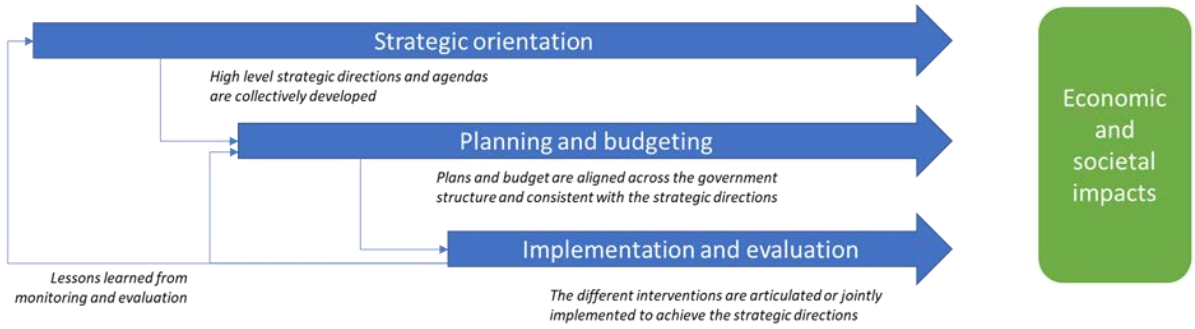
5 Science, technology and innovation governance for a new era of innovation in Korea

This chapter discusses the historic development and current state of the governance framework of Korea's science, technology and innovation (STI) system. This framework provides strategic orientation to the system, aims to ensure the necessary co-ordination to align actors' plans and resources and lead the implementation of related policies. The chapter also assesses the potential of this governance framework to help Korea face current and future challenges.

STI governance is defined in this chapter as the set of largely publicly defined institutional arrangements that supervise and co-ordinate how the various public and private actors engaged in socio-economic development interact in allocating and managing resources devoted to different policy fields (OECD, 2010[1]). It includes a wide range of components that are deeply embedded in national innovation systems, such as governing bodies and their assigned mandates, incentive structures, administrative rules and guidelines, networks, visions, social norms, values and culture, stakeholder and citizen representation mechanisms, and knowledge management strategies to inform the decision-making process.

The chapter begins with an overview of the historical evolution of STI governance and policy in Korea and the STI governance system currently. The three following sections examine the main current policy actors and review the arrangements to achieve the three key functions of STI governance systems: 1) strategic orientation; 2) programming and budgeting; and 3) policy implementation (Figure 5.1). A dedicated section then deals with the specific systemic strategic and policy initiatives that aim to support the sustainability transition of the Korean economy. The last section synthesises the main achievements and challenges in improving STI system governance in Korea.

Figure 5.1. The three main functions of STI governance in Korea



Source: OECD based on desk research and stakeholder interviews.

Building on a systematic review of the governance mechanisms and institutions in place, the main conclusions of this chapter are as follows.

First, Korea has set up a unique STI governance structure to provide STI strategic directions, align plans and budgets and articulate and monitor interventions across the whole of government. The particularity of this structure lies notably in the powerful mandate of the Presidential Advisory Council on Science and Technology (PACST) and the Ministry of Science and ICT (MSIT) in the cross-governmental co-ordination of the STI system via its Science, Technology and Innovation Office (hereafter, “STI Office”). This “control tower” plays a prominent role in developing the five-year Basic Plan and aligning sectoral ministries’ mid-term and annual plans with it, as well as in the annual budgeting review of research and development (R&D) programmes and their monitoring and evaluation. This governance has been instrumental in ensuring strategic coherence during a period of rapid expansion of the Korean STI system and the shift from a position of fast follower to that of scientific and technological leader in some key high-growth areas.

Second, this STI governance structure is now confronted, however, with two main issues that call for reforms. Firstly, the system's growth calls into question the sustainability of the current centralised co-ordination mechanisms, particularly when more flexible and inclusive governance is required to cope with a turbulent and complex environment. Secondly, like in many other advanced economies, the need to address growing societal challenges requires more issue-based and integrated co-ordination mechanisms that articulate for each challenge the strategic, planning and implementation functions of governance, with direct and continuous interactions between the main decision makers and stakeholders in each challenge area. A key element of agile governance is the integration of strategy throughout the policy cycle to attain

specific goals rather than a sequential process characterised by successive functional stages with their own actors and processes.

While there are numerous experimentations with new forms of governance and policy making in many countries, notably around the mission-oriented policy approach, no country has yet fully implemented "third generation" governance.[1] Building on the strengths of its existing governance structure, Korea can become a front-runner in this respect.

5.1. The development of the Korean STI governance system

This section presents the history of the formation of the Korean STI governance system with a view to better understanding the extent to which the current system is influenced by its past. Three main periods are distinguished in the development of Korea's STI governance system. This analysis shows the strong government top-down and centralised governance that has been essential to guiding the contribution of STI to Korea's remarkable growth during the catch-up period (first period). This system has been replaced by comprehensive centralised co-ordination and planning mechanisms in the post-catch-up period (200-22). Korea is now entering a third stage as it faces new economic and societal challenges and must transition to a new sustainable growth model, to be guided by a reformed STI governance system.

5.1.1. The emergence of an autonomous national innovation system (1962-2000)

The national orientations for STI development were set out in various plans, not least the five-year national economic development plans from 1962 until the 1990s[2]. Although the scope of these national plans extended far beyond technological innovation, the importance of their role in acquiring and learning from foreign technologies in targeted industries has been well documented (Pirie, 2008[2]) (Heo et al., 2008[3]). There were other national *dirigiste* planning mechanisms, such as the five-year Technology Promotion Plans. Although they played important roles in gradually building a more self-sufficient STI system that relied upon national knowledge and innovation resources and capabilities, government STI plans and interventions still depended significantly on companies' demand and remained subordinated to economic and industrial development policies. The government research institutes (GRIs) also played a major role in absorbing key foreign technologies and transmitting them to large Korean conglomerates. Private firms also received significant guidance and support from state authorities via subsidised loans, specific licences to enter targeted industries and protective regulations. The benefits of these new technologies and associated learning partially trickled down to other parts of industry through backward linkages and long-term production networks with local small- and medium-sized enterprises (SMEs).

While the first Korean Technology Development Promotion Policy covered the period from 1962 to 1966, the government's role in supporting research and innovation (R&I) activities remained embedded in the national development policy until the 1980s. More autonomous STI policies – i.e. policies that are still connected to other parts of the economy but are driven by a distinct strategy to develop knowledge and innovation with proper decision centres, modes of intervention and resources – started to emerge during this decade. The first national R&D programme, known as the Specific R&D Programme, was initiated by the former authority in charge of science and technology (S&T) (Ministry of Science and Technology) in 1982, based on the Technology Development Promotion Act. This programme was designed to incubate national S&T capacity and promote the development of core technologies. At the same time, following the examples of the United States and Japan, the government introduced a new tool in the form of large pre-competitive consortia that gathered multiple firms and focused on targeted industrial technologies, such as semiconductors and various information technology (IT) technologies. The first was created in 1982 as the Industrial Research Association, modelled after the Japanese Technological Research Associations. Others soon followed, including those in sectoral ministries (Sakakibara and Cho, 2022[4]).[3]

In the second half of the 1990s, an increasing emphasis was put on fundamental research to produce the indigenous R&I knowledge base needed to support cutting-edge technological development (Yim and Kim, 2005[5]). Initiatives to support research commercialisation complemented these investments. Following the need for a nationwide and more co-ordinated R&D programme, the Highly Advanced National (HAN) Project (also known as the G7 Project)[4] was launched in 1992 and ended in 2001. It was the first mid- to long-term national R&D plan. It was deemed instrumental in fostering industries where Korean companies are now global leaders: semiconductors, various IT segments, electronics and automobiles.

During this first period, and particularly until the 1990s, the governance structure of the nascent STI system that underpinned the progressive strengthening of indigenous R&D capabilities was led by the president, the Presidential Secretary's Office and a group of high-level government officials (Seong, 2011[6]). Implementation was also centralised in one organisation that managed all national R&D activities, the Agency of Science and Technology (the precursor of the ministries in charge of research). The first co-ordination council was created in 1973 with the Prime Minister as chair and composed of 14 ministers under the name of the Science and Technology Review Committee. It was not very active in the 1970s and 1980s. However, the need for effective co-ordination increased significantly in the first half of the 1990s as the scale and scope of the system expanded rapidly. It called for a more elaborated governance framework, with a range of specialised competencies and decision-making institutions in different parts of the government. This system expansion was manifest in the rise of private R&D investment[5] and the number of sectoral ministries (agriculture, transport, health, land and construction, etc.) that started to invest significantly in R&D activities. This translated into growing issues of inter-ministerial co-ordination (Oh and Lee, 2013[7]). Issues ranged from overlaps between ministries' programmes and conflicting policy objectives in a context of fierce competition for power and budget to a tendency of ministries to imitate and duplicate each other's programmes rather than initiating ones based on sound strategy and understanding of stakeholders' (notably in industry) needs in their policy area (Hong, 2005[8]).

5.1.2. The maturing of the STI governance system (2001-22)

The growing need for more strategic steering in a changing national and international context and the increase of co-ordination issues led the government to radically change the governance structure at the beginning of the 2000s. The context of significant increases in government R&D expenditures made these reforms at the same time possible and necessary, as an increasing number and broadening range of programmes and projects had to be planned, managed and evaluated. Within five years, the legal framework and organisational structure were set up that, although reformed many times since then, still prevail. These include the creation of the Ministry of Science and Technology in 1998 (based on the previous form of the Ministry of Science and Technology[6]); the establishment of a new, more powerful, co-ordination council (the National Science and Technology Council, NSTC) in 1999; the enactment of the Framework Act on Science and Technology in 2001; the launch of the first five-year S&T Basic Plan in 2002; and the creation of an executive office to take charge of an increasing range of STI governance functions (the Science, Technology and Innovation Office; hereafter "STI Office").

Creating the Framework Act on Science and Technology in 2001 was a key milestone in elaborating the Korean STI governance system. It provided the legal basis for the main organisations and mechanisms to centrally co-ordinate all STI-related policies. Since then, it has been amended several times and implemented through a multiplication of new or reformed funding bodies, enforcement decrees, regulations and programmes. It has also been progressively complemented by various other laws in specific areas (evaluation, management of agencies, etc.).

The launch of the first five-year S&T Basic Plan in 2002 (covering the period 2002-06) marked another important step in developing a system of innovation, with its own strategic orientations developed from the system itself and implemented by competent authorities with their respective modes of interventions. The Basic Plan was the first plan to cover and integrate into one common framework the different facets of the

Korean National Innovation System Model enacted in 2002, from the management of national R&D programmes to the promotion of public awareness of STI, to the development of R&I human resources and skills, to the improvement of technology transfer, and to international research co-operation.

