nuclear weapon equity issues.



[Table 5] Status of Nuclear Suppliers Group (NSG) Member States (As of Dec. 2025)

No.	Country Name	Accession Year
1	Germany	1974
2	Russia	
3	United States	
4	United Kingdom	
5	Japan	
6	Canada	
7	France	
8	Netherlands	1978
9	Belgium	
10	Sweden	
11	Switzerland	
12	Italy	
13	Czech Republic	
14	Slovakia	
15	Poland	
16	Australia	
17	Finland	1980
18	Greece	1984
19	Denmark	
20	Luxembourg	
21	Bulgaria	
22	Ireland	
23	Hungary	1985
24	Portugal	1986
25	Spain	1988
26	Norway	1989
27	Romania	1990
28	Austria	1991
29	New Zealand	1994
30	Argentina	
31	South Africa	1995
32	Republic of Korea	
33	Brazil	1996
34	Ukraine	
35	Latvia	1997
36	Cyprus	2000
37	Turkey	
38	Belarus	
39	Slovenia	
40	Kazakhstan	2002
41	Lithuania	2004
42	Malta	
43	Estonia	
44	China	
45	Croatia	2005
46	Iceland	2009
47	Mexico	2012
48	Serbia	2013

The main purposes of the NSG are to ① prevent nuclear trade for peaceful purposes from contributing to the proliferation of nuclear weapons or nuclear explosive devices, ② ensure that international trade and cooperation in the nuclear field are not hindered in the process, and ③ ensure that obligations to facilitate peaceful nuclear cooperation are implemented in a manner consistent with international nuclear non-proliferation norms, through the specification of the Trigger List of the Zangger Committee and nuclear-related export control guidelines under the leadership of countries capable of supplying nuclear-related equipment. It is a multilateral informal consultative body for the non-proliferation of nuclear weapons and nuclear explosive devices by export controlling nuclear materials and items (nuclear material, reactors and auxiliary equipment, non-nuclear material for reactors, enrichment facilities, etc.) and technologies. NSG member states continuously discuss export control lists regarding nuclear-exclusive items, dual-use items, and technologies that can be used for nuclear weapons through annual Technical Experts Group meetings, and revise them through the unanimous consensus of member states. The NSG has binding force at the level of mutual understanding and norms among member states, but does not have powers of implementation and sanctions, or provisions for enforcement and sanctions against violations. Accordingly, major NSG implementation matters are applied based on the domestic laws of member states, and each member state decides whether to grant export licenses according to its national laws and export control norms when exports related to relevant matters occur. NSG meetings are generally held three times a year and can be divided into Technical Experts Group (TEG) meetings, Consultative Group (CG) meetings, and the Plenary.



[Figure 5] Composition of NSG Meetings

For the Plenary, member states from 48 countries gather once a year under the chairmanship of the chair country to decide on NSG operational matters and elect the chair country for the next one-year term. The Plenary discusses political matters such as NSG control guidelines, procedural arrangements, outreach activities, and member accession issues, and finalizes matters agreed upon at the Consultative Group (CG) and Information Exchange Meeting (IEM). Korea hosted the Plenary twice, in Busan in 2006 and in Seoul in 2016. The Consultative Group (CG) meeting is held 2–3 times a year in Vienna under the supervision of the Point of Contact (POC), and discusses matters related to NSG guidelines and annexes during the inter-sessional period. The second half CG meeting is usually held in conjunction with the second half meeting of the Zangger Committee. The Technical Experts Group (TEG) meeting is held twice a year in Vienna under the supervision of the POC, and discusses revisions to control item criteria to reflect the latest technologies and items in the NSG control list. The Information Exchange Meeting (IEM) is held once a year during the Plenary week, and through this meeting, NSG member states exchange information related to the goals and contents of NSG guidelines, such as trends in sensitive countries and technical information. The IEM Chair submits a report including the results of the Licensing and Enforcement Experts Meeting (LEEM) to the Plenary. The Licensing and Enforcement Experts Meeting (LEEM) is held once a year during the Plenary week, sharing practical implementation and enforcement cases such as export licensing and relevant law enforcement, and discussing related matters. The LEEM is a part of the IEM, and meeting results are included in the IEM report. A characteristic of the NSG is that it includes not only the Trigger List of the Zangger Committee but also technologies necessary for the production and use of nuclear-exclusive items in the control target. Also, while the 'safeguards' required by the Zangger Committee are partial safeguards under INFCIRC/66, the NSG requires the application of IAEA full-scope safeguards as a condition for export. A notable point in NSG Part I is that it has a provision ('Guideline Paragraph 10: Non-Proliferation Principle') that restraint in exports must be exercised if there is a possibility that the export may lead to nuclear weapons proliferation, even if the requirements under the NSG guidelines are met, in order to prevent the abuse of the right of peaceful use of nuclear energy guaranteed under Article 4 of the NPT to develop nuclear weapons. Both NSG Part I and Part II require special caution regarding the transfer of equipment and technology related to enrichment and reprocessing, and when exporting dual-use items, the question of whether the importing country intends to use them for purposes related to enrichment and reprocessing is considered one of the judgment criteria. NSG Part II stipulates that in reviewing export licenses for dual-use items, exports must be denied not only when there is concern over use for nuclear weapons but also for nuclear terrorism, and nuclear non-proliferation policies, including the importing country's accession to the NPT or nuclear-weapon-free zones and past secret nuclear development, must be considered. NSG Part I targets nuclear-exclusive items (Trigger List) and consists of Guidelines, Annex A (Export Control Items), Annex B (Clarification of Strategic Items on the Trigger List), and Annex C (Criteria for Levels of Physical Protection).

Meanwhile, the export control guidelines of NSG Part I consist of 16 paragraphs, the main contents of which are as follows.

- Suppliers export controlled items upon receiving assurances from the recipient country that they will not be used for the purpose of manufacturing nuclear explosive devices
- Suppliers export controlled items only when IAEA full-scope safeguards are applied within the recipient country
- Recipient countries have an obligation to implement physical protection measures for nuclear material to prevent illicit trafficking
- Recipient countries cannot produce uranium enriched to 20% or more using facilities and technology to be transferred without the consent of the supplier
- Consent of the original supplier is required for the re-transfer of controlled items and the transfer of controlled items produced from transferred facilities, equipment, and technology
- Consent of the original supplier is also required for the export of items produced from items related to reprocessing, enrichment, and heavy water production, and the re-transfer of materials usable for weapons manufacturing or heavy water

Controlled items of NSG Part I refer to nuclear-exclusive items (material, equipment, and technology).

- Source material and special fissionable material
- Nuclear reactors and equipment therefor, and non-nuclear material for reactors
- Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor
- Plants for the separation of isotopes of uranium, and equipment, other than analytical instruments, especially designed or prepared therefor
- Plants for the production of heavy water, deuterium and deuterium compounds, and equipment especially designed or prepared therefor
- Plants for the conversion of uranium and plutonium for use in the fabrication of fuel elements and the separation of uranium isotopes, and equipment especially designed or prepared therefor

NSG Part II targets nuclear-related dual-use items and technologies and consists of Guidelines, Annex (Controlled Items), and Appendix to Annex (Detailed Specifications for Machine Tools). In addition, NSG Part II has a Memorandum of Understanding to handle matters not mentioned in the guidelines, and notably stipulates the need for notification of denial to other member states ("denial notification") and the "No-undercut Rule" which prevents other member states from transferring materials substantially identical to those for which one member state has denied export to a specific country. The purpose of NSG Part II is to control the export of specific nuclear-related equipment, materials, and related technologies that can contribute to nuclear explosive activities or unsafeguarded nuclear fuel cycle activities. NSG Part II stipulates that end-user statements and assurances that transferred items will not be used for nuclear explosive activities or unsafeguarded nuclear fuel cycle activities must be secured upon transfer. Controlled items of NSG Part II consist of a group of nuclear-related dual-use items. The Zangger Committee is an export control regime that was established to implement the obligation to prohibit the export of nuclear material and equipment without safeguards to non-nuclear-weapon states in accordance with Article III, Paragraph 2 of the Nuclear Non-Proliferation Treaty (NPT), and is officially called the NPT Exporters Committee. On the other hand, unlike the Zangger Committee established to implement Article III, Paragraph 2 of the NPT, the NSG is not directly related to specific articles of the NPT. However, the two maintain a cooperative relationship, and cooperate closely in revising the Trigger List. For the NSG, even if a country is not a party to the NPT, it can become a member state if it meets certain requirements. On the other hand, only NPT member states can join the Zangger Committee. Also, in terms of export control targets, the Zangger Committee only controls the export of nuclear-related items to non-nuclear-weapon states that are not parties to the NPT, whereas the NSG applies to all non-nuclear-weapon states regardless of whether they are parties to the NPT. The NSG has been active as an export control regime for nuclear materials, equipment, and technologies, replacing the Zangger Committee, whose activities have been relatively diminished since 1992. The NSG's biggest difference from the Zangger Committee is that it implements controls on the transfer of dual-use items and technologies. Part I of the NSG is also called the Trigger List, but its control targets are broader than the Trigger List of the Zangger Committee.

3.3 MTCR

Etymologically, a missile is a flying weapon, such as a javelin, arrow, or bullet, but in modern times, the word 'missile' means a weapon equipped with a guidance function to strike a target precisely with its own propulsion function[6]. Unlike shells fired from artillery which are aimed at a specific target, a missile has a device equivalent to human senses, nerves, and brain inside, so it achieves its function of hitting the target by continuously correcting speed and direction even after launch by commands from the ground, ships, or air or by internal devices[7]. Together with rockets and unmanned aerial vehicles (UAVs), missiles are representative asymmetric weapons, as they can be used as delivery vehicles for weapons of mass destruction such as nuclear, biological, and chemical weapons. Here, asymmetric weapons are weapons that can attack vulnerable parts with weapon systems that the enemy does not possess, thereby preventing the enemy from responding effectively[8]. Rockets, which can be said to be

6 Oxford English Dictionary (2021), Oxford University Press
7 Defense Science and Technology Dictionary (2018), Defense Agency for Technology and Quality
8 Evaluating Novel Threats to the Homeland: Unmanned Areial Vehicles and Cruise Missiles (2008), Brian A. Jackson, David R. Frelinger, Michael J. Lostumbo, Robert W. Button, Rand Cooperation

the precursor to missiles, were first developed in the 13th century, and at that time had relatively simple forms that gained acceleration by burning gunpowder, used to set fire to enemy camps or ships. They gradually developed into their modern form by the 19th century, but disappeared from the battlefield as they were pushed back by artillery in terms of range and firepower.[9] Modern missiles were used for military purposes in earnest during World War II, with Germany's V1 and V2 particularly renowned. The V1 can be considered the world's first cruise missile; it was in the form of an unmanned aerial vehicle equipped with a pulse jet engine, carrying an 850kg warhead, and was able to fly up to 250km at a speed of 640km/h using an autopilot utilizing a compass, altimeter, and timer.[10] The V2 is considered the world's first ballistic missile; it was launched vertically using a liquid-fuel rocket and its attitude was then controlled by control vanes inside the rocket nozzle. After the rocket fuel was completely exhausted, it descended in a parabolic trajectory like a shell to strike the target, capable of flying up to 320km with a maximum flight speed of 5,760km/h, ground impact speed of 3,960km/h, and maximum altitude of 90km.[11] While the V-series weapons did not have a decisive impact on the outcome of the war, it became clear that missiles would become important weapons in the future, and so the Allied forces obtained German missile-related data immediately after the war and sent researchers to their own countries to support technology development.[12] Accordingly, the Soviet Union succeeded in launching the intercontinental ballistic missile R-7 in 1957, and utilizing this, launched the world's first artificial satellites, Sputnik 1 and 2, into space. Sputnik 2 had a weight of 508kg, similar to that of early-stage nuclear weapons, and thus indirectly showed that the Soviet Union already possessed intercontinental nuclear ballistic missile technology. The United States also mobilized its national capabilities to successfully launch the artificial satellite Explorer 1 in 1958, followed by the successful launch of its SM-65 Atlas liquid-fuel ballistic missile in 1959, and eventually the launch of its Minuteman solid-fuel ballistic missile in 1962.[13] As time passed, ballistic missile and cruise missile technologies spread to countries other than great powers such as the U.S. and the Soviet Union. Recognizing the dangers arising from missile development by developing countries, the U.S., under the Reagan administration, led an agreement among the G7 countries (U.S., U.K., Germany, France, Italy, Canada, Japan) to prevent the spread of related technologies, resulting in the formation of the Missile Technology Control Regime (hereinafter MTCR) on April 16, 1987.[14] This regime started from the premise that if producers of ballistic missiles (including rockets) and cruise missiles (including UAVs) could control the export of related products and technologies, the horizontal proliferation of delivery systems for weapons of mass destruction could be prevented; subsequently, NATO and EU member states joined in 1992, Russia in 1993, and Ukraine in 1994. Korea joined as the 33rd member state in March 2001; today, a total of 35 countries are participants. Currently, the MTCR not only provides basic international standards to address the problem of proliferation of WMD delivery systems but also delivers a key organizational framework.

9 Missile Bible (2019), Lee Seung-jin, Planet Media
10 Weapons Systems for Strengthening Jointness (2015), Lee Jin-ho, Kim Jong-hyun, Kim Woo-ram, Bookorea
11 The Story of Rockets (2005), Chae Yeon-seok, Seungsan
12 Rocket Science I Rocket Propellants and Inertial Guidance (2015), Jung Gyu-su, Jiseongsa
13 Rocket Science III All About Ballistic Missiles (2015), Jung Gyu-su, Jiseongsa
14 A CHRONOLOGY OF THE MISSILE TECHNOLOGY CONTROL REGIME (1994), Deborah A. Ozga

In addition, MTCR member states established guidelines explaining in detail the general principles of the regime and the annex defining control targets at the time of establishment.