The Framework Act and Basic Plan provided the legal and strategic foundations of the system, but powerful institutions were needed to operate STI governance in practice. This gap was soon filled with the creation of a new and more powerful co-ordination council (the NSTC, as mentioned above), then later the STI Office. Apart from short periods of reduction in size and change of mandate, these two organisations saw their prerogatives significantly augmented in several waves of reforms.[7]

Despite these reforms, co-ordination was still deemed insufficient. Issues of policy co-ordination between different ministries were highlighted in the World Bank review of 2000 (Dahlman and Anderson, 2000[9]) and the OECD 2009 and 2014 Innovation policy reviews of Korea (OECD, 2009[10]; OECD, 2014[11]). To overcome these issues, new laws and mechanisms were set up (i.e. for monitoring sectoral ministries' plans and programmes for forming the R&D budget), and additional power and legitimacy were granted to central executive and deliberative institutions.

There have also been attempts to merge or reorganise ministries and agencies to improve co-ordination and/or streamline structures. For instance, in 2008, the Ministry of Science and Technology (MOST) and the Ministry of Education (MOE) merged to become the Ministry of Education, Science and Technology (MEST). Also significant was the creation in 2008 of the Ministry of Knowledge Economy (MKE), integrating parts of the former Ministry of Commerce, Industry and Energy (MOCIE), the Ministry of Information and Communication (MIC) and MOST. The aim of this "super ministry", active until 2013 when it was disbanded,[8] was to have a more integrated policy structure and to increase co-operation between policy portfolios to strengthen the knowledge and technological base of industries in key industries to develop new sources of growth (not least around semiconductors, IT and biotechnology).

Agencies also underwent several structural changes, such as the creation of Korean Energy Technology Evaluation and Planning (KETEP) from the mergers of four energy R&D organisations. In addition, GRIs have been transferred among various ministries and research councils, though the structure seems to have stabilised somewhat since 2014 (see Chapter 4).

Alongside these structural changes, Korea set up in the 2000s a unique governance system to steer, co-ordinate and implement a fast-growing array of STI government interventions across more than 20 ministries and many agencies. To reconcile this expansion with a tradition of strategic integration inherited from the model in place during the catch-up period, the government granted a powerful mandate to central executive and co-ordination bodies and introduced an increasing number of co-ordination, budgeting and monitoring mechanisms, rules and guidelines throughout the entire government structure.

5.1.3. Towards a new STI governance system: From 2022 onwards

Korea is currently entering a third stage. It is confronted with new challenges, not least the imbalances and polarisation (social, geographic) resulting from its rapid growth period and the threats of societal challenges, such as climate change and ageing. Although significant reforms were implemented during the 2000s as Korea was searching for a "post-catch-up" model, the legacy of the Korean "developmental state" period, during which the government's proactive policies and regulations led the country's growth trajectory, is still present in the centralised STI governance structure and embedded in many actors' mindsets. This could be an asset in finding a new governance model, provided it can be repurposed toward new objectives (a combination of societal and economic objectives), made more integrated (beyond administrative and sectoral silos) and inclusive (to co-create STI agendas with key actors, including citizens when relevant) and focused on experimentation and learning (rather than compliance).

The need for better integration of STI policies, which drove many of the second-stage reforms, is still topical. However, the solutions will have to be different. Although the current model is claimed to allow

significant efficiency gains, it needs to evolve to better help Korea tackle the economic and societal challenges it faces today and in the future.

Korea needs to start designing and implementing a "new type of top-down policy" that incentivises more diversified initiatives from all parts of the system to experiment and learn different ways to fulfil inclusively developed and commonly agreed objectives and priorities.

5.2. Overview of the Korean STI governance system

This section presents an overview of Korea's STI governance system, the result of several reforms over the past two decades. As in many advanced economies, the succession of these reforms shows a process of trial and error in seeking the right governance model. The general trend of these reforms to date has been a reinforcement of the power, legitimacy and resources of central institutions and processes to improve simultaneously: 1) inter-ministerial co-ordination; and 2) better alignment of all ministries' plans with the central five-year Basic Plan. The government has often justified new changes by arguing that the progress made following previous reforms was insufficient (Hong, 2005[8]; Chon, 2017[12]). The voluminous literature that deals with this period of maturing of the STI governance system focuses on many co-ordination weaknesses: insufficient power of the central councils and the STI Office in relation to the sectoral ministries and/or the financial public authorities; lack of linkages between the council co-ordination and the budgeting functions; insufficient attention of the president on innovation co-ordination issues; and weak secretariat and strategic policy intelligence to feed into council decisions. Efficiency rationales also played a role, such as in 2008, when the new administration strongly emphasised the need for a smaller, more efficient government (Schhüller, Conlé and Shim, 2012[13]).

The section starts with a presentation of the system's organisational structure before providing a review of the powerful central institutions and the multiple governance functions they oversee.

5.2.1. A well-established three-tier STI governance structure

Korea has a well-established three-tier governance structure composed of dedicated institutions with clear legal mandates to perform the essential functions necessary to steer, co-ordinate and implement STI policies. As is typical of advanced economies, the Korean STI system is composed of three main levels of governance:

1. **Strategic orientation/agenda setting**: the level of the executive and legislative branches of government where the strategic framework guiding STI activities is developed.
2. **Co-ordination and programming**: the level of the individual ministries or "administrations".
3. **Policy implementation**: the level of funding agencies (also known as intermediary or management agencies) which implement policy on behalf of the ministries.

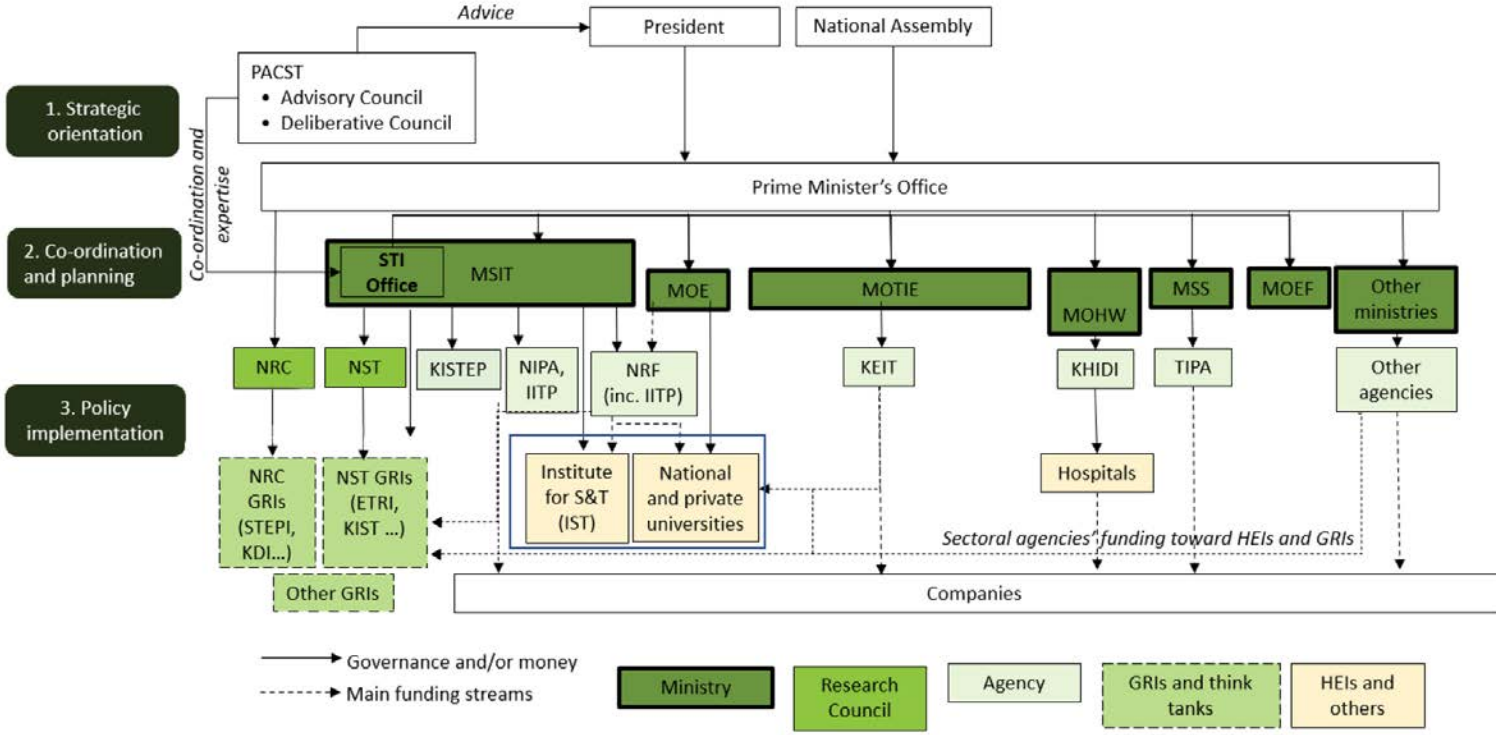
The organisations that perform R&D or innovation (universities, public research institutes, companies and others, such as hospitals, farmers, and so on) form a fourth level that receives funding and associated strategic orientations and conducts activities to generate impact.

Following this typical structure of STI systems, Figure 5.2 presents the Korean STI governance structure across the six ministries and ten agencies that fund and operate significant amounts of R&D in Korea. A more complete picture would include a far greater number of ministries and agencies that develop policies and manage R&D programmes.

The main institutions that compose the Korean system of innovation have distinct roles at the three different levels of the system:

1. **At Level 1 (strategic orientation/agenda setting)**, the president is a powerful actor elected for a single and non-renewable five-year term. Members of the National Assembly serve for four years. The president appoints the Prime Minister as his/her deputy. The president appoints the other ministers, and the Prime Minister runs the Prime Minister's Office (Chancellery). The PACST advises the president and co-ordinates R&D policy across the ministries (except defence, which is treated separately from the rest of the system) (see below).
2. **At Level 2 (co-ordination and programming)**, many ministries fund some R&D.[9] The MSIT is the lead ministry for R&D in terms of funding volume. Importantly, it also hosts the STI Office that supports MSIT's co-ordination function horizontally across the entire government structure. The STI Office is a powerful unit that performs crucial functions that pertain to the three levels: it leads key processes to set orientations, co-ordinate plans and budgets, and monitor and evaluate policy implementation. The Ministry of Trade, Industry and Energy (MOTIE) is another important ministry that deals notably with industrial policy. Therefore, as in many countries, innovation policy is somewhat shared between the MSIT and MOTIE. A comparison with Germany and Japan shows that Korea's R&D expenditures are more distributed across the government structure, which has important consequences for governance. The combined shares of the authorities in charge of research, higher education and industry represent 59% in Korea, 81% in Japan and 77% in Germany.[10] Almost all ministries experienced increased R&D budgets between 2019 and 2023 (Figure 5.3).[11]
3. **At Level 3 (policy implementation)**, agencies implement the government's STI policy and many programmes, most often under the authority of their respective principal ministries. These are normally funding agencies, but often, due to their proximity to public and private organisations that perform R&I activities and their monitoring and evaluation role, they also provide strategic intelligence to their "principals".

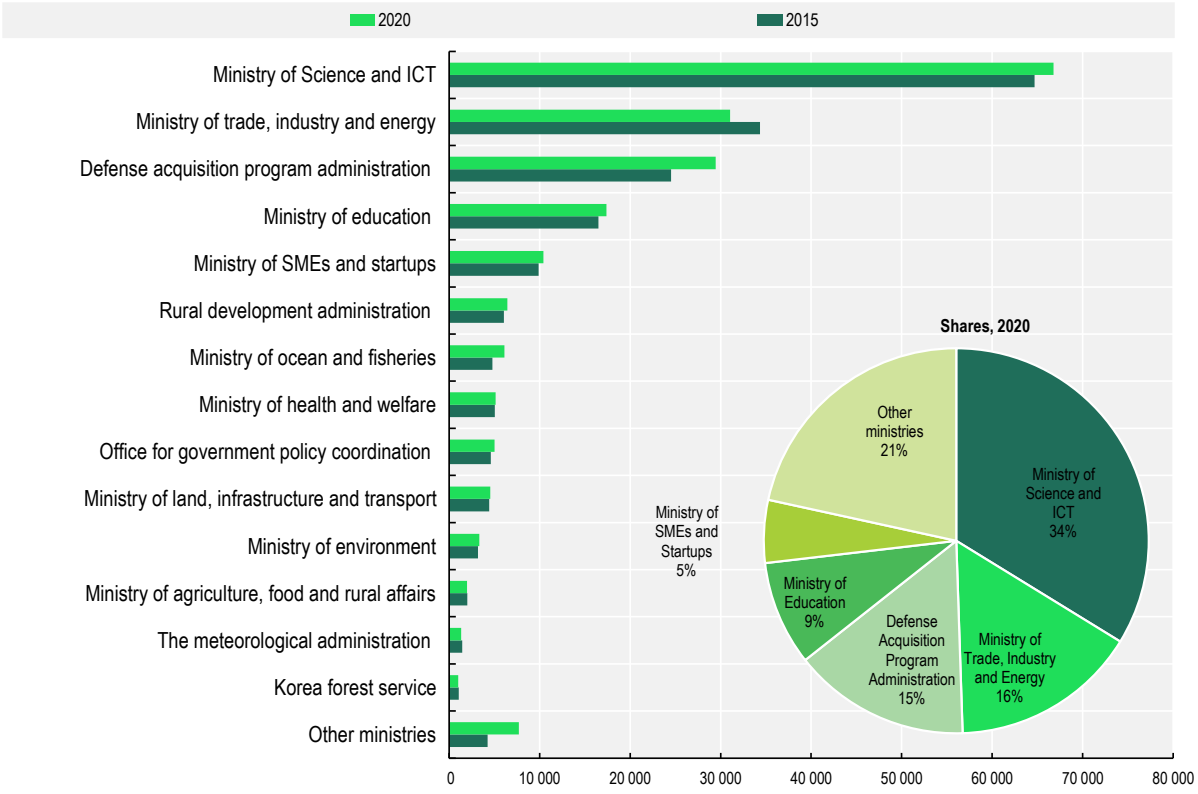
Figure 5.2. Korea's STI governance structure



Note: Full names of institutions here in descending order: Presidential Advisory Council on Science and Technology (PACST), Ministry of Science and ICT (MSIT), Ministry of Education (MOE), Ministry of Trade, Industry and Energy (MOTIE), Ministry of Health and Welfare (MOHW), Ministry of SMEs and Start-ups (MSS), Ministry of Oceans and Fisheries (MOF), National Research Council for Economics, Humanities and Social Sciences (NRC), National Research Council for Science and Technology (NST), National IT Industry and Promotion Agency (NIPA), Institute of Information and Communications Technology Planning and Evaluation (IITP), National Research Foundation (NRF), Korea Evaluation Institute of Industrial Technology (KEIT), Korea Health Industry Development Institute (KHIDI), Korea Technology and Information Promotion Agency for SMEs (TIPA), Korea Institute of S&T Evaluation and Planning (KISTEP), Korea Institute for Industrial Economics and Trade (KIET).
Source: OECD based on desk research and stakeholder interviews.

Figure 5.3. Trends in implementation of national R&D programmes by ministry, 2019 and 2023

In KRW 100 millions (Korean won)



Note: The figure does not entirely reflect the institutional changes during the measured period. For instance, the Administration for SMEs (in Korean, *중소기업청*) was elevated to the Ministry of SMEs and Start-ups (*중소벤처기업부*). The Ministry of Science, ICT and Future Planning (*미래창조과학부*) was renamed to Ministry of Science and ICT (*과학정보통신부*).
Source: Ministry of Science and ICT (2021[14]), *Science and Technology Yearbook 2021 (과학기술연감 2021)*, https://www.msit.go.kr/bbs/view.do?sCode=user&mId=89&mPid=83&pageIndex=&bbsSeqNo=70&nttSeqNo=1887581&searchOpt=ALL&searchTxt=, p. 602; Ministry of Science and ICT (MSIP, 2015[15]), *2015 Report on National R&D Programme Analysis (Statistics)*, https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201800037422&dbt=TRKO&rn=, p. 3.

Under these three levels, the governance system steers, incentivises, supports and monitors the activities of R&I-performing organisations, such as state universities, industrially focused universities of technology, and GRIs, as described in previous chapters.

Many legal acts set out the roles and rules guiding these institutions at all levels. Some of the main ones are presented in Box 5.1.

Box 5.1. Legislation underpinning Korea's STI governance system

The foundations of the STI governance system were set in the Framework Act on Science and Technology (hereafter, "Framework Act") in 2001. It has been amended several times since then and still sets the main legal basis for all STI governance processes, from strategic orientation to co-ordination, programming, budgeting, monitoring and evaluation. It positions MSIT as the main actor

steering and monitoring these processes. The different generations of amendments record the gradual strengthening of the central STI functions.

Another major reform is the National R&D Innovation Act of 2021 (hereafter, "Innovation Act"), which aims to rein in and homogenise the structures and processes of the "R&D management agencies" and form an "autonomous and responsible" environment for supporting R&D activities. This act sets out general guidelines to govern the way all ministries fund and implement R&D activities in universities, GRIs and private sector actors. Previously, under the Framework Act, each ministry could establish procedures and standards for selecting, funding, managing and evaluating the R&D activities performed by its agencies. Another objective of normalising processes and procedures across the government structure is to ease joint and co-ordinated activities by ministries. Granting more autonomy and stability to researchers was one of the main objectives of the reform. Management organisations, including universities, must also establish a sound research support system in terms of infrastructures and staff working environment. The act notably includes provisions for management agencies to reduce the accountability burden on researchers. Also, funded projects' annual contract renewal and annual evaluation were replaced with, respectively, multi-year contracts (for the project duration) and a two-stage monitoring process (i.e. mid-term and final) (Ministry of Government Legislation, 2021[16]); MSIT, 2022[17]).

The Industrial Technology Innovation Promotion Act was enacted in 2006 and most recently revised in 2020. It sets all competencies and procedures to promote innovation of industrial technology and develop the necessary infrastructure. Given the importance of industry in Korea, this is an important legal document that covers the whole policy cycle from strategic plans to evaluation.

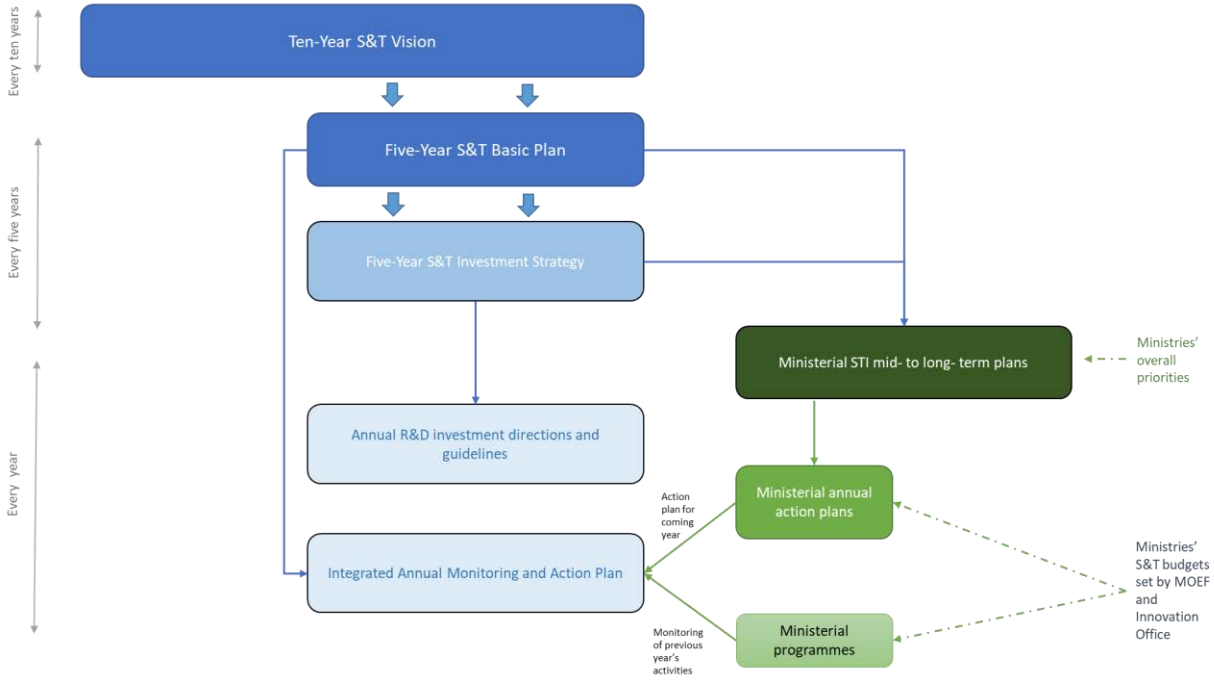
5.2.2. Central processes govern the steering, co-ordination and implementation of STI policies

As in other countries, the sectorisation of STI governance systems in Korea is a strength in that it means many policy actors promote and fund STI. However, sectorisation is a weakness in that it hinders the development of a shared agenda between authorities in different policy areas; complicates the co-ordination of their respective plans to implement this agenda; and makes it difficult to implement joined-up initiatives. While this also holds for small countries – Norway and its strong "sector principle" illustrates this point – it is even more challenging for larger countries like Germany and Korea, with more numerous actors.