[Table 6] Status of Nuclear Suppliers Group (NSG) Member States (As of Dec. 2025)

No.	Country Name	Accession Year	No.	Country Name	Accession Year
1	United States	1987	19	Greece	1992
2	United Kingdom		20	Switzerland	
3	Germany		21	Ireland	
4	France		22	Portugal	
5	Canada		23	Argentina	1993
6	Italy		24	Iceland	
7	Japan		25	Hungary	
8	Netherlands	1990	26	South Africa	1995
9	Norway		27	Russia	
10	Denmark		28	Brazil	
11	Luxembourg		29	Turkey	1997
12	Belgium		30	Ukraine	1998
13	Spain		31	Czech Republic	
14	Australia		32	Poland	
15	New Zealand	1991	33	Republic of Korea	2001
16	Sweden		34	Bulgaria	2004
17	Austria		35	India	2016
18	Finland				

Notably, the guidelines required member states to voluntarily and independently block the export of items or technologies subject to control in the annex for dangerous uses. To this end, specific judgment guidelines such as nuclear proliferation concerns, characteristics of WMD delivery system development programs, end-use assessment methods, and relevant multilateral agreements are presented together. During that time, the MTCR played a role in delaying or stopping various types of WMD delivery system development programs by making it difficult for potential demand countries to obtain the goods or technologies needed for the development of WMD delivery systems or by condemning specific acts or programs related to the development of such items. For example, Argentina, Egypt, and Iraq abandoned their joint ballistic missile development program (Condor II), and Brazil, South Africa, Korea, and Taiwan have suspended or discontinued their missile or space launch vehicle programs. In addition, Eastern European countries such as Poland and the Czech Republic destroyed some of their ballistic missiles to join the MTCR, and the regime also hindered missile development in Libya and Syria. On the other hand, non-MTCR members such as Iran and North Korea are known to be continuously pursuing missile development programs and have been observed engaging in external exports, leading to criticism that the MTCR alone is not sufficient to block the proliferation of missile technologies.[15]

15 Report of the Panel of Experts established pursuant to resolution 1874 (2016~2018), S/2016/157, S/2017/150, S/2018/171 UN Security Council

The initial purpose of the MTCR was to reduce the risk of nuclear proliferation by placing controls on the transfer of equipment and technologies that contribute to the development of unmanned nuclear delivery systems. Therefore, export controls at the time targeted only missiles and rockets intended for nuclear weapons delivery, and as a result, the control criteria of a 500kg payload and a 300km range, which are maintained to this day, were introduced. Here, a payload of 500kg is estimated to be the minimum weight of the simplest form of nuclear warhead that could be developed initially by emerging nuclear states, and a range of 300km is estimated to signify the distance covering most of a strategic theater of conflict where a nuclear attack could be considered.[16]

As time passed, a consensus emerged that exports contributing to delivery systems for weapons of mass destruction (WMD) other than nuclear weapons, such as biological and chemical weapons, should also be controlled; accordingly, in 1993 the guidelines were revised to expand the scope of regulation so that the regime controls all delivery systems for various types of WMDs. Generally, since the specifications of warheads carrying biological and chemical weapons fall short of the 500kg payload and 300km range criteria, this change can theoretically be seen as a significant expansion of the scope of control. At the same time, a provision was added to clarify that even if a specific item is not listed in the Annex as a controlled item, if it is judged to be intended for use in the delivery of WMDs, it is subject to a strong presumption of denial for export licenses. Following the 9/11 terrorist attacks in 2001, as the risk of terrorist groups or individuals possessing WMDs increased, significant efforts were also directed toward controlling the proliferation of WMD delivery system technology by these actors. Importantly, as ballistic missiles and space launch vehicles share similar physical characteristics in many respects, technology can be diverted between them.[17] For example, if technologies such as ① warhead design and mounting technology, ② navigation and guidance device technology for delivering the warhead to the target point, and ③ ablation material design technology to reduce frictional heat upon warhead re-entry are added to space launch vehicle production technology, a ballistic missile can be produced. For this reason, contents related to space launch vehicles were also included in the MTCR regulations. Sanctions for violations of the regime's regulations depend on the domestic legislation of each member state, but export control measures among member states are harmonized through regular annual meetings, and the non-proliferation system for items and technologies related to WMD delivery systems, such as missiles, rockets, and unmanned aerial vehicles, is propagated worldwide through information sharing on countries of concern and joint outreach activities. The MTCR is an informal group of countries whose purpose is to block the risk of WMD proliferation by controlling the transfer of items and technologies related to the development of delivery systems for WMDs such as nuclear, biological, and chemical weapons. The regime operates to limit the risk of controlled items and technologies being proliferated or diverted by countries of concern and terrorist groups. The detailed guidelines of the regime serve as the basis for regulating items or technologies related to WMD delivery systems so that they are not exported to any destination outside the government's control scope. Meanwhile, export restrictions apply to all items and technologies specified in the Missile Technology Control Regime. Typically, items subject to export licensing can be broadly divided into Category I items and Category II items. Category I items include complete rocket systems (including ballistic missiles, space launch vehicles, and sounding rockets) and unmanned aerial vehicle systems (including cruise missiles, target drones, and reconnaissance drones) capable of delivering a payload of at least 500kg to a range of at least 300km, as well as their major subsystems; the principle of a strong presumption of denial applies during the export licensing process, regardless of the purpose of use. However, export licenses may exceptionally be granted if there is a guarantee from the importing government that the items will not be used for purposes other than the declared use and that the items (including replicas and derivatives) will not be transferred to a third party without permission. On the other hand, Category II items include complete rocket systems and unmanned aerial vehicle systems capable of a range of at least 300km with a payload of less than 500kg, or complete unmanned aerial vehicle systems capable of a range of less than 300km that can spray aerosols and have autonomous flight control and navigation capabilities or can be controlled beyond the direct vision of the operator, as well as their components; generally, export licenses will be granted, but if the purpose of use falls under a WMD delivery system, the principle of a strong presumption of denial applies, just as with Category I items. Of course, all decisions related to such exports depend on the independent and sovereign judgment of the Korean government. Exports of design technology and production technology directly related to any items in the Missile Technology Control Regime are also subject to the same level of due diligence and control as the export of the equipment itself, within the scope permitted by domestic law. Also, the MTCR does not impede trade for peaceful purposes, such as the space development programs of each country. Member states must manage their national laws and implementation guidelines to align with the regime's guidelines, and upon the transfer of controlled items or technologies, must confirm the end-use and end-user, obtain a pledge that they will not contribute to WMD proliferation, or obtain confirmation that shipment inspections can be conducted by the exporter or the exporting government if necessary. Yet the following characteristics limit the capacity of the regime to prevent WMD proliferation. First, the maintenance of the coordination system among member states is vulnerable. For example, it is difficult to restrain a specific member state if it prioritizes its national interests and does not comply with the coordination system among MTCR member states. Next, not all countries possessing missiles, rocket, and unmanned aerial vehicle technology have been secured as member states. By failing to include countries such as China, Iran, and North Korea, all of which possess long-range ballistic missile technology, there is a limit to the extent to which the proliferation of related technologies to third countries can be blocked. In addition, it controls only exports, which is the final stage of missile, rocket, and unmanned aerial vehicle development. In other words, there are no regulations on acts other than exports, such as the development, testing, and deployment of related items. The U.S. and others are addressing some of these shortcomings through bilateral cooperation measures such as missile guidelines. Finally, there is no international verification organization related to the non-proliferation of missiles, rockets, and unmanned aerial vehicle technology, and the regime is not a treaty with legally binding force. To resolve some of the above problems, member states officially declared the entry into force of the Hague Code of Conduct (HCOC) with the participation of a total of 93 countries at the plenary meeting held in The Hague in 2002. This code, an international code of conduct, is a voluntary and political commitment without legally binding

16 Missile Technology Control Regime (MTCR) and International Code of Conduct Against Ballistic Missile Proliferation (ICOC): Background and Issues for Congress (2003). Analyst in National Defense Foreign Affairs, Defense, and Trade Division

17 Weapon Systems by Battlefield Function (2019), Kim Cheol-hwan, Lee Chae-eon, Ha Cheol-soo, Korea Institute for Military Affairs

force, and accession is possible simply by signing; Korea joined during the Hague Plenary on November 25, 2002. The main contents of the HCOC are as follows.

[Table 7] Main Contents of the Hague Code of Conduct (HCOC)

Classification	Main Contents
Chapter 1	Emphasizes the role and responsibility of the UN within the framework of international peace and security
Chapter 2	Recognizes space utilization for peaceful purposes, but specifies that international cooperation related to space technology should not be used for ballistic missile proliferation and that Space Launch Vehicle (SLV) development programs should not be used to conceal ballistic missile development programs
Chapter 3	In the resolution on the implementation of general measures, urges all countries to reduce the number of missile holdings for international peace and safety and to exercise maximum restraint in the development, testing, and deployment of ballistic missiles; in particular, prohibits support for the missile development programs of countries suspected of developing or acquiring weapons of mass destruction
Chapter 4	Secures transparency by preparing annual reports on policy outlines related to ballistic missiles (BM) and SLVs, providing annual reports on the types, launch sites, and number of launched BMs and SLVs, and mutually exchanging information on BM and SLV launches or test flights
Chapter 5	Regarding the implementation organization, stipulates that a regular plenary meeting shall be held annually and decision-making shall be by consensus

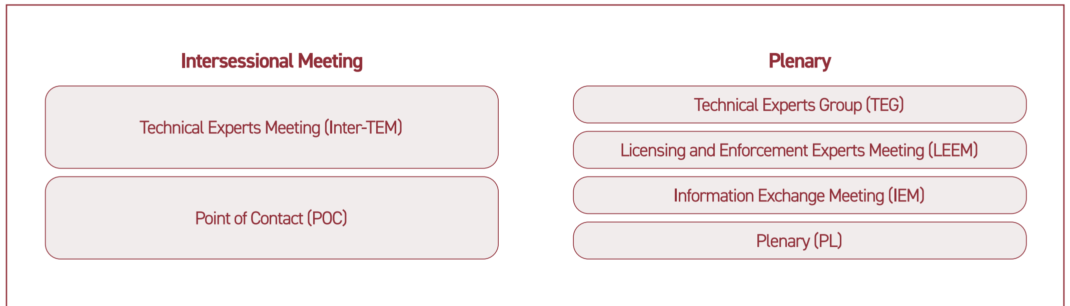
The Hague Code of Conduct operates on the principle that while the right of space utilization for peaceful purposes is recognized, international cooperation related to space technology must contribute to the non-proliferation of WMD delivery systems, and Space Launch Vehicle development programs must not be used to conceal ballistic missile development programs. In particular, as a measure to implement transparency, member states must mutually exchange Pre-Launch Notifications (PLN) before launching or test-flying ballistic missiles and Space Launch Vehicles (SLV), and share with member states an Annual Declaration (AD) specifying the outline of each member's ballistic missile-related policies and the ballistic missiles and space launch vehicles launched during the relevant year. The regular meeting of the Hague Code of Conduct is held annually in Vienna, Austria; unlike the MTCR, accession is not subject to unanimous consensus but is possible by voluntary will; as of 2021, 143 countries are members. Recently, in order to establish a plan to unify the subjects of Pre-Launch Notification (PLN), the opinions of each member state were surveyed and discussed, but no agreement was reached on establishing clear criteria, and notifications are being made based on each member state's voluntary transparency implementation criteria. Meanwhile, in addition to the MTCR, Korea is restricted in its development of missiles and rockets and the transfer of related goods and technologies under the ROK-US Missile Guidelines. These guidelines were signed in 1979, prior to joining the MTCR, and at that time, included an agreement not to develop ballistic missiles with a range of 180km or more and a warhead weight of 500kg or more. Subsequently, as Korea became an MTCR member in 2001, the ballistic missile range was extended to 300km; in 2012, the ballistic missile range was further extended to 800km. Later, in 2017, the warhead weight limit was abolished, and in 2020, the development of solid-fuel-based civilian space launch vehicles was permitted.[18]

[Table 8] Comparison of MTCR and ROK-US Missile Guidelines

Classification	MTCR	ROK-US Missile Guidelines
Nature	• Multilateral cooperation system centered on member states • Defines the scope of restrictions on exports and technology transfers to third countries	• Promise based on bilateral agreement under the combined defense system • Defines the permissible scope of possession of missiles, rockets, etc.
Scope	• Restrictions on export and technology transfer of missiles, rockets, etc., with a range of 300km or more and a payload of 500kg or more	• Range of 800km or less allowed for all missiles, rockets, etc. • Unlimited payload weight allowed • Solid-fuel-based civilian space launch vehicles permitted • Guidelines revised when security requirements change
Criteria	• MTCR Guidelines and Technical Annex	• Missile Guidelines

The Plenary is typically held once a year, roughly in September or October, in the chair country of the year, and discusses issues such as MTCR guidelines, the Technical Annex, information exchange, and outreach activities for non-member states. Notably, the results of the TEM, IEM, and LEEM sub-meetings held in the relevant year are shared, and joint meetings are held if necessary. Generally, the Technical Experts Meeting (TEM) discusses revisions to the MTCR Technical Annex, which lists control criteria for controlled items and technologies. The Licensing and Enforcement Experts Meeting (LEEM) discusses issues related to export licensing and relevant law enforcement or information exchange for export control implementation. The Information Exchange Meeting (IEM) aims to exchange the information necessary to achieve the objectives of the MTCR, and discusses trends in missile proliferation worldwide. The Point of Contact (POC) meeting is regularly held for officers in charge at member states' diplomatic missions in Paris, hosted by the French Ministry of Foreign Affairs, which serves as the contact point for member states of the regime. This meeting has the nature of a face-to-face meeting for routine information exchange through the MTCR website, in addition to administrative duties related to major meetings such as the Plenary and the Reinforced Point of Contact meeting. The Reinforced Point of Contact (RPOC) meeting is a kind of inter-sessional meeting, held in Paris under French chairmanship in April every year. Unlike the POC meeting, the RPOC meeting is attended by the MTCR Chair group and all member states. Similar to the Plenary, discussions and decision-making on all agenda items can be carried out at this meeting, but major decisions are made at the Plenary.

18 What South Korea is facing with the New Missile Guideline (2020), Lee Soo-hoon, Korea Institute for Defense Analyses



[Figure 6] Composition of MTCR Meetings

Generally, the Chair is elected at the annual Plenary for a one-year term; Korea hosted the Plenary in 2004 and served as the Chair country in September 2005. There is no separate secretariat, and the French Ministry of Foreign Affairs acts as the Point of Contact. The MTCR controls the export of complete rocket systems and unmanned aerial vehicle systems capable of a range of at least 300km and a payload of at least 500kg, their major subsystems (Category I), and components and technology related to these items; it also controls complete rocket systems and unmanned aerial vehicle systems capable of a range of at least 300km with a payload of less than 500kg, or complete unmanned aerial vehicle systems capable of a range of less than 300km that can spray aerosols and have autonomous flight control and navigation capabilities or can be controlled beyond the direct vision of the operator, and their components (Category II). Sanctions for non-compliance with the system depend on the domestic legislation of each member state. For Category I items, the principle of 'Strong Presumption of Denial' applies regardless of the purpose of use; even for Category II items, if it is judged that the export of the item is for the purpose of WMD delivery, the principle of strong presumption of denial applies. In other words, Category I items use the 'capability' possessed by the item as the criterion for control, while Category II items use the 'intent' of the country importing the item as the criterion for control. Although the principle of strong presumption of denial applies to the export licensing of Category I items, exports can exceptionally be allowed if the importing government guarantees that the items will not be used for purposes other than the declared use and that the items (including replicas and derivatives) will not be transferred to a third party without permission. However, the transfer of production facilities for Category I items is always prohibited. Annex Category I targets complete systems (Item 1) and subsystems (Item 2) of missiles, rockets, and unmanned aerial vehicles. This includes rocket systems such as Ballistic Missiles, Space Launch Vehicles, and Sounding Rockets, and unmanned aerial vehicle systems such as Cruise Missiles, Target Drones, and Reconnaissance Drones capable of delivering a payload of at least 500kg to a range of at least 300km. It controls the transfer of major subsystems used in Item 1, such as Production Facilities, Rocket Stages, Reentry Vehicles, and Rocket Engines. If an item falling under Category I is included in a system, that system is also considered Category I, except when it cannot be separated, removed, or duplicated. Category II includes all equipment, components, and technologies used in Item 1, such as Propellants, Inertial Navigation Systems, Structural Composites, Flight Control Systems, Avionics, Launch Support Equipment, Test Equipment, and Stealth technology. In addition, it also includes complete systems and components of missiles, rockets, and unmanned aerial vehicles with a maximum range of 300km or more and a payload of less than 500kg, or unmanned aerial vehicles capable of a range of less than 300km that can spray aerosols and have autonomous flight control and navigation capabilities or can be controlled beyond the direct vision of the operator.