Korea has taken up this challenge by setting a unique, comprehensive, and centralised multi-step process to ensure that long and mid-term strategic orientations are concretely considered by all relevant ministries when deciding on their interventions (that mostly take the form of programmes) (Figure 5.4). At the centre of this process is the STI Office, a unit of about 110 employees that plays the role of "STI control tower" with a powerful mandate to review the STI-related plans and "Specific Programmes"[12] of a wide range of ministries, agencies and GRIs who are active in this area. Once reviewed, these plans and specific programmes are to be approved by PACST.

Strategic steering, planning and co-ordination are done centrally with a significant level of detail through a number of processes and mechanisms to ensure policy coherence. Annex 5.A summarises the different governance arrangements involving central interventions from the STI Office and high-level bodies.

Figure 5.4. Korea's STI governance system: From long-term strategic orientations to annual programming and budgeting



Source: OECD based on desk research and stakeholder interviews.

5.2.3. Powerful central STI institutions lie at the core of the STI governance system

Two main organisations jointly lead and/or execute most of the central STI functions, from setting directions to providing guidelines and monitoring and evaluation. These are: 1) PACST, in a deliberative and advisory function; and 2) the STI Office, in a decision-making and executive role. Over the past decades, these organisations have experienced many changes in composition, mandate and institutional status, as well as position in the STI governance system.

High-level advisory and co-ordination bodies

Until 2018, the two highest-level STI bodies for, respectively, strategic advising and co-ordination were PACST and the NSTC. In 2018, these two bodies became two councils under the heading of the PACST General Meeting, following a long history of bodies with advisory and co-ordination functions since the 1970s.

The National Science and Technology Commission until 2018

The NSTC was established in 1999 to strengthen STI co-ordination, which was considered too weak to align the plans of a growing number of ministries increasingly active in R&I to serve their own agendas. An important new feature relative to its predecessors,[13] the NSTC was chaired by the president, who concentrates an important part of administrative power in Korea.

The NSTC has undergone several reforms since its creation, changing its responsibilities, composition and status. The NSTC, for instance, gained and sometimes lost some competencies (e.g. in budget formation through the reforms in 2008 and in *ex ante* and *ex post* evaluations of programmes). It also changed

position and chairmanship, and its secretariat evolved. NSTC reforms also reflect the changes in ministries' portfolios and different political choices regarding the desirable level of centralisation.[14]

A key point is that the evolution of NSTC cannot be disconnected from the changes that affected the STI Office during the same periods. The role of the STI Office as the STI co-ordination control tower varied significantly in relation to the priorities of the president and the reluctance of sectoral ministries to accept MSIT's central role (Seong and Song, 2014[18]).

The President's Advisory Council on Science and Technology until 2018

The President's Advisory Council on Science and Technology, currently chaired by the president, was created in 1991 to provide strategic, medium- to long-term advice on S&T. There have been some variations and periods of pause in its operation through amendments to the Presidential Advisory Council on Science and Technology Act. For instance, in 2004, the chair, who previously was a civilian, was made the president to increase its legitimacy and power. Also, from 2008 until 2012, PACST changed its name to the President's Advisory Council on Education, Science and Technology in parallel with the merger of S&T and education ministries and the creation of MEST.

Since its creation, PACST has reported on average 20 times during the presidential cycle of 5 years (PACST, 2022[19]) on national tasks that present a future-oriented vision in the S&T field that deserve comprehensive co-ordination across ministries and relevant stakeholders, and that require a decision from the highest level of the S&T community, namely, the president. Overall, PACST has developed and advised on the role of mid- to long-term S&T policies that reflect the socially and economically important agenda at the time and contribute to the achievement of national goals established by the government.[15]

The newly integrated co-ordination and steering committees under PACST since 2018

Since PACST integrated the National Science and Technology Deliberative Council (NSTDC) in 2018, the advisory and deliberation councils belong to the same overall body. It is chaired by the President of Korea, with a civilian acting as the Vice-Chair.[16] This "merger" aims to simplify the governance system, increase the legitimacy of the PACST (which can now meet in plenary, convening all members) and strengthen the linkages between the STI strategic and co-ordination functions.

PACST is now composed of two bodies (Table 5.1): an advisory body providing high-level strategic recommendations to the President of Korea and a deliberative body with a large mandate covering planning, budget formation and monitoring of R&D programmes. Both are chaired by the President of Korea and the PACST Vice-Chair. PACST also meets in a plenary meeting to deliberate on general matters, including the operation of the PACST and issues for which either the advisory or deliberative body needs the opinions of all PACST members. In 2021, the PACST met in plenary twice; the Advisory Council met eight times; the Deliberative Council five times; and the Expert Committee ten times (PACST, 2022[20]). For instance, PACST held its fifth plenary meeting in October 2021 to discuss revising the act that governs its activities. It was attended by 30 persons, including 6 government officials and 22 civilian members.[17]

Table 5.1. The Presidential Advisory Council on Science and Technology (PACST)'s councils and sub-committees

Councils and sub-committees	Purpose	Composition
PACST plenary meeting	Deliberates on the operational aspects, agendas that require hearings at plenary meetings as deemed necessary by the Deliberative Council or by the Chair	• Chair (President) • Vice-Chair of PACST (civilian) • All civilian and government members of the PACST
Advisory Council	Advises the President on major policy directions, institutional development and other matters concerning national STI development	• Chair (President) • Vice-Chair (civilian) • 12 civilian experts
- S&T Infrastructure Sub-committee	Provides specific expertise to the Advisory Council	• Civilian experts
- S&T Innovation Sub-committee		
- S&T Society Sub-committee		
Deliberative Council	Reviews, co-ordinates and approves the major STI policy directions, including mid-term STI strategies and plans and R&D funding	• Chair (President) • Vice-Chair of PACST (civilian) • Five ministers (MOEF, MOE, MSIT, MOTIE, MSS) • Ten civilian experts
- Management Committee	Deliberates on the agendas entrusted for deliberation by PACST and co-ordinates inter-ministerial relations	• Head of the STI Office • Government officials • Civilian chairs of expert committees
- Expert Sub-committee of the Management Committee	Supports the Management Committee by pre-examining the STI and R&D agendas submitted to the Deliberative Council	• Civilian experts
- Special Committee (incl. the CET Committee)	Deliberates on special matters when entrusted by the Deliberative Council	• Head of the STI Office • Government officials • Civilian experts
- Local Science and Technology Promotion Council	Deliberates on the investment in and policy directions for basic research	• Civilian experts
- Basic Science Promotion Council	Establishes the Comprehensive Plan for regional STI development and its implementation plan and co-ordinates the regional STI policies	• Civilian experts

Note: MOEF: Ministry of Economy and Finance; MOE: Ministry of Education; MSIT: Ministry of Science and ICT; MOTIE: Ministry of Trade, Industry and Energy; MSS: Ministry of SMEs and Start-ups.
Source: PACST (n.d.[21]), *Home page*, https://www.pacst.go.kr/jsp/main/main.jsp; PACST (2021[22]), *Council List*, https://www.pacst.go.kr/jsp/council/councilList.jsp?category_cd=2.

Assessing the influence of a strategic and/or co-ordination council is a difficult task. International experience suggests that the main limitations that often affect high-level councils' influence are (Schwaag Serger, Wise and Arnold, 2015[23]):

- Their legitimacy. The chairmanship by a high-level official is generally positively associated with a council's ability to ensure co-ordination and communication between the different sectors (Schwaag Serger, Wise and Arnold, 2015[23]). They can, for instance, be headed by the Prime Minister and include a handful of other ministers central to R&I policy, plus a small number of key stakeholders from academia, industry and society.[18] In Korea, the chairmanship by the President of Korea is meant to ensure a very high level of legitimacy. However, according to the interviews, the president from the former government barely attended the council meetings, and interactions between the council and the president based on some PACST proposals were limited.[19] This was said to have reduced its influence. Also important is the fact that the Advisory Council is composed of private members who theoretically provide direct input to the President without interference from government officials.

- Their scope. The ability of these bodies to influence STI policy as a whole is limited when their scope is not system-wide and/or parallel bodies are acting in their sphere. In Korea, the framework is clear that PACST can deal with all matters related to STI, regardless of ministries' portfolios, and that all ministries are expected by law to implement the decisions of the advisory and deliberative bodies. However, Korea has a multitude of high-level councils, which inevitably results in some overlaps and calls for communication between different councils.
- Their analytical resources. Decisions should be based on thorough analyses, which, if possible, should be carried out not by one ministry but rather by a dedicated secretariat, through interactions with the relevant authorities. PACST is supported by the PACST Support Group (about 25 staff) with significant analytical capabilities. This group is under the advisory body and comprises public officials from relevant S&T ministries and experts from GRIs.[20] However, this appears to be a rather small team for bodies with such a wide mandate. PACST collaborates closely with the STI Office, which oversees the overall STI strategy and policy across the whole government structure.

The Korean model for a high-level STI body is close to that of the Japanese Council for Science, Technology and Innovation (CSTI), which operates with a wide mandate (see Box 5.2). Three important takeaways from the Japanese centralised governance system are:

1. Like the PACST Deliberative Council, CSTI was tasked to review all ministries' STI programmes and budget proposals. However, this was abandoned after a few years as this was considered too resource-intensive and required a range of expertise difficult to handle centrally.
2. CSTI has a mandate and dedicated budget to supervise mission-oriented, high-risk, high-reward programmes that are considered better managed centrally than in any given sectoral ministry.
3. Another committee was created specifically to co-ordinate CSTI with other sectoral committees and develop the annual whole-of-government action plan to implement the S&T Basic Plan.

Box 5.2. The high-level STI committees in Japan

The Council for Science, Technology and Innovation (CSTI)

The CSTI took over from the Council for Science and Technology Policy (CSTP) in 2014. The CSTP was created in 2001 within the Cabinet Office to lead the agenda-setting process and support the inter-ministerial co-ordination of STI policies. One important task of the CSTP was drafting the Basic Plans. The CSTP held meetings headed by the Prime Minister almost once a month. Six out of fifteen members were ministers within the Cabinet, and four other members were executive members, i.e. they were appointed to work full-time for the CSTP. While meetings were short and dedicated to taking official policy decisions, the 4 executive members, a strong secretariat of about 100 staff, a dedicated budget to commission studies and several expert panels to deliberate on specific policy issues gave the CSTP a strong and hands-on role that went beyond simply providing advice to the government. The CSTP saw its power reinforced through various reforms until the CSTI replaced it.

The re-establishment of this high-level body aimed to further reinforce its prerogatives of a central STI "control tower" (while broadly keeping the same composition – the number of executive members has been reduced). After successive reforms of the CSTP mandate and since 2014, the CSTI has been given a wide mandate beyond providing strategic guidance on various key topics, as follows:

- Contribute to the co-ordination and monitoring of the implementation of the Basic Plan by sectoral ministries. CSTI took charge of drafting the new Comprehensive Strategy on S&T and Innovation, an annual action plan to refine the priorities for the coming year in line with the five-year Basic Plans. This role gave this committee more direct power over strategies and policies.