3.4 AG Regime

The oldest known use of chemical weapons is when the Spartan army used sulfur-burning toxic gas to attack the Athenian army in the Peloponnesian War in the 400s BC. However, chemical weapons were not widely used before World War I due to difficulties in their control, as environmental factors like weather and wind created a high risk of harm to friendly forces. Since the 19^{th} century, when mass production of chemical substances became possible, concerns over chemical warfare grew, centering on Western countries. Accordingly, the Western countries made efforts to restrict the use of chemical weapons, such as banning the use of poison gas through the Brussels Declaration (1874) and two Hague Conventions (1899, 1907). The Brussels Declaration (1874) included a clause specifically prohibiting the employment of poison or poisoned weapons as a means of injuring the enemy. While the Brussels Declaration was not ratified by the participating countries, it later influenced the Hague Conventions. The First Hague Convention (1899) included a Declaration concerning the Prohibition of the Use of Projectiles with the Sole Object to Spread Asphyxiating Poisonous Gases, and most Western countries other than the United States ratified it. Subsequently, in the Second Hague Convention (1907), the majority of Western countries ratified the Convention respecting the Laws and Customs of War on Land, which included a ban on the use of poisons. However, during World War I (1914–1918), Germany violated the Hague Convention by using chemical weapons such as chlorine gas and phosgene, and in response, the Allied forces also used chemical weapons. After the end of World War I, the Allies and Germany signed the Treaty of Versailles in 1919, which included a ban on the use of poison gas by Germany, the defeated nation. In 1925, Western countries adopted a resolution prohibiting the use of chemical and biological weapons for war purposes through the Geneva Protocol. In World War II (1939–1945), which occurred subsequently, a consensus was formed among the warring parties on the need to refrain from using chemical weapons due to concerns over retaliation or compliance with the Geneva Protocol. Under Article 171 of the Treaty of Versailles (1919), the use of asphyxiating, poisonous or other gases and all analogous liquids, materials or devices are prohibited, and their manufacture and importation are strictly forbidden in Germany. These limitations were later supplemented by the Biological Weapons Convention (1972) and the Chemical Weapons Convention (1997). However, in 1984, the UN confirmed that chemical weapons had been used in the Iran-Iraq War, a violation of the 1925 Geneva Protocol, and announced that the chemical substances used in these chemical weapons programs had been obtained through normal trade. As a result, the need for export controls on raw materials that could be used to manufacture chemical weapons was raised. Prompted by this, Western countries introduced export control systems on raw materials for chemical weapons. However, the export control measures introduced by each country lacked uniformity in their scope and application, and circumvention of controls was possible. Accordingly, Australia proposed a meeting with the aim of harmonizing national export controls and strengthening cooperation. As a result, representatives of 15 countries held the first meeting in Brussels in June 1985, and the Australia Group (AG) was officially launched. As of now, the number of countries participating in the Australia Group has increased from 15 in 1985 to 43, and Kazakhstan, Serbia, and Montenegro are interested in joining the Australia Group.

[Table 9] Status of Australia Group (AG) Member States (As of Dec. 2025)

No.	Country Name	Accession Year
1	Australia	1985
2	Belgium	
3	Canada	
4	Denmark	
5	EU	
6	France	
7	Germany	
8	Greece	
9	Ireland	
10	Italy	
11	Japan	
12	Luxembourg	
13	Netherlands	
14	New Zealand	
15	Portugal	
16	Spain	
17	United Kingdom	
18	United States	
19	Norway	1986
20	Switzerland	1987
21	Austria	1989
22	Finland	1991
23	Sweden	1991
24	Argentina	1993
25	Hungary	
26	Iceland	
27	Czech Republic	1994
28	Poland	
29	Slovakia	
30	Romania	1995
31	Republic of Korea	1996
32	Cyprus	2000
33	Turkey	
34	Bulgaria	2001
35	Estonia	2004
36	Latvia	
37	Lithuania	
38	Malta	
39	Slovenia	
40	Ukraine	2005
41	Croatia	2007
42	Mexico	2013
43	India	2018

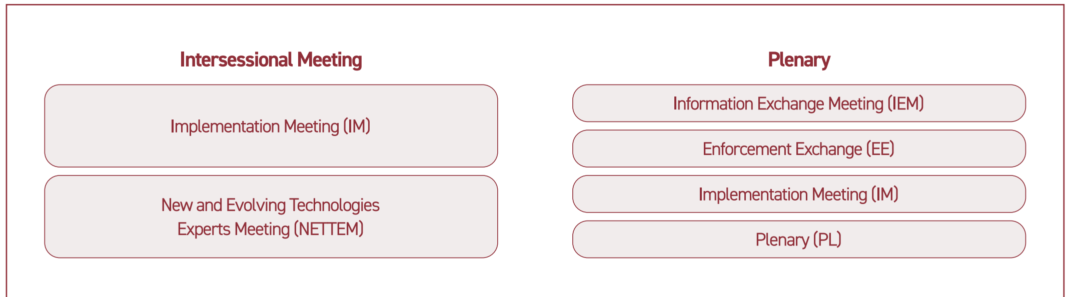
The scope of export controls discussed in the Australia Group aimed to address new threats. As a result, it initially focused mainly on chemical substance export controls, but in the early 1990s, its activities expanded to handle biological weapons as well. More recently, it has been expanded to include technology and equipment related to the development, production, and use of chemical and biological weapons. Currently, the Australia Group meeting is held in Paris every June, and recently, inter-sessional meetings have been held every February or March. At the meetings, sharing of export control systems, trends in the development of new technologies related to chemical and biological weapons, and revisions to control lists are discussed extensively. Member states continuously update the control lists through two implementation meetings every year, and as of March 2021, control 89 chemical weapon precursors, 12 types of chemical weapon manufacturing facilities and equipment, 121 biological agents, and 10 types of biological agent manufacturing facilities and equipment. Recently, amidst cases of the use of nerve agents, a type of chemical weapon, such as the Novichok terror attacks in the UK and Russia and the VX terror attack in Malaysia, and the continuous emergence of infectious diseases capable of being weaponized such as African Swine Fever virus and SARS-CoV-2, the role of the Australia Group is becoming more important than ever. The main purpose of the Australia Group is to ensure that countries adopt appropriate licensing measures so that exports of raw materials for chemical and biological weapons and equipment, software, and technology that can be diverted for their manufacture do not contribute to the proliferation of chemical and biological weapons. The Australia Group seeks to deter and block the proliferation of chemical and biological weapons by harmonizing the export control measures adopted by each individual country, sharing information on countries of concern for proliferation, and devising measures to suppress the use of chemical and biological weapons. The activities of the Australia Group are particularly important in that the international chemical and biotechnology industry is a target for proliferators as a source of materials for chemical and biological weapons programs.

The Australia Group provides the Australia Group Common Control List Handbook[19] to help maintain consistency among member states in the enforcement of export licenses. The handbook describes the basic explanation, notable features, packaging, and fields of use for Australia Group controlled items, and includes reference images and websites. All member states of the Australia Group are parties to both the Chemical Weapons Convention (CWC) and the Biological Weapons Convention (BWC), so upholding the objectives of these conventions is also one of the purposes. For example, export control measures enacted by each individual country must implement the obligations specified in the CWC (Article 1, 1(a) and 1(d)) and the BWC (Article 1 and Article 3). The Australia Group, a multilateral export control regime for chemical and biological weapons, is an informal consultative body of countries that has the purpose of thwarting and blocking the proliferation of chemical and biological weapons by harmonizing national export controls on raw materials for chemical and biological weapons and equipment and facilities that can be diverted for their manufacture, sharing information on countries of concern for proliferation, and devising various measures to suppress the use of chemical and biological weapons. Australia Group member states continuously discuss export control lists regarding chemical and biological agents and related equipment and facilities that can be used as chemical and biological weapons through annual plenary meetings, and revise them based on unanimous consensus.

The Australia Group delegates the regulation and implementation of export licensing procedures for the export control list that are commonly defined by member states to the individual member states, but requires the member states to ensure that such regulations can be effectively implemented as a prerequisite to joining the Australia Group. Australia Group member states are all members of the Chemical Weapons Convention (CWC) and the Biological Weapons Convention (BWC), and their implementation basis is also found in the CWC and BWC. Since the BWC currently has no internationally defined control list or inspection regulations, the Australia Group serves as an effective control tool in the implementation of the BWC. Australia Group meetings are held twice a year and are divided into inter-sessional meetings and the Plenary.

19 Downloadable at http://www.australiagroup.net

Inter-sessional meetings are typically held around February or March, and are hosted by one of the Australia Group member states. The meeting consists of the Implementation Meeting (IM), which discusses revisions to the control list, and the New and Evolving Technologies Experts Meeting (NETTEM), which discusses the setting of control directions. The Plenary is held in Paris, France in the first or the second week of June. The meeting consists of the Information Exchange (IE), which exchanges trends on countries of concern for proliferation; the Enforcement Exchange (EE), which shares the enforcement status and cases of member states; the Implementation Meeting (IM), which discusses revisions to the control list; and the Plenary (PL), which discusses new member accession and outreach.



[Figure 7] Compilation of AG Meetings

The Implementation Meeting (IM) is a meeting at which working-level officials from chemical and biological research institutes discuss agenda items proposed by each country regarding the addition, deletion, and specification changes of Australia Group controlled items and draw practical conclusions. While the Implementation Meeting of the Australia Group is part of the Plenary and inter-sessional meetings, in the other three international export control regimes (WA, NSG, MTCR), meetings on the revision of controlled items that have the nature of implementation meetings are held 1–3 times a year, separately from the plenary. The New and Evolving Technologies Experts Meeting (NETTEM) is a meeting for discussing the setting of the Australia Group control direction, and major agenda items include trends in the development of new technologies in each country related to chemical and biological weapons and preliminary reviews for revising the control list, which is mainly handled in the Implementation Meeting. Ultimately, through this, it can be said that the future scope of Australia Group controlled items is set. In the Information Exchange (IE), government officials from each country exchange information on trends and on the chemical and biological weapons programs of major countries of concern for proliferation in regions such as the Middle East, Europe, and East Asia, the status of exports/imports and export denials of AG controlled items in each country, and new technologies that could be diverted for the proliferation of chemical and biological weapons. Countries of concern mainly mentioned include Libya, Iran, and Syria. The Enforcement Exchange (EE) is a meeting at which officials from export control enforcement departments discuss the systems and legislative status of each country regarding Intangible Technology Transfer (ITT), brokering, and transshipment of strategic technologies, in addition to introducing cases of detection of illegal exports of controlled items. At the Plenary (PL), matters worth referencing regarding the operation of the

Australia Group or the non-proliferation of chemical and biological weapons, such as new member accession, adoption of Australia Group statements, outreach, and chemical/biological terrorism, are shared. The Australia Group is an informal consultative body, and its member states do not bear additional legal obligations upon joining. The effectiveness of Australia Group export controls is determined by the effectiveness of national measures implemented to prevent the proliferation of chemical and biological weapons. The Australia Group has drawn up Common Control Lists related to chemical and biological weapons, and laws must stipulate that export licenses be obtained when exporting chemical substances, equipment, and technology. Also, export licenses cannot be granted for exports of essentially identical items that have been denied export by other member states without consultation with the member state that originally denied the export. Here, the term 'essentially identical items' refers to the same biological agents or chemical substances exported to the same recipient, or in the case of dual-use items, products with identical or similar specifications or performance. Also, this does not apply to export denial cases based on Catch-All controls.

4. Analysis of Latest Export Control Issues and Implications

Since the 9/11 attacks in 2001, 'network-style' controls such as financial sanctions, cargo security, and strengthened end-use screening have been expanded to prevent the transfer of WMD-related materials and technologies to terrorists and non-state actors. Export controls and human rights-based sanctions on equipment related to human rights, cyber surveillance, and internal repression (wiretapping/surveillance systems, etc.) have emerged, and are being utilized not only for traditional security but also as diplomatic tools. Recently, amidst the US-China strategic competition, advanced technologies with significant economic and military impact, such as semiconductor equipment, high-performance chips, AI, quantum computers, aerospace technology, advanced materials, and advanced manufacturing (e.g., advanced additive manufacturing) are emerging as key control targets. Major countries, including the EU, are strengthening a kind of minilateral control through independent revisions of dual-use lists and separate national regulations (e.g., establishing specific semiconductor equipment, quantum, and AI-related items) in

a situation where agreements in the Wassenaar Arrangement, etc., are delayed. Notably, the developed countries are seeking ways to increase the precision and efficiency of export control enforcement, such as item classification, suspicious transaction detection, and automated license review through utilizing artificial intelligence (AI) and data analytics. Attempts are also being made to utilize technology itself for export control implementation, such as verifying the movement of strategic items and the authenticity of related documents using Distributed Ledger Technology (DLT) like blockchain.

5. Korea's Cooperation Strategy

Recently, in the WA, a number of agenda items have been submitted to strengthen controls in emerging technology fields such as quantum computers, artificial intelligence, advanced semiconductor equipment, and aerospace. It is predicted that agenda items controlling advanced technologies will continue to be discussed through multilateral regimes in the future, and that technologically advanced countries such as the US, Japan, and the EU will also apply independent export controls using their domestic laws.

Considering our country's comparative advantage in manufacturing technology, we need to fulfill our responsibility to maintain international peace and regional security by preventing the proliferation or destabilizing accumulation of sensitive items and technologies by countries of concern or terrorist groups. To this end, it is urgent to participate in multilateral regime meetings such as WA, NSG, MTCR, and AG and at the same time we need to join in minilateral or bilateral meetings with like-minded countries that share our position.

The export control system is not a system that hinders free export by companies, but one that aims to revitalize safe import and export by increasing trade transparency, based on the concept of "setting the standard" so that each country can be equipped with a stable and effective export control system. In this respect, the Korean government should actively engage in international export control regime activities in the future and actively strive to secure the essential materials, parts, equipment, SW, and technologies for advanced industries that will lead the market in the future.

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3 Multilateral Cooperation for Science, Technology and Innovation Policy: The Case of OECD/CSTP

Yongsuk Jang, Chair of CSTP, OECD & Research Fellow Emeritius, STEPI

In an era shaped by geopolitical tensions, technological rivalry, and global challenges ranging from climate change to digital security, multilateral cooperation on science, technology and innovation (STI) has become indispensable. Among global platforms, the OECD Committee for Scientific and Technological Policy (CSTP) stands as the most established, institutionalized, and analytically sophisticated forum where governments negotiate shared understanding, develop comparable evidence, and build policy consensus on national and global STI priorities.

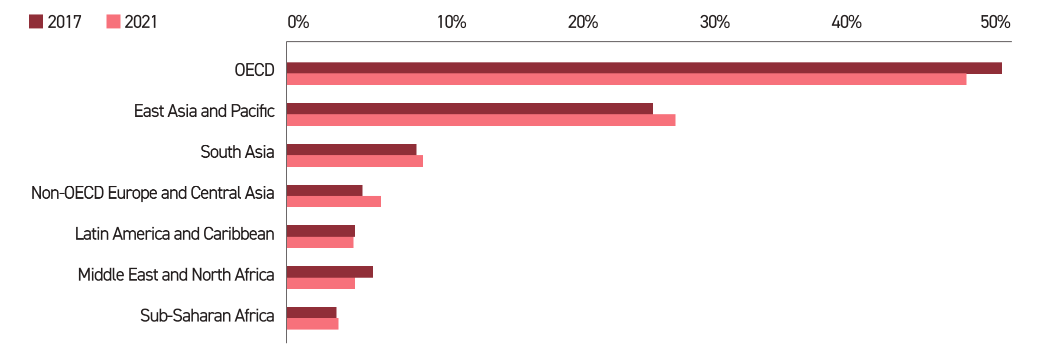
Founded in 1972, the CSTP has evolved into the central global venue for high-level STI policy dialogue, generating methodologies, indicators, and policy frameworks that influence national strategies across OECD members and partners. Over the last five decades, CSTP has shaped major themes in STI governance—national innovation systems, technology diffusion, emerging technologies, mission-oriented innovation, responsible innovation, and resilience—supported by a robust analytical infrastructure including the Frascati family of manuals, the STIP Compass, and cross-country policy reviews. Today, CSTP faces a dual challenge: meeting the rising demand for technology-driven security and economic competitiveness while also strengthening multilateral cooperation on solutions to transboundary problems.