- Contribute to annual budgetary allocations, reviewing budgetary requests from different ministries. CSTI was tasked with collecting information from ministries on STI budgets and advising them and the Ministry of Finance (MOF) on these matters. Prior to this, the budget formation in each policy field was mainly the result of bilateral consultations between the relevant ministries and MOF. For this newly created function, the Science and Technology Budgeting Strategy Committee, located under CSTI, is chaired by the minister in charge of S&T policy and consists of senior officials (Director-General level) from the relevant ministries and agencies. The CSTI executive members attend the committee meetings. The CSTI is tasked with reviewing the budget plans of all relevant ministries before any budget appropriation request, consolidating these budgets to acquire an overall view of the whole-of-government STI budgets and, on this basis, providing these ministries and MOF with advice via a "resource allocation policy". This process functioned for only three years due to operational difficulties. To consolidate the budget, CSTI members and the secretariat scrutinised the budget plans of various ministries in detail to identify projects with significant STI content. This required technical expertise in both budget mechanics and the substantive content of projects that, even with the support of experts, proved to be beyond the capacity of CSTI and its committee. The rotation of the Cabinet Office staff supporting CSTI compounded this problem. These tasks were also very time-consuming, which hindered the other activities of the CSTI. While the process has not been officially terminated, the Science and Technology Budgeting Strategy Committee has not met in recent years. CSTI currently retains an advisory role in the budget formation process. It dedicates significant effort to clarifying and consolidating the overall STI budget. A new information and accounting system has been developed with a dedicated classification matrix and the use of Natural Language Analysis to scan all ministries' budgets and identify STI initiatives with less fastidious human intervention.
- Direct involvement in the governance, funding and implementation of key STI programmes. In 2014, the CSTI became responsible for steering and implementing two newly created programmes: the mission-oriented, cross-ministerial Strategic Innovation Promotion (SIP) programme and the high-risk, high-reward, Impulsing PAradigm Change through disruptive Technologies (ImPACT) programme. CSTI provides advice and plays a concrete role in these programmes, in their orientation, selection of powerful programme directors, evaluation, etc. This role in the implementation of programmes that the government deems necessary to manage centrally rather than through sectoral ministries is unique internationally. This creates a direct channel for the high-level strategic orientations contained in the Basic Plan to be implemented across the whole government structure.

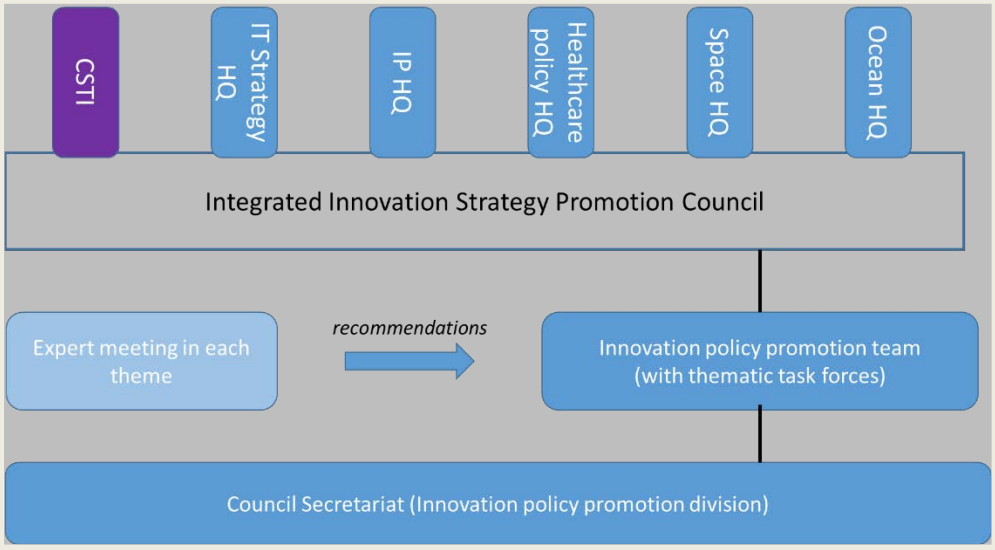
To fulfil this challenging and broad mandate, the CSTI, like its predecessor, is led by the Prime Minister and supported by a robust secretariat under the Cabinet Office. The secretariat includes around 100 staff who generally come from other parts of the government and the private sector for a period of two to three years.

The Integrated Innovation Strategy Promotion Council

In parallel to the strengthening of the CSTP and, later, the CSTI, the government created several headquarters under the Cabinet Office and the Cabinet Secretariat with STI inter-ministerial co-ordination functions in their respective areas (e.g. the IT Strategy Headquarters, the Headquarters for Healthcare Policy, etc.). These bodies take important decisions regarding STI policy interventions in these areas, which contributes to improving inter-ministerial co-ordination, but also runs the risk of overlaps with CSTI. This created a need for co-ordination between CSTI and these systemic sectoral headquarters. In 2018, the annual Comprehensive Innovation Strategies changed name to become the Integrated Innovation Strategies and their scope was widened to include all policy fields beyond those directly in charge of R&I.

In order to co-ordinate the functions of CSTI with those of the area-specific headquarters, the Integrated Innovation Strategy Promotion Council was established in 2018. This council works under the Cabinet Secretariat and is chaired by the Chief Cabinet Secretary. It is composed of several "ministers of state for specific missions" (i.e. ministers positioned in the Cabinet Office who act as heads of headquarters) and CSTI (Figure 5.5). It supports co-ordination between ministries and between "control towers" closely related to innovation and develops and promotes the annual Integrated Strategies. In practice, the CSTI, with its secretariat, leads the drafting of the annual Integrated Strategies.

Figure 5.5. Overview of the headquarters and the Integrated Innovation Strategy Promotion Council



Source: Larrue (2021[24]), "Mission-oriented innovation policy in Japan: Challenges, opportunities and future options", https://doi.org/10.1787/a93ac4d4-en.

The Science, Technology and Innovation Office

The STI Office oversees S&T policies, co-ordinates R&D-specific programmes and evaluates some large-scale and high-priority programmes as defined by law. It was first established in 2004 as a semi-autonomous body following the policy decision to separate the R&D budget authority in the STI area from finance authorities. The Minister of Science and Technology position was promoted to Deputy Prime Minister level to give it more power in relation to other ministries since, with the creation of the STI Office, the ministry received new cross-governmental responsibilities, including defining the R&D budget. The STI Office was reduced to a small bureau in 2008 when the Lee administration (2008-13) took office. In 2011, the government created the NSTC with a structure similar to that of the former STI Office and with a Chair at the Minister level to take charge of the key functions of STI governance – strategic orientation, budgeting and evaluation. During the Park administration (2013-17), the MSIP (the previous name of MSIT) absorbed the NSTC structure and function under a new STI Office (with the Head of the Office at the Assistant Minister level, below Vice Minister). Under the Moon administration, a Head of the STI Office at the Vice Minister level was added on top of the Assistant Minister. The current structure of the STI Office was established at that time.

The main pillars of the STI Office work represented by its three bureaus are: 1) S&T policy planning and co-ordination (Science and Technology Policy Bureau); 2) deliberation and adjustment of the national R&D

budget (R&D Investment Co-ordination Bureau); and 3) performance evaluation of national R&D (Performance Evaluation Policy Bureau) (see Table 5.2). Part of the R&D budgeting authority was delegated to the STI Office by the Ministry of Economy and Finance (MOEF), and since 2016, the STI Office has taken charge of the pre-feasibility test of large programmes, as well as co-ordination of the operational costs of the GRIs. The organisational form and scope of authority are more or less the same as those of the 2004-07 period.

Table 5.2. Internal structure and functions of the Science, Technology and Innovation Office

Bureaus	Divisions	Functions
Science and Technology Policy Bureau	Science and Technology Policy Division Science and Technology Strategy Division Science and Technology Policy Co-ordination Division Growth Engine Planning Division	- Develops S&T policy agenda - Establishes S&T Basic Plans and annual action plans and monitors their implementation - Reviews, analyses and co-ordinates mid- to long-term plans (on R&D) of sectoral ministries - Supports the operations of PACST - Establishes policies bridging R&D budgeting and evaluation - Facilitates inter-ministerial co-ordination - Establishes promotion plan for social problem-solving technology development programmes - Establishes promotion plan for critical and emerging technologies
R&D Investment Co-ordination Bureau	R&D Budget Co-ordination Division R&D Investment Planning Division Public and Energy R&D Budget Co-ordination Division Advanced Manufacturing and ICT R&D Budget Co-ordination Division Biotechnology R&D Budget Co-ordination Division	- Establishes annual investment direction and guidelines - Establishes mid- to long-term investment plans - Oversees matters concerning: o Allocation and co-ordination of national R&D programmes and budget of GRIs o Establishment and co-ordination of investment strategies for national R&D programmes among R&D actors (industry, academia, GRIs) o Improvement of investment efficiency in national R&D programmes, such as co-ordination of overlapping programmes and structuring and restructuring by industry fields - Oversees the establishment of strategies, budget allocation and co-ordination and/or investment directions for specific disciplines/industry fields/technology areas (e.g. space, energy, and environment, ICT and convergence technologies)
Performance Evaluation Policy Bureau	Performance Evaluation Policy Division R&D Assessment and Evaluation Division Research System Division R&D Ethics and Researchers' Rights Protection Division S&T Information and Analysis Division R&D Feasibility Study Team	- Establishes and implements plans and actions related to: o Performance evaluation of national R&D programmes o Performance management and diffusion of outputs of national R&D programmes o Performance evaluation of R&D projects - Provides institutional support for the creation of knowledge ecosystems - Performs (*ex post*) meta-evaluation of national R&D programmes and special programmes - Performs meta-evaluation of GRIs and National Research Council for Science and Technology (NST) - Performs pre-feasibility tests - Oversees matters concerning: o Foresight exercises and strategic policy intelligence o Improvements in administrative processes in national R&D management (including agencies, regulations, etc.) following the adoption of the Innovation Act

Note: The list of functions is not exhaustive.

Source: Adapted from MSIT (2022) and Ministry of Government Legislation (2022[25]), *Enforcement Decree on Ministry of Science and ICT and the affiliated organisations*.