This essay overviews the OECD/CSTP and discusses its future directions. It concludes with some personal lessons (or observations) drawn from CSTP engagement over the last twenty years, both as a country delegate and as CSTP Chair. These observations underscore the political–economic realities behind multilateral STI governance and highlight the importance of strategic and diplomatic capacities for countries engaging in CSTP.

1. What is OECD/CSTP?

The Committee for Scientific and Technological Policy (CSTP), nested within the Organisation for Economic Co-operation and Development (OECD), stands at the center of the international landscape for science, technology and innovation (STI) policy. In essence, CSTP is the principal global forum where governments coordinate strategies, develop shared understanding, and advance policy alignment on STI. Its role derives from the institutional weight and policy infrastructure of the OECD.

The OECD began as the OEEC in 1948 to manage the Marshall Plan, later transforming into the OECD in 1961 as democratic, market-economy nations recognized the need for permanent cooperation on economic and social policy. Today, the OECD, now composed of 38 countries including Korea (which became a member in 1996), represents 46% of global GDP, more than half of global R&D investment and scientific output, and a large share of the world's innovation and industrial capacities. OECD brings together governments that collectively shape the architecture of modern knowledge-based economies. Its role has evolved far beyond economic coordination to become a global hub of policy intelligence, standard-setting, and cross-country learning.



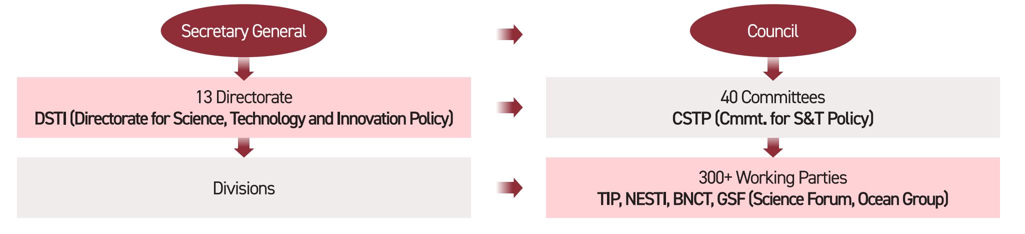
Source: OECD Website, accessed on October 25, 2025

[Figure 1] Share in world GDP by region, revised 2017 and new 2021 results (Share in world GDP in current USD PPP)

Within this ecosystem, CSTP is the OECD's primary venue for government-level discussions on STI policy. CSTP's origin dates back to the Committee for Scientific Research (CSR), which began meeting in 1961, before being formally reorganized as CSTP in 1972. Since its inception, CSTP's mandates have focused on promoting international cooperation among members and partners to achieve economic growth, job creation, sustainability, social well-being, and scientific advancement. With these mandates, CSTP has played a pivotal role in shaping global understanding of how research policy should be structured, how innovation systems function, and how governments can manage the opportunities and risks of science and technology.

CSTP maintains a dual identity: on the one hand, it functions as a strategic and political forum where high-level officials negotiate priorities and coordinate national positions; on the other hand, it serves as a knowledge-generating engine that organizes analytical work, reviews, and global metrics forming the foundation of STI policymaking worldwide.

The OECD's organizational structure places CSTP among its most prominent policy committees, alongside those focused on economics, education, competition, and environment. Like these other committees, CSTP reports to the OECD Council and operates with support from the OECD Secretariat, particularly the Directorate for Science, Technology and Innovation (DSTI). This structure ensures that CSTP's discussions remain connected to broader economic and social priorities and that STI policy is not isolated from other policy domains.



Source: Author creates

[Figure 2] CSTP in OECD Structure

CSTP's mandate encapsulates several core responsibilities: overseeing the development of internationally comparable STI indicators; reviewing emerging policy challenges; and creating analytical frameworks that guide national and international action. It connects STI policy to major themes such as productivity, sustainability, digital transformation, and global security. It also builds on a long legacy of methodological leadership, particularly through the development of the Frascati Manual, Oslo Manual, and other internationally recognized statistical standards that underpin the measurement of R&D, innovation, and scientific activity.

Importantly, CSTP is not merely a technical forum but also a space where countries negotiate shared language around concepts that are inherently political—such as open science, research security, responsible and inclusive innovation, technology sovereignty, and strategic competition. The committee's emphasis on consensus ensures that outputs reflect the collective view of member governments, creating a degree of legitimacy and global acceptance rarely found elsewhere.

Overall, CSTP is a unique global institution: a place where STI policy challenges are addressed not in isolation but through a lens integrating economic, social, and political dimensions. It serves both as a guardian of methodological rigor and as a space for diplomatic negotiation in an increasingly complex technological landscape.

2. How CSTP Works

CSTP's mode of operation blends formal governance structures with flexible, evolving mechanisms of collaboration. Two formal meetings are held each year, usually in April and November, bringing together high-level delegates responsible for national STI policies. These meetings serve as the apex of decision-making: countries review progress, approve new work, share national developments, and deliberate on strategic directions. They also provide a rare environment in which senior officials compare notes on global trends, policy pressures, and emerging threats or opportunities.

Much of CSTP's decision-making capacity comes from its Bureau, composed of one Chair and six Vice-Chairs. The Bureau is the steering body that works closely with the Secretariat to select themes, prepare agendas, anticipate emerging issues, and balance competing interests. It operates between formal meetings, often convening virtually to guide the strategic direction of the Programme of Work and Budget (PWB). The Bureau serves as a bridge between national policy priorities and the collective interests of the committee.

The biennial PWB—now in the process of transitioning into a quadrennial cycle—enables CSTP to pursue both long-term strategic projects and more flexible, demand-driven initiatives. It is financed through a mix of mandatory contributions (Part I and Part II budgets) and voluntary contributions (VCs). VCs often support in-depth analytical work, allowing leading countries to shape specific projects, but CSTP maintains strong norms to ensure transparency and inclusiveness in agenda-setting.

At the operational level, CSTP draws support from several working parties: TIP (Technology and Innovation Policy), NESTI (National Experts on Science and Technology Indicators), BNCT (Biotechnology, Nanotechnology and Converging Technologies), GSF (Global Science Forum), and sectoral groups on space and the ocean. Each plays a distinct role in providing analytical foundations for CSTP's decisions. TIP advances understanding of national innovation systems, mission-oriented innovation, and policy mixes. NESTI oversees R&D and innovation statistics, ensuring methodological consistency across member countries. BNCT examines governance challenges related to emerging and converging technologies. GSF discusses global research infrastructures, national science policies, and research security.

The Space Forum and Ocean Group extend STI policy discussions into areas where scientific research, technology development, and economic interests intersect in complex ways. The Space Forum supports interdisciplinary analysis of satellite data, launch systems, and innovation dynamics. The OECD's work on the ocean economy integrates scientific research, sustainability, and industrial development.

The interaction between CSTP and these substantive bodies forms an integrated policy–knowledge ecosystem: CSTP provides political direction, while the working parties and sectoral groups deliver analytical depth. This relationship ensures that CSTP decisions are grounded in robust evidence and maintain a long-term perspective.

CSTP also interacts actively with other international organizations. Coordination with the G7 and G20 allows CSTP's analytical work to feed into global policy discussions at the highest political levels. Collaboration with UN agencies, the World Bank, APEC, and regional organizations broadens the impact of CSTP's outputs and enhances their legitimacy. OECD accession processes further extend CSTP's reach, as candidate countries must align their STI policies with OECD norms and statistical frameworks.

CSTP's operational culture places heavy emphasis on consensus-building. Because outputs must reflect the collective will of its members, the committee invests significant time in negotiating language, accommodating national differences, and balancing competing visions. This diplomatic dimension is particularly important in areas such as technology governance and economic security, where national interests often diverge. Yet CSTP retains an environment that prioritizes intellectual honesty and policy rigor, supported by the Secretariat's analytical independence.

3. What CSTP Has Done and Is Doing?

Over the past fifty years, CSTP has played a leading role in shaping how governments conceptualize and implement STI policy. The historical trajectory of CSTP's work mirrors broader changes in the global economy and technological landscape. In the 1970s, CSTP helped establish the foundations of modern STI policy by standardizing the measurement of R&D and statistical definitions. This work provided the first internationally comparable data on research investment, human resources, and scientific outputs—an essential prerequisite for evidence-based policy.

In the 1980s and 1990s, CSTP contributed to the rise of the national innovation systems (NIS) framework. It also advanced thinking on industry–science linkages, technology diffusion, and the organization of research systems. These conceptual advances shaped how countries designed R&D programs, technology transfer mechanisms, and industrial innovation strategies. They also influenced global debates about competitiveness, globalization of production, and scientific collaboration.

By the 2000s, CSTP expanded its work to address the emerging knowledge economy. It engaged with issues such as intellectual property, human capital, and research infrastructure. As countries began to grapple with digital transformation, CSTP became an important venue for debating how digital technologies—stemming from long-term scientific advances—affect innovation processes, productivity, and social well-being.

In the 2010s, CSTP shifted toward systemic challenges. Concepts such as inclusive innovation, responsible research and innovation, and mission-oriented policy became central themes. Discussions increasingly addressed how STI could be mobilized to address social inequality, environmental sustainability, and public trust.

CSTP also led global efforts on open science and data governance, reinforcing principles of transparency, access, and reuse in scientific research.

Since the 2020s, CSTP has focused intensively on resilience, emerging and critical technologies, and mission-oriented innovation for global challenges. The COVID-19 pandemic exposed vulnerabilities in research systems, supply chains, and global scientific collaboration. CSTP responded by examining how to strengthen the resilience of research infrastructures, accelerate innovation under uncertainty, and ensure the continuity of international cooperation.

CSTP's recent work addresses the governance of emerging technologies including AI, quantum technologies, synthetic biology, and other frontier fields. The committee's agenda now reflects the growing intersection of STI policy with security concerns, including economic security, supply chain diversification, research integrity, and protection of critical technologies. At the same time, CSTP continues emphasizing the need for global cooperation, recognizing that emerging technologies cross borders and require coordinated policy responses.

Outputs such as the OECD Science, Technology and Innovation Outlook (OECD, 2023 & 2025b), the STIP Compass, cross-country STI reviews, and continued advancement of STI measurement form the backbone of global STI policy infrastructure. These resources inform national strategies, international agreements, and public investment decisions. They also reinforce CSTP's role as the leading institution for STI policy intelligence.

The 2024 CSTP Ministerial Meeting resulted in the Paris Declaration (OECD, 2025a), the Agenda for Transformative STI Policies (OECD, 2024a), and the Framework for Anticipatory Governance of Emerging Technologies (OECD, 2024b). These documents define CSTP's strategic direction, emphasizing responsible innovation, societal engagement, inclusion, and strengthened STI policy intelligence.

4. Looking Forward

CSTP is now preparing its next Programme of Work and Budget (2027–2030). This marks a shift from the traditional two-year cycle to a four-year cycle, highlighting the need for sustained, long-term attention to complex and cross-cutting STI challenges. In this disruptive period characterized by deep uncertainty, complexity, and systemic vulnerability, CSTP faces a dual mandate requiring a balance between national competitiveness and global cooperation.

On one hand, member countries face intense pressure to secure leadership in frontier technologies. Concerns about geopolitical rivalry, technological dependence, and economic security are shaping STI policy in unprecedented ways. Governments expect CSTP to provide high-quality policy intelligence, comparative evidence, and foresight to inform national strategies. Issues such as supply chain resilience, research security, and strategic technologies are at the forefront of national agendas. CSTP must respond with rigorous analysis that helps countries make informed decisions.

On the other hand, CSTP must strengthen its role in promoting international cooperation. Global challenges—climate change, biodiversity loss, pandemics, and emerging technology governance—require coordinated action that no single government can achieve alone. CSTP is uniquely positioned to create shared frameworks, articulate collective priorities, and facilitate the diffusion of policy approaches that accelerate mission-oriented innovation. It is also one of the few international forums capable of integrating STI policy insights across economic, environmental, and social domains.

To meet these dual imperatives, the next PWB should prioritize several areas. First, CSTP should deepen and expand its policy intelligence capabilities. Enhancing STI data infrastructures, improving R&D and innovation indicators, and developing new metrics for emerging technologies are essential. Countries increasingly expect the OECD to provide early warnings and foresight that help them navigate technological disruptions.

Second, CSTP should identify and elevate key thematic agendas that align national interests with global objectives. This includes governance frameworks for emerging technologies including AI, quantum, and biotechnology; policy mixes for green and digital transitions; and global talent policies addressing shortages in scientific and technical fields.

Third, CSTP should strengthen its role in building policy consensus. Through ministerial processes, expert dialogues, and working party activities, CSTP can help countries converge on shared principles. This may include frameworks for technology risk management, mission-oriented innovation, responsible innovation, and open science.

Fourth, CSTP should improve alignment with other international organizations. Enhanced collaboration with the G7, G20, APEC, UN agencies, the World Bank, and other global fora can amplify CSTP's influence and promote coherent global STI governance. CSTP's evidence base, combined with the political visibility of these bodies, offers significant potential for synergy.

Finally, CSTP must ensure that the next four-year PWB balances policy demands. Projects should address immediate national concerns while also advancing global public goods. Achieving this balance will require diplomatic skill and analytical rigor, particularly in an era when technological issues are deeply intertwined with political interests.

5. Epilogue

Reflecting on personal experience at CSTP as a Korean delegate for nearly 20 years, and as CSTP Chair for the last five years, four lessons stand out—lessons that illuminate not only the committee's internal dynamics but also broader truths about international cooperation in STI policy.

First, power works. In a consensus-based organization like the OECD, no country formally dominates. Yet political and economic power inevitably shape discussions. Large economies influence agenda-setting, define emerging priorities, and often set the tone for debates. Recognizing this dynamic is critical for understanding how to position national interests effectively.

Second, money talks. Voluntary contributions fund many of the most ambitious CSTP projects. Countries that provide financial resources can exert disproportionate influence over the direction, scope, and speed of analytical work. While CSTP maintains strong norms to ensure fairness, the reality is that funding matters—and it often determines which ideas become projects and which remain proposals.

Third, intelligence is valued. High-quality analysis earns respect. Delegates who consistently contribute substantive insights, provide clear evidence, and engage constructively in discussions become influential regardless of their country's size or political and economic power. CSTP values expertise and rigorous thinking, and this meritocratic dimension helps sustain its intellectual credibility.

Fourth, diplomacy helps. Consensus-building lies at the heart of OECD operations. Navigating differences, proposing compromise language, and reading the political landscape are indispensable skills. Even when analytical arguments are strong, advancing them requires diplomatic finesse. This is especially true in sensitive areas like technology security or emerging technology governance, where national interests diverge sharply.

Together, these lessons underscore the complex interplay between analysis, politics, and diplomacy in multilateral STI governance. CSTP remains a place where evidence matters, but also a venue where strategic behavior, negotiation, and coalition-building shape outcomes. Understanding this balance is essential for countries seeking to engage effectively and for scholars aiming to analyze the evolution of global STI policy.

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4 Multilateral Cooperation on Climate Change and Korea: What Path Should We Take?