As shown in Table 5.A.1 (Annex 5.A), the STI Office supervises multiple cross-government co-ordination processes in close collaboration with PACST, which offers expertise and a forum for engaging with various policy bodies and stakeholders. These processes range from the formation of the Basic Plan, the review of the sectoral mid-term and annual plans of sectoral ministries, and the annual budgeting review of strategic programmes and their monitoring and evaluation. A number of strategic documents (e.g. about

90 mid-term plans, as many annual action and monitoring plans, and more than 1 000 strategic programmes) are involved in these processes. Although the STI Office and PACST are selective, for instance, dedicating more attention to some key plans and programmes (in particular the new ones), the expansion of the volume of STI activities and of the number of programmes (which has grown even faster than the STI budget) may challenge the added value of the whole process in the future. The extent to which the STI Office and PACST can ensure the necessary strategic consistency of a growing scale and broadening scope of plans and programmes is an open question. While this is difficult to evaluate in practice, one illustration can be found in the agenda of PACST Deliberative Council meetings, which can include more than 12 mid-term plans to be reviewed. In addition, although the formal budget review process for the numerous strategic programmes takes only a month, the STI Office devotes an entire year to preparing for it.

This challenge has been dealt with in the past mainly through new laws that strengthened the mandate of the STI Office and new steering and monitoring mechanisms, which has increased the weight of these centralised processes. Given the extent of its whole-of-government co-ordination function, there have been proposals to position the STI Office above the ministerial level. However, there are concerns that the cyclical changes in high-level government bodies could disrupt its functions and continuity (KISTEP, 2021[26]).

5.3. Providing strategic directions to steer the Korean STI governance system

This section analyses in more detail the first level (see Figure 5.1) of the STI governance system in Korea, where STI strategic orientations are developed.

The key criteria for assessing the satisfactory performance of strategic steering mechanisms are:

- They should involve a relevant balance of top-down and bottom-up dynamics. Although the results of the deliberation on and selection of the priorities are most often formalised and conveyed by the highest level of policy making, it is a diffuse process that should embed the knowledge and preferences of multiple actors, from politicians and policy makers to experts and citizens. This ensures that different inputs (knowledge and expertise but also values and interests) feed into the formation of these strategies. It also creates more buy-in from these actors and, therefore, enhances their engagement in the ensuing resourcing and implementation of the strategies.
- Strategic policy directions should clearly define the desired endpoints to concretely guide public action. The different strategic documents and mechanisms at different time horizons (long-term, mid-term and annual plans) should be consistent and interlinked. They should also be anticipatory, i.e. factoring in knowledge about possible futures so that alternative directions and their potential impacts are explored.
- While being flexible to adapt to new conditions and evolving consensus, they should be stable and robust, extending beyond political terms to address ambitious and long-term challenges.

5.3.1. A cascading system of well-elaborated whole-of-government strategies

In the Korean system, high-level policy orientations are set in three main strategic frameworks: the long-term vision, the presidential programme agenda, and the five-year S&T Basic Plan. The latter is the most authoritative document, which aims to steer the interventions of policy bodies directly in charge of STI activities and all sectoral ministries and related agencies. This mid-term plan is well structured and includes objectives and quantitative targets that are monitored and serve as the basis for its evaluation when developing the next plan.

The long-term STI vision

Korea establishes long-term visions for S&T about every ten years. Previous visions include the Long-term Vision for S&T Development by 2025, launched in 1999, and the S&T Future Vision for 2040, launched in 2010. The current vision is Innovate KOREA 2045 – Challenges and Changes for the Future (hereafter, "Innovate KOREA 2045"), launched in 2020. The STI Office developed it following consultations with the line ministries and a dedicated ad hoc committee, the Future Strategic Committee 2045,[21] composed of around 20 experts from industry, academia and research institutes. The current vision aimed to create linkages between the former Going Together Hopeful Korea 2030 vision established in 2006 and the 2045 Vision for Innovative, Inclusive Growth announced in 2019, which, although both are economy- and society-wide visions, emphasises the important contribution of S&T to enhancing the sustainability and inclusivity of economic growth (MSIT, 2020[27]). These documents, which have a timeframe of between 25 and 30 years into the future, aim to provide long-term guidance for S&T mid-term strategies and plans, which are established every 5 years, particularly the S&T Basic Plans.

Innovate KOREA 2045 sets out the vision for the long-term desired orientations for Korean society and identifies the S&T challenges that must be addressed to realise the vision. Looking ahead to the next 25 years, it defines eight main "challenging tasks" that include both immediate issues (e.g. climate challenge, the COVID-19 pandemic) and those with a longer-term horizon (e.g. space exploration). In solving these tasks, the vision maps 16 "directions for technology development" along different time horizons, namely, short-term (within 5 years), mid-term (around 10 years) and long-term (over 20 years). Examples include autonomous robots for disaster relief, AI semiconductors, human space flights and brain-to-brain communication. The vision recognises that the government's traditional approach of selecting promising technology sectors is no longer effective in the fast-changing environment. Instead, it emphasises the government's role in identifying and presenting a blueprint of the key challenges of national importance and supporting various innovation actors to develop the necessary technologies and be at the forefront of innovation (MSIT, 2020[27]).

The eight challenging tasks are followed up with eight S&T "policy directions". One of these policy directions is, for instance, to shift from a fast-follower research model to a model of "challenge-led creative research". Another calls for a shift toward research to address social issues rather than "research to develop technologies". Other priorities include: supporting individuals in realising their true potential; exploring new types of government-industry partnerships to create markets; creating regional clusters and ecosystems; using S&T in the public sector; increasing the role of Korea as an international science and innovation leader in some areas; and using foresight to drive STI policy.

The presidential agenda

The presidential agenda provides broad directions for future reforms. For instance, the programme of the newly elected president includes 110 "policy tasks", including 7 that are directly under MSIT.

Some agendas that are not under MSIT also include items related to R&D and innovation.

The S&T Basic Plan

The S&T Basic Plan is an overarching strategic document that includes broad directions to guide all ministries, i.e. ministries in charge of R&I policy per se and sectoral ministries when they develop their STI strategies and plans in their respective areas. The Basic Plan is aligned with the presidential agenda (launched before the Basic Plan in the policy cycle) and sets more specific orientations for its realisation.

This overarching strategic framework, reflected in and complemented by area-specific strategies and plans, has driven and provided legitimacy for some important changes in the past. Notably, there was the turn to a post-catch-up STI system with a strong increase in basic research funding and related reforms. The overall increase of government-funded R&D expenditure of 150% in ten years from 2005 to 2015

(OECD, 2021[28]), leading to one of the world's highest R&D intensities, is another example of bold orientations taken by Korea. Proactive measures were also taken to support the emergence of new industries. One notable example is the support provided to the biotechnology sector since the beginning of the 1990s through the creation of specific R&D programmes in close co-operation with the private sector. This has resulted in significant growth and societal impacts in the form of domestic solutions to some health and ageing challenges.

Structure and content of the Basic Plan

The Basic Plans are structured along broad strategic directions and corresponding policy areas increasingly focused on solving societal issues, in line with the overall vision to build a more inclusive STI system. In contrast with most western STI strategies that only include objectives and targets, followed by an action plan in the best case, the wide orientations of the Basic Plans are complemented with more or less concrete "agendas" to be implemented by different policy bodies across the whole government structure.[22] Therefore, the Korean Basic Plans are both a mid-term strategic framework and a mid-term action plan.

The 5th Basic Plan was announced in 2022 and will cover 2023-27 in response to national societal challenges, such as technological hegemony, supply chain, climate change, digital transition and low birth rates. In line with these challenges, the 5th Basic Plan is structured around three main strategic thrusts and the necessity to keep strengthening national STI capacity in general:

- transforming the S&T system for qualitative growth
- strengthening capacity-building ecosystems for open innovation
- resolving national challenges and preparing for the future based on S&T.

To implement the policy directions, each strategic thrust includes a number of implementation projects (each of them containing five to seven detailed tasks and subsidiary action initiatives). The 5th Basic Plan also includes 12 critical technology areas and 50 core technologies, selected based on 3 criteria: supply chain and trade; emerging technology; diplomacy and security.[23] These technologies will receive enhanced support and investment from the government based on the strategy roadmap and R&D funding based on a mission-oriented funding distribution system. Efforts to strengthen international and private partnerships will also be intensified. Starting with advanced small modular reactors (SMRs) and quantum technology projects, ten projects are set to be launched in 2023.

Lastly, the 5th Basic Plan sets quantifiable targets for some important indicators. For instance, the objective for the share of the top 1% cited papers is set at 4.8% for 2022-26, a 1.27 percentage-point increase from 3.53% in 2015-19. An example of a similar target is the number of triad patents, which is set to increase from 2 057 in 2019 to 2 500 in 2027 (MSIT, 2022[29]).

Process for developing the Basic Plan

Developing the Basic Plan involves several consultation stages and concertation with a broad range of communities. It follows a multi-stage, multi-stakeholder process led by the Innovation Office, which begins before the presidential election with preparatory work by institutions such as the Korea Institute of S&T Evaluation and Planning (KISTEP) and the Science and Technology Policy Institute (STEPI). It includes an assessment of the realisation of the former plan and the provision of analytical support for S&T planning, notably through an analysis of changes in the overall context; a "policy demand" survey among STI institutions; and various forms of consultations with the main STI communities (universities and various types of research institutes, industry, and intermediary organisations, etc.). STEPI's Division for Strategy Research for Future Innovation also participates in this process.

The Planning Committee of the S&T Basic Plan, a specific ad hoc committee, is formed every five years by MSIT to support the ministry in planning the process for developing the Basic Plan. This committee

supervises an elaborated planning structure, while the STI Office is responsible for drafting the plan. In the case of the 5th Basic Plan, a Co-ordination Committee of approximately ten members appointed by the Minister of Science and ICT develops the overall direction and collects feedback at the level of the overall plan. Divisional Committees (all composed of approximately 11 experts) develop the specific corresponding agendas for each of the four areas, as well as implementation strategies and detailed action initiatives. The four Divisional Committees are supported by several sub-committees focusing on specific issues (e.g. digital transformation or regional decline). Once a first draft of the plan is developed, PACST's role is to approve the plan prepared by the MSIT and other ministries.

An evaluation of the outcomes and weaknesses of the last Basic Plan is also conducted every five years by MSIT with support from relevant organisations, such as KISTEP and STEPI, as part of developing the next plan.

5.3.2. The long-term consistency of strategic directions

A key issue in Korea and many other countries concerns the long-term orientation of the STI system. This has become important as countries face societal challenges which, like climate change, involve consistent efforts towards realising goals over decades.

While Korea's "vision" can provide the long-term framework, it remains rather broad. The main strategic document is the Basic Plan, which serves as a reference for guiding resource allocation and monitoring STI interventions across the government. However, the Basic Plan is a mid-term plan that, moreover, can be, in principle, impacted by new government priorities set out in the presidential agenda. Although it is encouraging that there is political interest in and commitment to R&I, the need to adjust to new priorities every five years after a presidential election can cause discontinuity in the R&I governance and funding system.