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1. Introduction

Multilateral Cooperation on Climate Change has adopted the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), accelerating a system that mandates and manages all Parties' obligations to reduce greenhouse gas emissions and adapt to climate impacts. By establishing effective international governance, countries are actively addressing climate change, a common challenge for humanity. The international community is gradually making progress as systems and frameworks take shape and advance toward comprehensive effort to address the root causes of climate issues across direct and indirect sectors such as production, consumption, and waste management. However, faced with rapidly changing and diverse climate disasters, there is a recognized need for more ambitions and robust action to stabilize the global climate.

However, various factors are revealing limitations or obstacles in addressing the climate crisis. Beyond the fundamental issue of coordinating diverse interests within a multilateral decision-making structure, multilateral cooperation also faces limitations represented by major powers withdrawing from the conventions following changes in political leadership, resistance or inaction from key oil-producing nations on climate issues, and varied levels of commitment based on individual countries' circumstances. Korea has positioned itself as a bridge between developing and developed countries in the international community, announcing innovative reduction targets or expressing strong carbon neutrality commitments through international events. However, it has not sufficiently demonstrated exemplary leadership through actual implementation and continues to be perceived as a "climate villain."

In this context, it is meaningful to reexamine Korea's role within multilateral climate cooperation and derive policy implications for charting our future path. From the perspective of understanding the direction Korea should take, this paper provides an overview of multilateral climate cooperation, examines key issues, and identifies Korea's activities and achievements. Specifically, it aims to highlight key implications, discussion points, and proposals regarding Korea's orientation and core activities within the multilateral framework.

2. Multilateral Climate Cooperation: United Nations Framework Convention on Climate Change (UNFCCC)

2.1 Overview of UNFCCC

The most influential governance framework in the international community for addressing climate change is the United Nations Framework Convention on Climate Change (UNFCCC), established in 1992 and now a major institution with 198 member countries participating. An overview of the UNFCCC's origins and activities will help us understand humanity's fundamental principles and commitments in addressing climate issues, the significance of its major achievements, and provide insights into future prospects.

To understand the value and meaning of the UNFCCC's establishment, we will review the historical background of its creation. In human history, modern scientific discoveries regarding climate change response began in the 19th century. Efforts were made to identify the greenhouse gases causing global warming, validate them with quantitative data, and develop theoretical frameworks.[1] In the 20th century, with the development of science and technology, the current state and causes of climate change began to be analyzed and explained with increasing scientific precision.

Since the 1970s, humanity has recognized the climate change problem confirmed through modern scientific discoveries and has begun to institutionalize responses through formal multilateral organizations. In 1972, when environmental issues were formally addressed as an agenda item at the United Nations Conference on the Human Environment (UNCHE), the international community began to focus on environmental problems. In 1973, the United Nations Environment Programme (UNEP) was established, and in 1988, the Intergovernmental Panel on Climate Change (IPCC) was founded. These early initiatives established the foundational infrastructure for addressing environmental and climate issues.[2]

[Table 1] Stages of the Emergence of Multilateral Cooperation on Climate Change Response

Scientific Discoveries on Climate Change		International Agenda-Setting on Environmental Issues		Establishment of International Institutions
- Hypothesis on global warming and the greenhouse effect (Joseph Fourier) - Establishment of the hypothesis linking CO_2 emissions from fossil fuel combustion to global warming, and quantitative calculations demonstrating the climate impact of human activity (Svante Arrhenius) - Theory explaining the correlation between increasing carbon dioxide and global temperatures (Guy Callendar) - Development of computer simulation models for climate projection	➔	- First global conference to focus on environmental issues, initiating cooperative dialogue between developed and developing countries on balancing economic development with environmental protection (UN Conference on the Human Environment, 1972, Stockholm) - Establishment of the United Nations Environment Programme (UNEP) - "The Limits to Growth" report emphasized the necessity of environmentally conscious development (1972). - The report "Our Common Future" presented sustainable development linking environment, development, and society (1987). - IPCC established to assess and report on climate change science and policy responses (1988).	➔	- UNFCCC Agreement (1992) - Kyoto Protocol Agreement (1997) - Kyoto Protocol entered into force (2005) and implemented (Phase 1: 2008-2012, Phase 2: 2013-2020) - Paris Agreement (2015) - Paris Agreement entered into force (2016) and implemented (2021)

1 French physicist Joseph Fourier proposed a hypothesis analogous to the greenhouse effect by explaining discrepancies between the theoretical calculations of Earth's temperature and actual temperatures. Swedish chemist Svante Arrhenius presented a climate model based on quantitative calculations as a research hypothesis exploring the relationship between carbon dioxide emissions and global warming. British engineer Guy Callendar developed the theory that carbon dioxide emissions raise global temperatures (Seon In-kyung et al., 2024)

2 Same as above

While the institutional structures of multilateral organizations were created, the conceptual and operational frameworks for addressing climate and environmental issues also began to develop. The report "The Limits to Growth" presented the challenges arising from environmental degradation caused by mass production through system dynamics analysis. The report "Our Common Future" defined sustainable development and advocated a perspective that considers economic development, environmental, and social dimensions together. These reports played a significant role in establishing global agendas, including climate change, that humanity must address collectively through multilateral cooperation, and in establishing principles and directions for effective responses.[3]

As global warming was identified through modern scientific discovery, climate change emerged as an agenda item. Consequently, as recognition grew within the international community that this is a shared problem requiring joint solutions, the UNFCCC was established. The objective of this Convention (Chapter 2) is defined as "to stabilize greenhouse gas concentrations in the atmosphere at a level that will allow the world to prevent dangerous human interference with the climate system.[4] It explicitly articulates the goal and direction that global warming is a problem caused by humans and must be addressed through human action. Furthermore, it establishes several principles (Chapter 3) to provide a basic framework and approach for solving common problems: common but differentiated responsibilities and respective capabilities; consideration of the particular vulnerabilities of developing countries to the adverse effects of climate change; and the need to take preventive measures to anticipate, prevent, minimize the causes of climate change and mitigate its adverse effects.[5]

3 The Limits to Growth (Meadows et al., 1972) and Our Common Future (World Commission on Environment and Development, 1987) significantly influenced subsequent environmental and climate-related agendas and international discussions by raising awareness that development disregarding environmental and social issues ultimately poses risks to humanity.

4 United Nations Framework Convention on Climate Change (1992)

5 Same as above

[Table 2] Comparison of the Kyoto Protocol and the Paris Agreement

Kyoto Protocol	Classification	Paris Agreement
Annex 1 countries (developed countries)	Scope of Parties	All Parties
Binding reduction targets	Commitment Type	Nationally Determined Contributions (NDCs)
Focus on greenhouse gas reduction	Policy Coverage	Including mitigation, adaptation, and means of implementation (financing, technology transfer, and capacity building)
Phase 1 (2008-2012): 5.2% reduction, Phase 2 (2013-2020): 18% reduction	Emission Reduction Goals	Temperature goal: Limit warming to below 2℃, with efforts to limit to 1.5℃
Top-down (internationally negotiated)	Target-Setting Approach	Bottom-up (voluntary national commitments)
Punitive (1.3 times penalty for shortfalls)	Compliance Mechanism	Non-punitive (non-binding, leveraging peer pressure)
Not specified	Enhanced obligations	Progress principle (no rollback), Global Stocktake (every 5 years)
Negotiations required for each commitment period	Long-term Continuity	Periodic implementation reviews without termination date
Agreement: 1997, Entry into force: 2005, Implementation Phase 1: 2008-2012, Implementation Phase 2: 2013-2020	Timeline	Agreement: 2015, Entry into force: 2016, Implementation: 2021-

Source: Ministry of Foreign Affairs (2017), with some content added by the author[6]

The UNFCCC was established through an agreement among 198 member states to address global climate issues, and it develops concrete activities based on established goals and principles. Two of its major achievements are the Kyoto Protocol and the Paris Agreement, which present binding and voluntary frameworks, respectively, for achieving emission reduction targets. Both frameworks emerged from years of deliberation, leading to mutual agreements and establishing concrete reduction targets and implementation mechanisms.

Since the establishment of the UNFCCC, member states have deliberated on specific implementation methods and ultimately adopted the Kyoto Protocol, which centered on binding targets for developed countries. Under the Protocol, Annex 1 countries were obligated to reduce their greenhouse gas emissions by 5.2% (Phase 1) and 18% (Phase 2) below 1990 levels by 2020. Implementation was scheduled in two phases: Phase 1 (2008-2012) and Phase 2 (2013-2020). Due to the absence of major emitters such as the United States of America and the withdrawal

6 Ministry of Foreign Affairs (May 29, 2018): Significance and Characteristics of the Paris Agreement

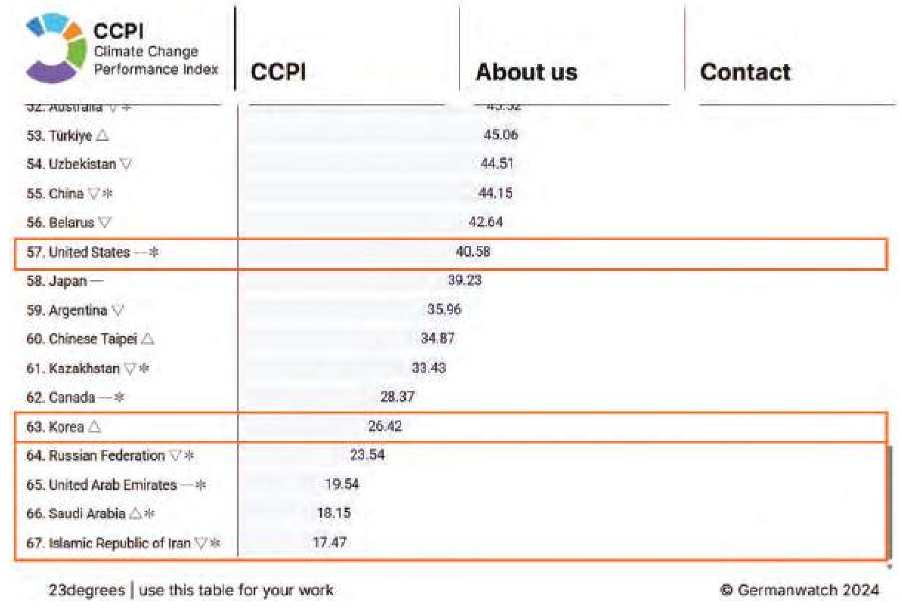
of significant parties around the end of the first commitment period, the Kyoto Protocol was assessed as a partial success with limited global impact.[7] However, these lessons from the Kyto Protocol's limitations directly informed the development of the Paris Agreement.

The Paris Agreement was adopted to address the limitations identified through the Kyoto Protocol and is currently being implemented. It expanded emission reduction obligations from developed countries alone to all Parties, and it shifted the approach to setting reduction obligations from top-down (internationally mandated targets) to bottom-up (nationally determined commitments). To encourage broad participation and prevent withdrawals, the Agreement also introduced a non-punitive compliance framework with voluntary nationally determined contributions (NDCs), moving away from the penalty-based approach of the Kyoto Protocol. The Paris Agreement establishes a long-term goal of limiting global warming to well below 2°C above pre-industrial levels, with efforts to limit warming to 1.5°C. It also relies on supplementary mechanisms – such as carbon border adjustment mechanism (CBAM) and carbon pricing instruments – to incentivize or enforce the achievement of emission reduction targets across different national contexts.

2.2 Key Issues

Since the implementation of the Paris Agreement began in 2021, expectations for the new framework have grown alongside accumulated consultations, agreements, and collaborative problem-solving efforts. However, negative situations have also been identified. Opposing currents can be broadly identified around two primary concerns: national interests and the implications of emerging technological changes such as artificial intelligence.

Regarding national interests, the United States exemplifies a country whose domestic political divisions have created obstacles to collective climate action. The United States, as the world's most powerful economy, is divided between two major political parties with fundamentally opposing views on climate policy. This has resulted in a pattern of joining and withdrawing from the UNFCCC with each change of administration, implementing drastically different climate polices that undermine the continuity and credibility of multilateral efforts.[8] Beyond the United States, major oil-producing nations, manufacturing-export-dependent developed countries, and rapidly industrializing emerging economies have also demonstrated limited progress in achieving their emission reduction targets and rank among the lowest performers in international climate change assessments. When a nation's primary economic sectors and energy sources rely heavily on manufacturing and fossil fuels, this pattern of underperformance is particularly pronounced. Korea, with a similar economic structure, also ranks among the lowest-performing nations in climate change mitigation efforts (see Figure 1).[9]



Source: Climate Change Performance Index (CCPI)

[Figure 1] Country Rankings (Bottom Tier) in the Climate Change Performance Index (CCPI)

As major energy consumers, advanced economies and technology companies face a critical challenge posed by artificial intelligence (AI), which has complicated the debates over nuclear power plant operations and energy policy. before the transformative emergence of generative AI, leading global technology companies were advancing climate action through initiatives such as RE100[10]. ES, the world's largest asset manager, emphasized climate-conscious investing and publicly opposed investments in fossil fuels, creating momentum among major global corporations to adopt and publicize climate commitments and sustainability practices.[11] However, since the introduction for ChatGPT in November 2022, the rapid deployment of generative AI systems such as Gemini and Perplexity has dramatically altered the energy landscape.

7 Ralph Winkler emphasized that the Kyoto Protocol was significant for establishing a foundational framework that enabled the subsequent Paris Agreement to address the climate crisis comprehensively, and that it demonstrated the necessity of complementing multilateral agreements with supplementary mechanisms such as carbon border adjustment mechanisms (CBAM) and carbon pricing instruments. (Foresight, 2022).

8 The United States has demonstrated a cyclical pattern in which Republican administrations withdraw from the UNFCCC (e.g., George W. Bush and Donald Trump), while Democratic administrations rejoin and pursue ambitious climate policies (e.g., Barack Obama and Joe Biden). As both a leading developed economy and the world's second-largest greenhouse gas emitter, the United States bears significant shared responsibility to address climate change. However, it has faces considerable criticism for falling to meet its historical responsibility, prioritizing domestic interests over international cooperation, and inadvertently providing justification for other governments and corporations to reduce their climate commitments (Lee Hye-kyung, 2025). For reference, the United States accounts for approximately 12% of global greenhouse gas emissions, rankng second after China (33.98%) and ahead of India (7.57%) (World Population Review, CO2 Emissions by Country 2025).

9 Korea ranks second among OECD countries in manufacturing's share of GDP at 27.6% (with Ireland first at 31.0%), surpassing Germany (20.1%) and Japan (20.7%). Additionally, Korea's merchandise exports represent 44.4% of its GDP, exceeding the OECD average of 30.0% and exceeding the levels of most G7 nations (Chosun Biz, 2025).

10 RE100 is a corporate initiative launched in 2014 that commits participating companies to source 100% of their electricity from renewable energy sources by 2050.

11 Larry Fink, CEO of BlackRock, signaled strong commitment to climate action and fossil fuel phase – out in his 2020 annual letter, positioning the firm as a prominent advocates for sustainable business practices. This message influenced major global corporations, including those based in Korea, to accelerate their transition toward lower-carbon operations (Laird, 2025).