Many governance systems strive to establish consistency between the short- to mid-term political and long-term STI policy cycles. One possibility is to organise a partial overlap between the political term and the STI strategic plan. This is, to some extent, the case in Korea, as the development of the Basic Plan starts about one year before the presidential election. Some countries have developed nested structures of long-term strategic and mid-term investment plans (Box 5.3).

Box 5.3. "Nested" long-term strategic and mid-term investment plans in Sweden and Norway

The Swedish Research and Innovation Bill

While budgets in Sweden are annual, a specific framework applies to the STI area to promote a more strategic and multi-annual programming process. The Swedish Research and Innovation Bill establishes strategic STI directions every four years to guide activities, implement concrete policy measures and allocate budget appropriations for the next four years. These appropriations are not formally binding, but a decision by the parliament stipulates that the funds can be earmarked for upcoming years. However, they can be recalled if there is a need to reallocate due to contextual changes. In practice, it has never happened.

The bill process, led by the Ministry of Education and Research, involves wide consultation every four years on policy needs. Important new policies are debated in this framework and announced in the bill with the reasoning behind proposals. For instance, the 2012 Bill included a new initiative meant to stimulate interactions within broad new configurations of industrial, academic and research institute actors by supporting the development of strategic innovation areas (SIAs). These SIAs were to be followed by selected Strategic Innovation Programmes run by the relevant community of actors themselves to implement the SIAs.

In the 2016 Bill, the government argued that four years was too short to allow long-term strategies and investments needed in this area to be carried out. Further, the R&I Bill had a ten-year perspective and included the government's vision for R&I in the coming decade. For instance, the 2016 R&I Bill covering 2017-20 included broad objectives for the ten-year period 2017-27. The goal for the research policy is that:

- Sweden shall be an internationally attractive country for investments in R&D. Public and private investments in R&D should continue to exceed EU goals.
- Research quality shall be reinforced overall, and gender equality shall increase.
- Engagement and societal impact shall increase.

These are, however, broad objectives that do not provide precise directions. Although there is no planned process, progress toward the stipulated goals is monitored at the end of each bill period.

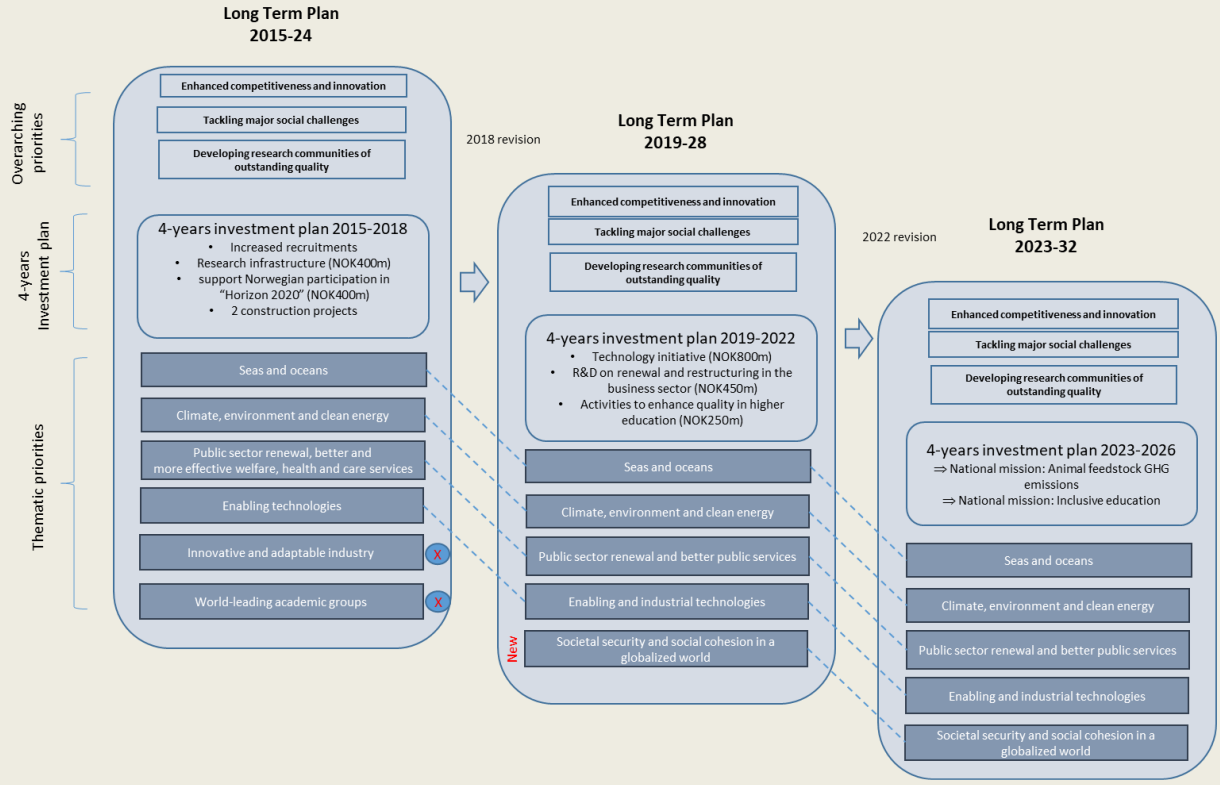
The 2020 Bill planned an appropriation increase of SEK 3.4 billion (Swedish krona) in 2021, SEK 3.2. billion in 2022, SEK 3.3 billion in 2023 and SEK 3.75 billion in 2024. Some of these funds will contribute to funding new national research programmes (in the areas of oceans and water, viruses and pandemics, mental health, digital development, crime, and segregation) and reinforcing existing programmes (in the areas of climate, sustainable community development, food, antimicrobial resistance, and working life).

The Norwegian Long-Term Plan for Research and Higher Education

In Norway, the Long-Term Plan for Research and Higher Education 2015-24 (hereafter, the "LTP") was launched in 2014 by the Norwegian government following a number of stakeholder consultations and inter-ministerial negotiations led by the Ministry of Education and Research. It covers research, innovation and, to a lesser extent, despite its name, higher education policy. The LTP is built around three overarching government objectives: developing research communities of outstanding quality; enhancing competitiveness and innovation; and tackling major societal challenges. It also includes specific objectives in priority areas (e.g. seas and oceans, climate environment and energy, public sector renewal, enabling technologies).

While the LTP has a ten-year perspective for designing longer-term avenues in broad terms, it includes a more precise four-year plan with financial commitments. Its revision every four years allows the government to add more concrete structural and programme-style policy activities to the LTP without changing the plan's general orientation. The new plan under development will cover 2023-32, with budget appropriations and concrete measures for 2023-26. The structure of the second LTP (2018 revision) was changed in order to better link the ten-year priorities and the four-year investment plan. In the latest revision of the LTP (2022), two national missions have been included in the plan (see Figure 5.6).

Figure 5.6. Norway's rolling long-term plan with national missions



Source: Based on OECD (2017[30]), *OECD Reviews of Innovation Policy: Norway 2017*, http://dx.doi.org/10.1787/9789264277960-en; OECD (2016[31]), *OECD Reviews of Innovation Policy: Sweden 2016*, http://dx.doi.org/10.1787/9789264249998-en; Swedish Research Council (2021[32]), "New initiatives in the Government's research bill that relate to the Swedish Research Council", https://www.vr.se/english/just-now/news/news-archive/2021-01-15-new-initiatives-in-the-governments-research-bill-that-relate-to-the-swedish-research-council.html.

5.3.3. STI strategies and plans in specific sectors and areas

Advisory and/or co-ordination committees active in other domains also provide advice on how STI could best contribute to achieving their mandates. This advice may come in the form of strategies and roadmaps. For instance, the National Economic Advisory Council has a sub-committee dedicated to innovation issues. Increasingly, committees are created to co-ordinate cross-cutting actions to tackle specific challenges, such as low fertility, ageing or climate change. By way of example, in 2021, the Carbon Neutrality and Green Growth Commission released two policy roadmaps to achieve Korea's net-zero emissions goal by 2050 (see below). Until 2022, the Presidential Committee on the Fourth Industrial Revolution also had a wide mandate with regard to all matters related to technologies such as AI, information and communications technology (ICT) and data technology (including in specific sectors or areas, e.g. smart cities or digital healthcare). Like the PACST, but with a different scope, it delivers advice and recommendations, co-ordinates policy measures submitted by various ministries, organises public campaigns, prepares related regulatory and institutional reforms and fosters ecosystems for new "Fourth Industrial Revolution" industries.

In order to tackle fine dust pollution, the National Council on Climate and Air Quality (under the President of Korea; now disbanded and reorganized into the above-mentioned commission) provides advice to the Special Committee on Fine Dust (under the Prime Minister; committee with public-private membership),

which has a mandate to co-ordinate actions and take decisions. This committee supports the development and validates the cross-ministerial Comprehensive Plan on fine dust control, which is taken up by sectoral ministries in their respective policy field. MSIT, for instance, develops an R&D plan on fine dust.

While the Basic Plan is meant to be the highest-level strategic document in the area of S&T, important ones are also set by MOTIE to guide business innovation: the Industrial Technology Innovation Promotion Plan and Industrial Convergence Basic Plan (every five years since 2011, currently under its seventh edition covering 2019-23) (MOTIE, 2019[33]).[24] Although the Industrial Technology Innovation Promotion Act calls for effective connections with the Basic Plan, the link between these plans for industrial technologies and the Basic Plan is unclear. In principle, the consistency between these strategic strands is ensured by the review of MOTIE's plans by PACST and directly by the STI Office, which is tasked with co-ordinating the different plans. However, there is no formal mention of the Basic Plan in the industrial technology plans. Like in many countries, the limited connections between the two plans reflect co-ordination issues between authorities in charge of science and business innovation. In Korea, the MSIT is mandated by law to co-ordinate and steer all policy matters related to S&T (including in industry) via the previously mentioned Framework Act on Science and Technology. The Industrial Technology Innovation Promotion Act provides MOTIE with a strong responsibility to lead the development and commercialisation of industrial technologies in a country where industrial innovation plays a key role in national growth and competitiveness.

Other plans provide strategic guidelines for R&D in energy, transport and agriculture, among others. Some plans (such as the one by the Ministry of Land, Infrastructure and Transport [MOLIT]) have a ten-year horizon and are revised every five years.

5.3.4. Foresight is well connected to agenda setting and policy making but remains too focused on technology forecasting

Korea has traditionally been at the forefront of foresight, with a strong focus on technology forecasting. It has not only devised new methodologies and tools but also ensured that their results are used to inform strategic decisions, notably in the context of the Basic Plan development process. Foresight systematically informs whole-of-government and sectoral strategies and plans. These exercises create opportunities to debate and make better policy decisions, especially where these involve societal judgements or that have a systemic character. Foresight is particularly well connected to the process of developing the S&T Basic Plan.