While these systems provide significant computational capabilities that support human productivity, their proliferation has led to unprecedented levels of dependence on AI in daily operations and decision-making. The substantial energy consumption and water requirements associated with AI infrastructure have become unavoidable, directly contradicting and undermining global efforts to mitigate climate change.[12]

While most nations may share a similar understanding that the climate crisis is severe and its resolution is a common challenge for humanity, they often act in ways that diverge from this shared direction when prioritizing their own national interests during response and implementation activities. Depending on the stance and interests of the ruling party and its supporters, they may pursue policies that move in markedly different directions. Moreover, societies have become deeply dependent on the benefits of modern civilization provided by immense technological power. To effectively achieve climate change responses within a multilateral framework, the individual interests of each nation need to be aligned and integrated toward a common direction. Furthermore, there must be broader recognition that behind the convenience of human life lies significant environmental sacrifice, accompanied by a collective commitment to responsible consumption. Through the 2023 First Global Stocktake, the UNFCCC pointed out that on the whole, all countries' mitigation plans and implementation levels are insufficient to achieve the 1.5°C goal[13]. In 2024, the global average temperature reached 1.55°C above pre-industrial levels, marking the first year in which the 1.5°C threshold could no longer be maintained. Thereby underscoring the need for all societies to deliver greenhouse gas reductions under a more robust implementation framework.[14]

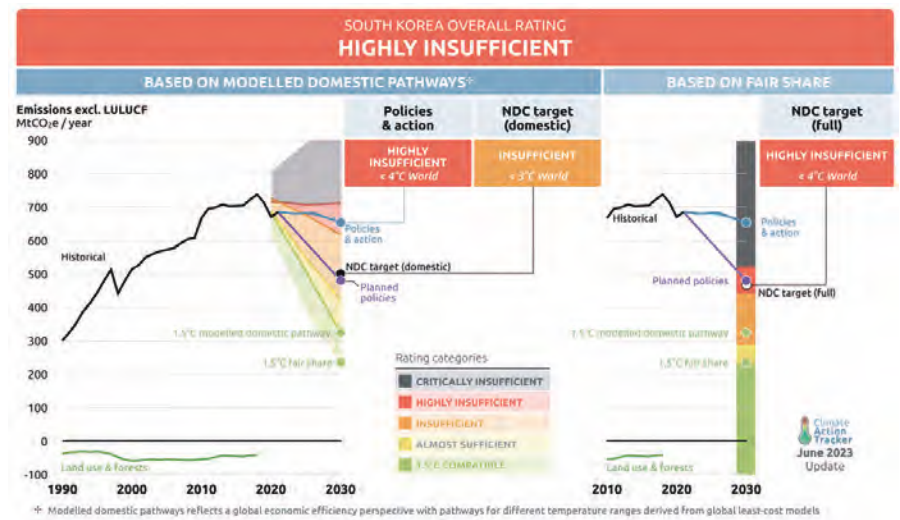
3. Climate Governance and Korea

3.1 Korea's Activities, Achievements, and Evaluation

At the time the UNFCCC, the multilateral climate governance framework, was established, Korea joined as a founding Party under the Roh Tae-woo administration in 1992. Korea also participated in the adaptation of the Kyoto Protocol under the Kim Dae-jung administration (ratified in 2002) and in the conclusion of the Paris Agreement under the Park Geun-hye administration (signed in 2015, ratified in 2016). Even when Korea had no binding reduction obligations, it signaled its intention to contribute by announcing national emission reduction targets at COP15 under the national slogan of “Low Carbon Green Growth” during the Lee Myung-bak administration in 2009. Korea has also reiterated its commitment by submitting national emission reduction targets on three occasions (including one updated submission) in 2016, 2020, and 2021.

While shaped by the international community's climate change frameworks and implementation efforts, Korea has also pursued its own initiatives, establishing higher-level legislation to build the necessary policy infrastructure. These include the Framework Act on Low Carbon Green Growth, enacted in 2010, and its successor, the Framework Act on Carbon Neutrality and Green Growth for Coping With Climate Crisis, enacted in 2021. Under these laws, the National Basic Plan for Low Carbon, Green Growth was implemented in three phases (Phase 1: 2009-2013, Phase 2: 2014-2018, and Phase 3: 2019-2023), and the Basic Plan for National Carbon Neutrality and Green Growth was adopted in 2023 under the new Act.[15] Korea's representative climate-related policy instrument is the Emissions Trading Scheme, introduced in 2015, and it also hosts key international organizations such as the Green Climate Fund (GCF) and the Global Green Growth Institute (GGGI).

Over the past 30 years, Korea's climate policy has gradually shifted from a passive stance to a more proactive approach, demonstrating a genuine commitment to fulfilling its obligations under international environmental governance. In addition, Korea has developed a relatively stable policy infrastructure in a logical sequence, including the enactment of governance arrangements. It has also consistently sought to enhance its international standing by attracting climate-related international organizations and hosting major global events. These efforts can be recognized as important achievements in Korea's integrated response to climate change. However, despite these activities, Korea has yet to deliver emission outcomes that are consistent with the reduction targets it has publicly announced and submitted.[16]



Source: Climate Action Tracker (July 2023)

[Figure 2] Assessment of Korea's Climate Action

12 The CAAD Report (2024) documented significant challenges posed by AI development, including substantial increases in energy and water consumption, as well as the amplification of climate-related misinformation through AI-generated content.

13 The UNFCCC's Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA) (the official decision-making body composed of representatives from countries that have joined the Paris Agreement, responsible for overseeing the implementation review and overall assessment) assessed that the overall efforts are "insufficient" and "not on track to achieve the long-term goal of the Paris Agreement" as a result of the first Global Stocktake (GST) (UNFCCC, 2023).

14 The World Meteorological Organization (WMO) announced that 2024 was the hottest year on record, with the average temperature 1.55°C higher than that of the pre-industrial period from 1850 to 1900 (October 10, 2025).

15 The Green Growth Committee was established as the top-level coordinating body under this framework and, after several institutional changes, currently functions as the 2050 Carbon Neutrality and Green Growth Committee. The Green Growth Committee, established during the Lee Myung-bak administration, was reorganized from a presidential agency to a prime ministerial agency during the Park Geun-hye administration. Under the Moon Jae-in administration, it was restored as a body directly under the President, renamed the "2050 Carbon Neutrality Committee," and has remained this status to the present.

16 The Lee Myung-bak administration pledged a 30% reduction compared to business-as-usual (BAU) levels by 2020, and the Park Geun-hye administration submitted the first National Determined Contribution (NDC). The Moon Jae-in administration submitted the second NDC and its second update, demonstrating strong commitment to climate action. However, Korea has never achieved an emissions reduction trajectory that aligns with these targets (See Figure 2.).

In the area of multilateral cooperation, Korea's contributions to the UNFCCC include sustained participation in negotiations and tangible achievements in technology cooperation. Since the Ministry of Science and ICT was designated as the National Designated Entity (NDE) in 2015, Korea has served on the Technology Executive Committee (TEC) for technology cooperation, with two representatives acting as Asia-Pacific members from 2016 to 2022, and has also strengthened its role as a board member of the Climate Technology Centre & Network (CTCN) since 2019. Furthermore, among the 958 CTCN network members eligible to participate in technology cooperation projects, Korea has the largest number, with 126 members (13.2%). In 2022, Korea also achieved the milestone of hosting the CTCN's only overseas Partnership and Liaison Office (PALO).[17]

3.2 Key Issues in Korea

Korea's climate action has been closely intertwined with the UNFCCC. At a time when public awareness of climate change and environmental issues was still limited in Korea, multilateral cooperation frameworks such as the UNFCCC functioned as external drivers by setting obligations and tasks that spurred the development of domestic legislation and policy infrastructure. Korea's accession to the UNFCCC and its agreement to the Kyoto Protocol are representative examples of this process. The Lee Myung-bak administration, which adopted “Low-Carbon, Green Growth” as a national slogan, can be regarded as a turning point from a largely passive stance to more voluntary climate action. Key initiatives during this period included enacting the Framework Act on Low Carbon, Green Growth, establishing the Green Growth Committee under this law, and formulating the Five-Year Green Growth Plan. Although these efforts did not fully translate into implementation consistent with announced targets, Korea, as a latecomer and industrializing economy, nonetheless contributed to advancing the global agenda by presenting its own national mitigation goals. The Moon Jae-in administration revised the existing framework into the Framework act on Carbon Neutrality and Green Growth for Coping with the Climate Crisis and pursued proactive and innovative climate policies, including the adaptation on multiple national plans and the enhancement of reduction targets. Furthermore, Korea’s 2020 carbon neutrality declaration positioned the country alongside other frontrunners in global climate governance and generated positive momentum both domestically and internationally.

While these efforts can be recognized and evaluated as meaningful achievements, constructive criticism is necessary to address remaining challenges and enable further progress. The most pressing issue is the need to analyze and review emission reduction targets that remain unfulfilled despite extensive policy efforts. When Korea prepared its first Nationally Determined Contribution (NDC) under the Paris Agreement, the target was submitted with limited analytical groundwork, insufficient academic validation, and inadequate consultation with civil society. By the time the second NDC and its subsequent update were submitted, Korea adopted a more advanced approach, setting and submitting its target based on an advanced-economy model rather than the previous developing-country model. However, the industrial sector criticized the upwardly revised target, arguing that it did not adequately reflect the structural characteristics of Korea’s manufacturing base and energy-intensive industries. Once a reduction pathway has been defined and quantitative targets have been set, corresponding implementation efforts should logically follow.

This outcome can be assessed as falling short of the primary target, similar to the 2020 reduction goal announced under the Lee Myung-bak administration. During the latter part of the Lee Myung-bak and Park Geun-hye administrations, the share of new and renewable energy in power generation - a key focus area for emission reduction – was only 3.67% in 2012 and 7.30% in 2016, indicating the results of insufficient implementation efforts.[18] Although the Moon Jae-in administration presented ambitious and innovative government targets, the share of new and renewable energy in power generation reached only 8.29%, raising questions about the implementation efforts of both governments and industry.[19] Due to this gap between declared ambition and actual implementation, Korea was labeled a “climate villain” by parts of the international community in 2016.[20] More recently, the Yoon Suk-yeol administration has come under renewed criticism, as Korea has received successive “Fossil of the Day” awards linked to continued fossil fuel investment and reductions in solar power generation.[21]

What explains this insufficient implementation of emission reduction targets? The causes can be broadly grouped into two dimensions: First, the internal dimension can be understood as arising from the fact that reduction targets were largely formulated by a small leading group without sufficient consensus among diverse stakeholders. During the Lee Myung-bak administration, climate policy was driven primarily by bureaucratic actors, whereas under the Moon Jae-in administration, decision-making was heavily influenced by civil society organizations and NGOs. As a result, perspectives from all segments of society were not systematically incorporated. This, in turn, contributed to non-participation and non-cooperation from industry, whose views were not adequately reflected, and to heightened criticism from civil society groups that felt their voices were selectively or insufficiently considered.

In the external dimension, Korea is influenced both by the shared obligations of the international community and by the actions of individual major powers, with the United States being the most prominent example. When Korea prepared its first emission reduction commitment under the UNFCCC, the Obama administration (January 2009–January 2017) pressed the Korean government to increase its target, and this pressure was subsequently reflected in the final goal.[22]

17 PALO was established in 2021 through an agreement between the Ministry of Science and ICT, Incheon Metropolitan City, and the United Nations Environment Programme (UNEP), CTCN's parent organization, and officially opened in July 2022.

18 This statistical data from the Korea Energy Agency combines new and renewable energy sources. Therefore, the proportion of renewable energy used as an indicator in the Climate Change Performance Index (CCPI) is estimated to be lower than this figure.

19 Same as above

20 Climate Home News (2016) labeled Korea a climate villain, citing its steep rise in emissions, investments in fossil fuels, and cancellation of its 2020 reduction targets.

21 According to an article in Hankyoreh 21 (November 22, 2024), Korea was ranked third place in the Fossil of the Day Award in 2023 and first place in 2024. This award is given to the country that is "doing the most to achieve the least" in terms of progress in climate negotiations. The primary reasons for receiving this award include opposing the prohibition of public financial support for fossil fuel projects and reviewing support for liquefied natural gas construction projects.

22 On June 12, 2015, the Seoul Economic Daily (2015) reported that President Obama requested President Park Geun-hye to demonstrate leadership in the field of climate change response by setting the most ambitious goals possible during their phone call. Prior to this call, Korea had been discussing four scenarios for setting its reduction target but ultimately raised its highest target from 31% to 37%, submitting it on June 30.

Korea later submitted an updated target in 2021 following its second NDC submission in 2020. At that time, the first term of Donald Trump (January 2017–January 2021), who showed limited interest in climate policy, has ended and the Joe Biden administration (January 2021–January 2025) has begun. Ahead of the May 2021 Korea-U.S. summit, Climate Envoy John Kerry strongly urged Korea to roughly double its reduction target, after which Korea submitted a 40% reduction plan relative to 2018 at the base year.[23]

Korea occupies an ambiguous position between developing and developed countries in the context of climate change. Although it is not included among the developed countries listed in Annex 1 of the Kyoto Protocol, Korea was recognized as a developed economy by the United Nations Conference on Trade and Development (UNCTAD) in 2021. Its industrial structure also differs from that of traditional advanced economies, as it only recently completed its transition from a newly industrialized country. Korea's greenhouse gas emissions peaked in 2018, significantly later than in many developed countries, such as those in Europe, where emissions generally peaked around 1990. This status makes it onerous for Korea to adopt fully proactive measures, yet it can no longer maintain the passive stance often associated with developing countries. Consequently, public awareness and engagement on climate change need to be elevated to the leven expected in advanced economies. In particular, with respect to responsible production and consumption, Korea must develop a model that reduces unnecessary purchases and curbs overall consumption through environmentally conscious choices.

4. Conclusion

To maintain a constructive multilateral relationship with the UNFCCC, Korea must strengthen its domestic preparedness, coherence, and institutional capacity for climate action. This requires building an internal culture of consensus among diverse stakeholders and aligning domestic interests toward a shared direction. In particular, government, industry, and civil society need to culviate mutual understanding and jointly pursue the value of green growth, seeking to reconcile economic prosperity with effective climate change mitigation and adaptation. Externally, Korea must position itself strategically between developed and developing countries in order to engage in productive negotiations, while simultaneously advancing multifaceted campaigns to raise public awareness. It will also need sufficient national capacity and diplomatic skill to respond flexibly to demands from major powers such as the United States.

The global community remains highly vulnerable to a catastrophic climate future if current levels of awareness, production and consumption patterns, and passive mitigation efforts persist. Yet the history of human development shows that societies have repeatedly overcome serious challenges and achieved new forms fo sustainable progress. In the specific context of climate change, there is also a hopeful trajectory: the establishment of a once-unimaginable multilateral regime, the gradual setting and implementation of voluntary targets, the tangible mitigation efforts made by Parties, and the increasing incorporation of sustainability principles into policy and practice. As recognition deepens that the climate crisis must be addressed collectively, and as this recognition is matched by more vigorous action, humanity can both resolve climate risks and pursue sustainable growth. The Path tha Korea must follow will be one that aligns with and contributes to this broader, wiser trajectory of human development.

23 The New York Times (May 20, 2021) reported that when John Kerry, the U.S. Special Presidential Envoy for Climate, visited Korea, he proposed to Korean government officials that Korea make efforts commensurate with those of the United States in reducing emissions. This level of effort was double Korea's reduction target at that time.

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PART 3

KISTEP News

KISTEP R&D and BEYOND

1

Inauguration Ceremony of Taeseog OH as the 11th President of KISTEP

Professor Taeseog OH of the Graduate School of MOT at Sogang University was inaugurated as the 11th President of KISTEP on April 1, 2025, beginning his three-year term.

The ceremony proceeded as follows:

- Opening remarks and the national anthem
- Introduction of President OH's background
- Inaugural address by President OH
- Presentation of a floral bouquet
- Group photo session

He earned a bachelor's degree in Economics from Seoul National University and a master's degree in Technology and Innovation Management from the University of Sussex in the UK. He entered public service after passing Korea's 35th Higher Civil Service Examination, and subsequently held senior positions including Secretary-General of the Presidential Advisory Council on Science and Technology, roles in the Office of Science, Technology and Innovation Coordination at the Ministry of Science and ICT (MSIT), and First Vice Minister of MSIT. Most recently, he has served as a professor at the Graduate School of MOT at Sogang University, teaching courses on innovation and policy, economic security, and national strategic technologies.

With over three decades in Korea's leading science and technology agencies, President OH has shaped R&D and innovation policies, and is widely recognized as an expert with deep insight, professional expertise, and steadfast leadership.

In his inaugural address, President OH said, "I am honored to assume KISTEP's presidency at a time of major global technological transformation and to lead an institution that has been a long-standing partner in innovation policy. To evolve beyond a policy-support agency into a leading innovation strategy think tank, we must achieve analytical excellence and provide timely, actionable recommendations."

He then outlined four strategic priorities:

- Integrating the end-to-end innovation-policy cycle—from strategy development and budget allocation to program evaluation
- Introducing new approaches to existing work streams
- Enhancing digital capabilities and cultivating skilled policy analysts
- Recruiting outstanding talent and nurturing a healthy organizational culture

He concluded by affirming KISTEP's commitment to proactively addressing pressing domestic and international challenges, underscoring its role in advancing Korea's innovation agenda.

President Taeseog OH delivering his inaugural address

President Taeseog OH delivering his inaugural address

2

Dr. Yujin Jeong of KISTEP Elected as the First Korean Vice Chair at OECD NESTI

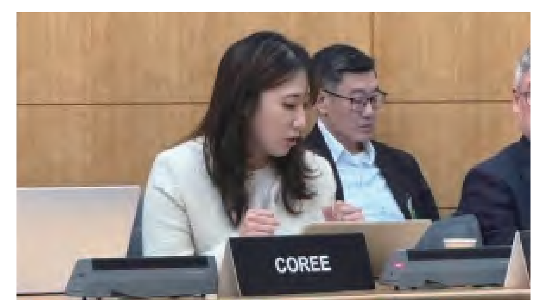
The Korea Institute of S&T Evaluation and Planning (KISTEP), led by President Byungseon Jeong, announced that Dr. Yujin Jeong, Associate Research Fellow at the Innovation Information Analysis Center, was elected Vice Chair of the OECD Working Party of National Experts on Science and Technology Indicators (NESTI). The election took place at NESTI's 120th plenary meeting in Paris last October. Jeong is the first Korean to serve as NESTI's Vice Chair. The term lasts for one year, and is subject to annual renewal.

About OECD NESTI:

Established in 1962 initially to develop the Frascati Manual, NESTI today supports the OECD's Committee for Scientific and Technological Policy (CSTP) through activities of a global network of experts specializing in science and technology indicators.

Dr. Jeong commented on her election, saying, "This appointment underscores Korea's growing leadership in the production and analysis of science and technology statistics and data. I will work to ensure Korea sets the agenda on the analysis and use of these statistics—particularly by leveraging AI and other emerging technologies—so that the achievements made on the global stage are effectively reflected in our domestic policies, contributing to a virtuous cycle."

▲ Overview of the 120th OECD NESTI plenary meeting

Vice Chair Yujin Jeong speaking as the Korean representative

3

KISTEP Receives a Ministerial Commendation from Minister of Science and ICT for Contributions to Materials, Parts, and Equipment Policy

The Center for Strategic Technology Policy at the Korea Institute of S&T Evaluation and Planning (KISTEP), led by President Byung-seon Jeong, received a Ministerial Commendation (group award) from the Minister of Science and ICT (MSIT) for its contributions to the National Research Infrastructure (3N) for materials, parts and equipment (MPE). The award was presented at the Integrated Awards Ceremony for Distinguished Service in Science and Technology Innovation, held at the Four Seasons Hotel on January 23, 2025.

The commendation was awarded to individuals and organizations in recognition of contributions to enhancing the National Research Infrastructure (3N) policy aimed at overcoming the materials, parts, and equipment (MPE) crisis and strengthening self-reliance over the year. Since the supply-chain crisis began in 2019, the Center for Strategic Technology Policy at the Korea Institute of Science and Technology Evaluation and Planning (KISTEP) has play a crucial role across the entire 3N policy cycle, including policy planning, selection and evaluation, operation, management, and monitoring, helping to establish the 3N collaboration framework and consolidate national capabilities.

At the ceremony, 75 additional contributors to science and technology innovation also received the Ministerial Commendation from the Minister of Science and ICT (MSIT). Six KISTEP staff members were among the honorees:

- Science & Technology Policy: Minjung Lee, Associate Research Fellow, Office of Policy Planning
- R&D Preliminary Feasibility Analysis: Moon Younghwan, Associate Research Fellow, Center for R&D Feasibility Analysis I ; and Hyejin Kim, Senior Program Administrator, Center for R&D Feasibility Analysis II
- National Strategic Technology: Jihye Ahn, Associate Research Fellow, Center for Strategic Technology Policy; and Taeyune Kim, Senior Program Administrator, Center for HRST Policy
- R&D Budget Allocation & Coordination: Mingyu Sung, Associate Research Fellow, Center for R&D Coordination

Jinyong Kim, Director of the Center for Strategic Technology Policy

Group photo

4

KISTEP Staff Members Receive Government Awards at the 2025 Science & ICT Day Ceremony

On Monday, April 21, the 2025 Science & ICT Day Commemoration Ceremony was held at the Korea Science and Technology Center. Marking the 58th Science Day (April 21) and the 70th Information and Communications Day (April 22), the event honored 157 individuals for their contributions to advancing science, technology, and ICT—as well as for excellence in national R&D performance evaluation.

Korea Institute of S&T Evaluation and Planning (KISTEP), headed by President Taeseog OH, was honored at this year's ceremony, with Center Director Myounghwa Kwon (Research Fellow) receiving the Presidential Citation and Center Director Juho Kim (Research Fellow) receiving the Prime Minister's Citation.

Myounghwa Kwon was granted the Presidential Citation in recognition of her efforts to establish a strategic support framework for regional and national science and technology innovation ecosystems, as well as for her work identifying policy-report agendas and providing advisory support to the Presidential Advisory Council on Science and Technology. Juho Kim was awarded the Prime Minister's Citation for his contributions to developing the cross-ministerial Integrated R&D Information System (IRIS), and for his efforts to drive performance improvements through the evaluation of research institutions under various ministries.

In addition, several KISTEP staff received Minister's Citations from the Ministry of Science and ICT:

- Kihun Kim, Senior Program Administrator Specialist Manager in Information Security
- Jungkyu Jung, Research Fellow in Science & Technology Promotion
- Geonwoo Choi, Senior Specialist Manager in Science & Technology Promotion
- Sein Kwon, Associate Research Fellow for National R&D Performance Evaluation
- Hyunhong Kim, Associate Research Fellow for National R&D Information
- Woongsup Shin, Senior Program Administrator in National R&D Information
- Saerom Lee, Researcher in National R&D Information
- Sooyoung Chi, Program Administrator in National R&D Information (awarded in absentia)

Myounghwa Kwon, Center Director (fifth from left)

Juho Kim, Center Director (fourth from right)

5

KISTEP Hosts Inaugural China Innovation Strategy Forum

On Tuesday, July 22, the Korea Institute of S&T Evaluation and Planning (KISTEP), led by President Taeseog OH, hosted the first China Innovation Strategy Forum at its headquarters in Chungbuk Innovation City. The aim of the forum was to offer fresh insights into China's high-tech industries while keeping discussions focused on innovation. Dr. Cheol Lee, an expert on China's economic policy, delivered a talk titled "China's Technology Strategy and Industrial Vision through the Lens of 'New Quality Productive Forces'."

In his opening remarks, President OH said, "We often benchmark advanced economies like the U.S., the EU and Japan, but tend to copy isolated cases without properly understanding the related institutions and context." Urging a sober view of the pace of Chinese innovation under the Communist Party-led socialist system in which the state and the private sector move in lockstep, he stressed that "what we need is not simple benchmarking, but a deeper understanding of China." He expressed hope that the forum would help Korea to gain a comprehensive understanding of China's strategies, and to explore appropriate policy directions that consider Korea's circumstances.

In his presentation, Dr. Cheol Lee argued that China is pursuing technology development strategies in the energy and digital sectors—both central to its national strategy—by integrating efforts across the military, economic and social domains. He contended that electric vehicles, AI, semiconductors and energy self-sufficiency are central instruments both in Beijing's pursuit of what it calls "reunification" with Taiwan and in countering U.S. influence. According to Dr. Lee, Xi Jinping has declared a shift toward "New Quality Productive Forces" to move the economy into higher-value-added industries through technological innovation and to "leapfrog the U.S." under the 15th Five-Year Plan (2026-2030). He urged Korea to craft a strategic response that is aligned with these developments.

Forum Highlights

1. Origins of Party Ideology and "Chinese-Style" Reform

To understand China's technology strategy, one needs to start with the identity of the Communist Party and the evolution of its ideology. Unlike European Marxism, Chinese communism adapted to Asian realities, particularly poverty and food scarcity. The ideology evolved from Mao Zedong's "class struggle" to Deng Xiaoping's "black cat, white cat" pragmatism and then to Jiang Zemin's "Three Represents," which expanded the Party's legitimacy to include not just workers but also capitalists and intellectuals. Hu Jintao held office with limited real power, and under Xi Jinping the current strategic line took shape.

2. Xi Jinping's Leadership and China's Centennial Goals

The Party set dual centennial goals: achieving a "moderately prosperous society" (xiaokang) by its 100th anniversary in 2021 and becoming a "modern socialist great power" by 2049. Dr. Lee argued that pursuing cross-Strait unification is central to achieving these goals; it is not merely a political issue, but is also a strategic objective directly tied to technology, defense and energy self-sufficiency. China sets quantitative targets—for air and water quality, income levels and more—and mobilizes the full range of state resources to meet them.

3. Technology Self-Reliance: De-Americanization and EV Promotion

To hedge against U.S. tech controls, China is pursuing a "Delete Plan" that directs state-owned enterprises to phase out U.S. software and technologies by 2027 under a confidential

Taeseog OH, President of KISTEP, delivering opening remarks

Dr. Cheol Lee delivering his presentation directive known as "No. 79." Operating systems are to be replaced with Huawei's HarmonyOS and chips with domestic alternatives. In addition, Beijing has designated electric vehicles as a national strategic industry to reduce the country's dependence on imported oil. While initially the quality of Chinese EVs was poor, rapid progress followed through sustained investment, Tesla's Gigafactory Shanghai, and fast-follower tactics such as benchmarking and reverse engineering. At Tesla's Shanghai plant, about 95% of components are now locally sourced—a shift that attests to the success of the localization push.

4. Energy and Food Security Linked to S&T Strategy

To achieve energy self-reliance, China is pursuing nuclear, solar and hydrogen energy alongside energy storage systems (ESS). It is rapidly electrifying transport, which accounts for roughly half of the national demand for fuel, and its high-voltage direct current (HVDC) transmission is among the most advanced in the world. Hydrogen-based transport networks are currently being developed, and China is also enhancing its investment in agricultural science and technology (S&T) to boost food self-sufficiency. In 2023, Chinese research on improving corn varieties won a national S&T award. Beijing has announced plans to reduce its grain imports to one-tenth of current levels by 2030, as it aims to lessen its reliance on the U.S. and Brazil.

5. AI- and Data-Centric Strategy and Digital Transformation

Shocked by the emergence of ChatGPT, China has come to regard AI development as a "national strategic weapon," and is pushing ahead with AI-chip development and data-nationalization policies. The government has established the National Data Administration (NDA), designating data as a strategic asset and bringing it under centralized state oversight. Regional data exchanges are being set up across China to collect and integrate privately held data, improving the efficiency of AI training. China has begun building an integrated system linking software-defined electric vehicles (built on a digital-layer architecture), smart roads, satellite communications (6G) and drones—with direct implications for defense readiness and military strategy.

6. Industrial Strategy: Transition to "New Quality Productive Forces" and Innovation Pressure

In the past, China drove GDP growth and employment through quantity-driven expansion, but it has since hit the limits of persistent overcapacity and a low-margin model. In response, Xi Jinping has declared a shift to "New Quality Productive Forces," urging a transition toward higher-value-added industries through technological innovation. More than a mere slogan, the Chinese Communist Party (CCP) considers technological innovation as imperative for national survival, tasking government S&T officials and researchers with explicit targets to overtake the U.S. In fact, the 15th Five-Year Plan (2026-2030) places surpassing the U.S. in technology at its core. China aims to realize this by mobilizing more than six million domestic STEM graduates.

7. Preparing for the Future: War-Risk Implications and Required Responses

U.S. assessments anticipate that China may move to forcibly unify with Taiwan around 2030, and Washington is preparing accordingly. China is also aligning the target dates for achieving energy and food self-sufficiency with that horizon. Strategic investments in autonomous weapons, drones, smart roads and robotic production systems are being made with potential wartime applications in mind. The recently unveiled "Walker S2" industrial humanoid robot—symbolizing the move toward autonomous charging and round-the-clock production—is being deployed on actual assembly lines.

8. Conclusion: Korea's Response Agenda

Dr. Lee emphasized that China's S&T strategy is more than an economic policy; it is intertwined with national strategy and a wartime-preparedness system. He argued that Korea needs coherence in its policy—aligning S&T policy across ministries and with industry—to enable immediate crisis response. He warned that current formalistic medium-term plans cannot support an effective response.

6

KISTEP Hosts National Strategic Technology Seminar on Physical AI

Physical AI is emerging as a core technology that can be applied in real-world industrial settings—from the factory floor to field operations—to boost industrial competitiveness. It is expected to play a pivotal role in advancing major national policies and the administration's key policy agenda over the next four to five years. It was on this background that on Thursday, August 14, the Korea Institute of S&T Evaluation and Planning (KISTEP), led by President Taeseog OH, hosted the National Strategic Technology Seminar on Physical AI at its headquarters in Chungbuk Innovation City.

The seminar was organized to explain the concept of Physical AI, assess its potential applications in industry and explore strategic directions to strengthen Korea's industrial competitiveness. Byung-hee Son, director of the Maeum AI Research Institute, delivered an in-depth presentation on the latest in Physical AI, including its social context and necessity, real-world use cases and global trends.

Son defined Physical AI as "AI that operates in the real world, where the laws of physics apply" and discussed its potential to expand into a wide range of sectors, including robotics, autonomous vehicles (AVs), agriculture, defense and public services. Highlighting case studies—including an unmanned pesticide sprayer, an autonomous air purifier and an accessible kiosk—she argued that Physical AI can help address the labor shortages that are resulting from an aging and declining population. She went on to identify on-device AI, model compression and optimization, and physics-informed learning as core competitive strengths. Finally, she called for the development of domain-specific models using digital twins and simulation, and highlighted the need to target global niche markets through partnerships with small and medium-sized enterprises (SMEs).

Taeseog OH, President of KISTEP, delivering opening remarks

Byung-hee Son, Director of the Maeum AI Research Institute

Seminar Highlights

1. What Physical AI Is, and Why It Matters

Unlike traditional AI, which is confined to digital environments such as text, images and video, Physical AI applies the laws of physics to operate in the real world. It goes beyond simple simulation or video generation, enabling robots and machines to perform tasks and take action in real-world settings. Generative AI focuses on content creation, AI agents on decision-making and task execution in digital environments, and Physical AI on robots and automation systems operating in the physical world. The need for physical AI is growing, particularly to address labor shortages amid population decline and to ensure safety and efficiency across industries, including manufacturing, agriculture and defense.

2. Core Technical Pillars

- **On-device AI:** Runs AI models locally on the device without relying on a network connection, ensuring their continued operation in unstable environments while strengthening security and privacy. A notable example is the world's first attempt to run AI models directly on Qualcomm's QCT6400 IoT chip.
- **Digital twin-based simulation:** Replicates real environments in a virtual space to generate large volumes of physics-based synthetic data, and then trains models on synthetic and real data in parallel to reduce error rates.
- **General-purpose foundation model + engineering:** Builds on a general-purpose foundation model and tailors it through fine-tuning and engineering to site conditions and domain-specific requirements to optimize performance.
- **Model compression and optimization:** Adjusts performance to model size and hardware resources and flexibly replaces or combines models depending on the objective.

3. Industry Use Cases

- **Agriculture:** An autonomous pesticide sprayer that uses GPS and voice recognition to avoid obstacles has secured a mass-production contract in Korea for 100 units, and has been successfully launched in the Indonesian market.
- **Defense:** Unmanned reconnaissance robot teams perform high-risk missions, including mine detection, battlefield reconnaissance and access to hazardous areas.
- **Home Appliances:** An autonomous, voice-enabled air purifier recognizes commands even in noisy environments and navigates to the requested room.
- **Public Services:** An accessible kiosk automatically adjusts the screen height when it detects a wheelchair approaching, and provides multilingual and voice-based interactions.

4. Global Landscape and South Korea's Strategy

While the United States prioritizes high-value, high-volume production with cloud-centric deployments for large-scale manufacturing, China is focused on low-cost production and entertainment-driven markets. Considering this, South Korea is well-positioned to pursue a niche-market strategy of pairing on-device AI with regionally specialized industries—automotive, shipbuilding, agriculture and tourism—to build a differentiated competitive edge.

5. Technology and Industry Recommendations

- **Data Strategy:** In a highly regulated domestic environment, leverage virtual environments and self-training to rapidly strengthen competitiveness and build on-site datasets using digital platforms tailored to regionally specialized industries.
- **Industrial Priorities:** Focus on industries with long value chains (e.g., automotive, shipbuilding) and on sectors where safety and efficiency are paramount (public sector, defense, agriculture).
- **Collaboration Model:** Build close partnerships between robotics and AI companies for hardware control, navigation and the development of perception and decision-making models.
- **Regional Specialization:** Tailor AI applications to local industrial structures and further refine custom datasets—for example, in Incheon (biotech, ports and aviation) and Jeju Island (agriculture and tourism).

6. Long-Term Outlook for Physical AI

Over the next one to two years, on-site collaboration between robots and AI is expected to see broad adoption, and within 10 years is projected to replace physical labor across industries while creating new jobs. Physical AI is expected to establish itself as a key technology for national competitiveness.

7

KISTEP Hosts 2nd China Innovation Strategy Forum

On Tuesday, August 26, the Korea Institute of S&T Evaluation and Planning (KISTEP; President Taeseog OH) held the 2nd China Innovation Strategy Forum at its headquarters in Chungbuk Innovation City. In alignment with Korea's strategy for technology-led growth, the forum was designed to look not only at China's experiences and case studies but also at its broader economy. Byung-seo Jeon, Director of the China Economic & Finance Research Institute, delivered a keynote titled "Why Are China's AI and Robots So Strong?"

In his opening remarks, President Taeseog OH said, "The government has emphasized technology-led and technology-frontier growth and is investing more than KRW 35 trillion, ensuring that research outcomes translate into industry is more important than anything else." He added, "China, too, is growing rapidly under a government-led model in which institutes, universities, and companies drive innovation together." Emphasizing the value of closely examining these trends for Korea, he noted, "I hope today's lecture offers a new lens through which to view China."

Director Byung-seo Jeon argued that AI has become more than a technology—it is now a core instrument of capital and national competitiveness, reshaping not only labor and industrial structures but also military and diplomatic strategy. As the U.S.–China technological rivalry intensifies, he said, clashes over semiconductors, batteries, rare earth minerals, and telecommunications—the infrastructure of national power—are accelerating. Under a consistent state-led strategy, China is building global competitiveness in big data, electric vehicles, robotics, and AI; it accounts for roughly 75% of the global EV market and is growing thanks to overwhelming scale [IR1.1] and sustained investments in talent. The United States possesses world-class technology but a weaker manufacturing base; in contrast, China has manufacturing might but lacks certain core technologies. In this context, Jeon emphasized that Korea should leverage its strategic advantages in semiconductors and batteries to strengthen its global standing and secure a distinctive position.

Forum Highlights

1. AI and Global Primacy

AI is not merely a technology; it is a central lever of national competitiveness, steering capital flows and fundamentally transforming industrial structures, labor, and even military and diplomatic strategy. The U.S.–China confrontation is escalating into a contest for technological primacy over strategic infrastructure—semiconductors, batteries, rare earth minerals, and telecom.

Opening remarks by KISTEP President Taeseog OH

Keynote by Director Byung-seo Jeon

2. Drivers of China's Rise

China's rapid emergence as a technology powerhouse is rooted in a long-term, government-led strategy that has been pursued with consistency. Unlike Korea—where policy direction often shifts markedly with each change of administration—China has carried the same national strategy forward for decades without wavering. Concentrating massive resources in core fields—big data, electric vehicles, robotics, and AI—while maintaining policy stability and continuity has been a decisive driver of China's remarkable ascent.

3. AI, Big Data, and Autonomous Driving

AI's success ultimately hinges on data, and autonomous electric vehicles—capable of accumulating hundreds of times the data generated by smartphones—are poised to become the focal point of future AI competition. China already accounts for roughly 75% of the global EV market, and has secured an end-to-end, self-reliant supply chain spanning batteries, minerals, and components. This vast data advantage, coupled with a fully integrated supply chain, underpins China's emergence at the forefront of the AI industry.

4. Industrial and Military Strategy with AI

AI now plays a decisive role not only in industry but also in military strategy. An era has arrived in which it is AI-enabled drones and unmanned weapon systems, rather than traditional troop-centric warfare, that are shaping the battlespace. Moreover, as U.S.–China tensions spread beyond trade and technology into finance, resources, and capital, securing strategic materials—such as rare earth minerals—is emerging as a key determinant of both national security and industrial competitiveness.

5. China's Innovation Ecosystem

Innovation in China is booming amid fierce competition—with approximately 25,000 new companies founded each day. Robotics, smart factories, and even consumer AI robots have already moved into commercial deployment, and the country holds a commanding lead in global patent filings. Crucially, China has sustained the same set of strategic technology priorities for more than a decade. This demonstrates that policy consistency and continuity are the bedrock of innovation.

6. Implications

The United States excels in technology but has a relatively weak manufacturing base; China, in contrast, has manufacturing strength but gaps in core technologies. Within this landscape, Korea holds strategic advantages in two pillars—semiconductors and batteries—and has an opportunity to leverage them to secure a distinctive position in global supply chains. To translate that opportunity into outcomes, Korea needs to:

- Sustain a consistent national strategy that continues regardless of changes in administration;
- Strengthen a talent-development system with deep specialization to counter China's vast talent pool; and
- Increase its strategic bargaining power amid U.S.–China competition and position Korean technologies as global strategic assets

Ultimately, in the age of AI, Korea's future hinges on maintaining a long-term policy horizon and strategically deploying its talent and technology.

8

Establishing the Deputy Prime Minister for Science and Technology; Forum on Roles and Tasks for Technology-Driven Growth Held

Beyond science and technology per se, broader authority to steer national innovation is needed … High expectations as the Deputy Prime Minister for Science and Technology reinstated after 17 years

Experts in Korea's science and technology community welcomed the decision to reinstate the Deputy Prime Minister for Science and Technology (hereinafter, DPM for S&T) after 17 years. They also reached a consensus that the post must be endowed with the authority to coordinate the nation's innovation policy end-to-end, in order for the DPM for S&T to aid in overcoming mounting domestic and international challenges.

The Korea Institute of S&T Evaluation and Planning (KISTEP; President Taeseog OH), the Korean Federation of Science and Technology Societies (KOFST; Acting President Min-su Kim), the National Academy of Engineering of Korea (NAEK; President Eui-joon Yoon), and the Science and Technology Policy Institute (STEPI; President Ji-woong Yoon) co-hosted a forum, "Establishing the Deputy Prime Minister for Science and Technology: Roles and Tasks for Technology-Driven Growth ," on September 23 at 2:00 p.m. in Grand Conference Room 2, Korea Science and Technology Center. About 200 experts attended, and engaged in a wide-ranging discussion on strengthening whole-of-government coordination and the agenda for technology-led growth following the creation of the DPM for S&T.

In his welcoming remarks, KISTEP President Taeseog OH commented, "The creation of the DPM for S&T role signals the government's firm commitment to genuine, technology-led growth based on science, technology, and AI." He urged that the DPM's coordinating role be strengthened so the office can link and align innovation policies across ministries and scale outstanding research outcomes across industries.

KOFST Acting President Min-su Kim called the timing "highly appropriate at this moment when technological paradigms determine national competitiveness," adding that he hopes the new system will deliver tangible results, laying the groundwork for R&D-system innovation and policy consistency and continuity.

NAEK President Eui-joon Yoon stressed that the revival of the post is "more than an organizational tweak; it is a consequential decision for Korea's future," and urged government, industry, and the S&T community to tear down silos and pool wisdom toward the shared goal of sustainable development.

In a video message, STEPI President Jiwoong Yoon described the DPM for S&T as a powerful control tower spanning science, technology, and AI, expressing the hope that, on the foundation of this institutional reform, inter-ministerial cooperation will be strengthened and science and technology will play a greater role in national-strategy domains.

The expert presentations followed. Prof. Joonmo Ahn (Korea University) spoke on "Innovating Science and Technology Policy Governance: The Meaning of the DPM for S&T and New Policy Directions." Citing the Huawei R&D campus (roughly half the size of Yeouido; KRW 31.5 trillion in R&D spending in 2023), he argued that in an era of technological sovereignty, coordination efforts by the DPM for S&T are essential. He proposed five priorities for the office: policy convergence, overhauling operating systems and budget authority, designing incentives for inter-ministerial cooperation, packaging regulation and policy tools, and making policy more evidence-based.

Welcome Remarks by KISTEP President Taeseog OH

Panel discussion

STEPI Vice President Chansoo Park presented on "Improving National R&D Coordination and Management Systems to Create Synergies Across Innovation Resources." He said, "If the Deputy Prime Minister for Economy oversees the present, the DPM for S&T should oversee the future," urging that the role should evolve into a Deputy Prime Minister for Innovation who coordinates national innovation resources. Citing the United States' specialist visa issues as an example, he noted that innovation challenges span multiple ministries—including the Ministry of Science and ICT, the Ministry of Foreign Affairs, the Ministry of Justice, the Ministry of Employment and Labor, and the Ministry of Trade, Industry and Energy—and called for a DPM capable of embracing policy holistically from an innovation perspective.

NAEK Vice President Su-kyung Park (Professor of Mechanical Engineering, KAIST) spoke on "Execution Tasks for Linking R&D Outcomes Under a Deputy Prime Minister System." She argued that the DPM for S&T should function as a Deputy Prime Minister for Innovation, and that rather than focusing narrowly on short-term metrics during a single term (papers, patents, tech transfer), the role should reset the definition of success to emphasize cultivating a culture of innovation and building collaboration platforms. She also stressed that the key is to build innovation governance that goes beyond the KRW 30 trillion R&D budget, integrating ministry, industry, and research resources.

In the subsequent panel discussion moderated by KISTEP Vice President ByoungHo Son, participants Joonyeon Chang (Vice President, KIST), Jaecheol Kwon (Research Fellow, Commercialization Promotion Agency for R&D Outcome (COMPA)), and Woo-seok Jang (Senior Research Fellow, Hyundai Research Institute) offered their views. Citing the example of Japan's revision of its Framework Act on Science and Technology into the Basic Act on Science, Technology, and Innovation, Vice President Son suggested that legal backing is needed so the DPM for S&T can lead innovation policy as a whole.

Vice President Joonyeon Chang urged the DPM for S&T to act as a national project manager (PM) steering national innovation projects, so that S&T policy not only drives technology-led growth but also translates into growth for all. Research Fellow Jae-cheol Kwon, a former policy aide to the DPM for S&T, proposed a fast-track mechanism be introduced so that decisions of the Ministers' Meeting on Science and Technology can be reflected quickly in the budget, thereby conferring real authority. Senior Research Fellow Woo-seok Jang emphasized the importance of mathematics education in the age of AI, asking the DPM for S&T to devote attention to elementary and secondary education reform and strengthening math education.

Former Minister of Science and ICT Sangim Yoo also attended, noting that in an AI great-transition, the control-tower function of the DPM for S&T is crucial. He emphasized the need for leadership that fosters inter-ministerial communication and for science-and-technology diplomacy to support global cooperation—underscoring the community's intense interest in the role.

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"South Korea Aims for a Global Leap Forward Through R&D Stability and AI Innovation" — 2025 INNOPOLIS Global Forum

Taeseog OH, president of the Korea Institute of S&T Evaluation and Planning (KISTEP), delivered a keynote address on Thursday, September 4, in the Crystal Ballroom at Lotte City Hotel Daejeon during the 2025 INNOPOLIS Global Forum. The forum was convened to address major challenges facing the Republic of Korea—including population decline, a falling potential growth rate, instability in global supply chains and intensifying U.S.-China technological competition—and to explore avenues for international cooperation through technology-driven innovation.

In his keynote address titled "Shifting Science, Technology and Innovation (STI) Policy for Technology-Driven Growth," President OH emphasized that Korea's advancement was achieved through science and technology, and that it must continue to rely on them to overcome future crises. He noted that while Korea has propelled its economy with one of the world's highest R&D investment ratios—4.96% of GDP in 2023—and strong research output, it now faces structural headwinds, including a potential growth rate that is projected to decline to 2% by 2026 and ongoing turbulence in global supply chains. He added that abrupt policy shifts—such as a 14% year-over-year cut in the 2024 government R&D budget—have weakened trust in the research community and discouraged long-term private-sector investment.

President OH pointed out that despite steady increases in government R&D spending, rapid year-to-year shifts in policy priorities have heightened instability across the research sector. As a result, the absence of a long-term strategy and the erosion of trust have become evident. Amid this uncertainty, companies have also expressed concern that the emphasis is increasingly shifting from long-term and basic research to short-term, results-driven projects.

Taeseog OH, president of KISTEP, delivers the keynote address

He introduced the Lee Jae-myung administration's "True Growth" strategy, whose core pillars are Technology-Driven Growth, Growth for All and Equitable Growth. To advance technology-driven growth, he outlined five directions: becoming a global AI powerhouse, fostering future industries, building an innovation ecosystem, cultivating talent and diversifying supply chains. President OH went on to present concrete steps: ensuring stability in R&D, concentrating investment in AI, modernizing the research environment, and reforming governance.

Finally, President OH underscored the need for international cooperation, noting that these challenges are global, and are not unique to Korea. "Instead of avoiding risk, Korea should use R&D and innovation as a breakthrough to open up new growth," he said, expressing hope that the forum would serve as a starting point. The panel that followed—moderated by Jiwoong Yoon, president of the Science and Technology Policy Institute (STEPI)—featured President OH and Mario Cervantes, a senior analyst at the OECD, in a session titled "The Evolution and Vision of Global Science, Technology and Innovation (STI) Policy."

Taeseog OH, president of KISTEP, joins the panel discussion

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