The government has established and mainstreamed formal processes to ensure the linkages between STI foresight and mid- to long-term strategy. The first major foresight exercise was run in 1994, and so far, six exercises have been undertaken.[25] Since then, foresight has become more systematic and formally integrated into strategic planning. Foresight plays an important role in informing the Basic Plan about recent changes in the domestic and international environment, devising scenarios about future technologies and deriving options for future mid-term and long-term evolution of Korean society and implications for STI priorities. The cycles of S&T foresight and Basic Plans are aligned, and a formal procedure, starting two years before the launch of the Plan, connects the two processes. Against this backdrop, the 4th Basic Plan was backed by the 5th S&T Foresight exercise (2016-2040), including Horizon scanning, a Delphi survey, scenario planning and technology tipping point analysis. The 6th S&T Foresight exercise in 2020-21 analysed the future trends from 2021 to 2045.

To this end, the MSIT formed the Foresight Executive Committee to review and co-ordinate foresight activities in collaboration with the Future Scanning Committee and the Future Technologies Committee. KISTEP is in charge of the general management of the entire process and provides support to these committees.

Foresight is implemented following a two-stage process:

1. The Future Forecast Committee and the Future Technology Committee operate a series of steps, including trend analysis using, notably, the STEEP (Social, Technological, Environmental, Economic and Political) analysis and domestic and foreign future outlook reports. The 6th Foresight exercise identified 5 megatrends, 12 trends and 62 major issues expected to considerably impact Korea's socio-economic prospects.
2. In a second phase, the Future Forecast Committee and the Future Technology Committee identified 241 technologies expected to emerge by 2045. The committees then conducted a two-round Delphi survey addressed to S&T experts to assess the potential impact and the corresponding societal and policy tasks to perform. Finally, based on the previous survey results, a tipping point analysis was conducted among members of the Future Technology Committee to identify 15 major future innovative technologies expected to have a considerable socio-economic impact when they are diffused in society in the future. The 6th Foresight exercise concluded that all 15 technologies are expected to reach their tipping point first in the United States.

The foresight exercises increasingly take into account societal trends, especially during the first review stage, and are well connected to the agenda-setting process. Nevertheless, the exercise culminates in a set of technological guidelines and the identification of future technologies with a forecasted diffusion timeline. While Korea is moving in this direction, the recourse to systemic, societal and human-centric exercises, including developing future visions regarding societal evolution, could be strengthened to help reflect on and design policies to support sustainability transitions.

Foresight, technology assessment and other types of analytical support for strategy and policy making are most often co-ordinated if not performed by the social science GRIs attached to the Prime Minister's Office or other research institutes. KISTEP (under MSIT) and, since 2021, STEPI have served as the secretariat of the Divisional Committees that deliver the content of the three strategic thrusts of the Basic Plan. The Korea Development Institute is one of the main providers of advice for the Blue House. The Prime Minister's Office also maintains the Korea Institute for Industrial Economics and Trade (KIET), a think tank that focuses more on economics and innovation, in line with the ministry's mission.

More generally, these research institutions and think tanks provide strategic intelligence to the ministries in their respective areas. KISTEP, for instance, supported the consultations during the preparation of the 2021 Innovation Act (see Box 5.1.). It held a number of legislative discussions in regions, conducted meetings with ministries and collected opinions from R&D actors to support the deliberation of the National Assembly.

More generally, various institutions (in particular, KISTEP and STEPI) provide strategic intelligence on science, research and innovation through foresight, planning and evaluation work.

5.4. Planning and budgeting STI policies across the government structure

This section analyses the second level of the STI governance system dedicated to policy co-ordination and planning (Figure 5.1). At this level, governance aims to ensure the alignment and consistent funding of STI public interventions implemented by policy-making institutions covering different policy fields and/or levels of government. The mechanisms for doing so greatly differ between countries as they are deeply embedded in the budgetary processes and various institutions where ministries can interact. The main differences between the different systems are the level of centralisation/decentralisation of the co-ordination tasks; the extent to which these mechanisms are systematic or depend on opportunities and goodwill; and their time frame (annual or multi-annual).

The key criteria for assessing the satisfactory performance of planning and budgeting mechanisms are:

- They should effectively connect the overall strategic STI priorities to the concrete implementation of programmes and policies across the government structure.

- They should result in securing and allocating resources among different policy-making institutions, such as ministries and agencies, that are commensurate with the importance of STI activities in achieving national priorities and addressing key challenges.
- They should allocate the responsibilities across the government structure in line with ministries' portfolios while eliminating unnecessary overlaps and promoting co-operation between different policy-making institutions where relevant.
- These mechanisms should be performed with minimal transaction costs and conflicts.

5.4.1. Korea's process to reflect its long-term strategic orientations in its mid-term and annual action plans across the whole of government remains too formal and mechanistic

This section describes the various steps of the programming and budgeting process in more detail.

The development and review of mid-term action plans

Korea has several formal procedures to ensure that the Basic Plans orientations concretely guide the programmes and activities of all ministries with R&I activities. Sectoral ministries are required by law to integrate the Basic Plan priorities into their mid-term plans, which are reviewed and monitored centrally by the STI Office and PACST.

In line with the Framework Act on Science and Technology, each ministry submits to MSIT (in practice, to the STI Office within MSIT) a mid-term action plan that provides an overview of the new and ongoing programmes and activities to be implemented in the coming five years. MSIT is tasked with reviewing these mid-term plans (under the name of "Mid- to long-term plans survey and analysis"),[26] notably to check whether they align with the Basic Plan and do not overlap with other ministries' plans. The STI Office can interact directly with the ministries when changes are needed.

This review of mid-term plans has been carried out every year since 2008, as all – new and ongoing – plans are sent to the STI Office. The number of submitted mid- to long-term plans varies each year within the 80-120 range. In 2020, there were 90 plans from 16 central government bodies (12 ministries, 3 administrations, 1 commission), of which 44 came from MSIT, followed by 11 from MOTIE, and 9 from the Ministry of Agriculture, Food and Rural Affairs (MAFRA). Given the difference in timelines for these plans, 15-20 are reviewed annually. Some of these plans concern specific technologies and industry developments, such as the National Strategy for Artificial Intelligence (2019-2030) of MSIT and the Comprehensive Plan on Environment and Health (2011-2020) of the Ministry of Environment.

At the end of the review process, MSIT delivers a list of recommendations that may require the ministries to amend the plans and should be taken into account in their annual action plans. Every year, the results of this review are transmitted to the PACST Deliberative Council for validation and notified to MOEF and other ministries.

The five-year R&D Investment Strategy[27] is an important new step in this process to better bridge the S&T Basic Plan and the sectoral ministries' mid-term plans. The STI Office delivered the first one in February 2023. Although it does not include budget figures (only determined yearly), the R&D Investment Strategy sets some indicative five-year R&D budgetary or spending targets for investments in specific technologies. The strategy is also more actionable than the Basic Plan and aims to facilitate the five-year programming by the sectoral ministries and the "consistency check" by the STI Office. Therefore, this document aims to be the missing link between mid-term strategic orientations and mid-term planning. For this reason, the five-year R&D Investment Strategy must be finalised within 90 days from the establishment of the Basic Plan, and the annual action plans are confirmed until the end of January every year (KISTEP, 2021[34]). This new process is too recent to assess its effectiveness, however.

The development and review of annual action plans

The formal link to policy implementation is ensured each year by the development of an action plan by the STI Office to guide ministries' annual programme proposals.

In line with the Framework Act on Science and Technology, all relevant ministries and agencies provide the STI Office with their Annual Plan for the Basic Plan. This report presents their actions undertaken in the different strategic thrusts of the Basic Plan, the outcomes of these activities and their plans for the coming year. The STI Office integrates these inputs into an annual Basic Plan submitted to PACST's Management Committee under the Deliberative Council for review. This plan is both a monitoring (activities of the past year) and an action plan (activities planned for the next year) covering the whole government structure. It does not include budget figures. In addition, some sectoral ministries develop and submit annual plans and submit them to the PACST's Deliberative Council via the STI Office.[28] The latter encourages this practice.

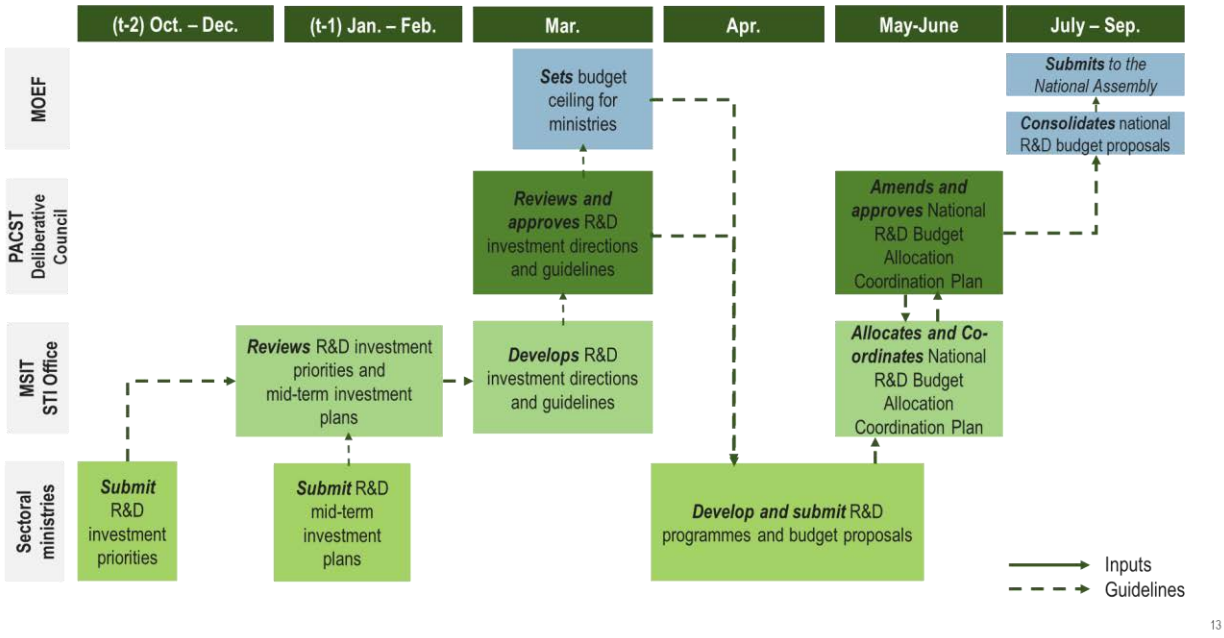
5.4.2. A comprehensive process for the annual cross-ministerial co-ordination of STI budgets

A comprehensive process is in place to determine the overall R&D budget and allocate it among the different ministries while adhering to the budget threshold set by the MOEF for each ministry. This process involves a review of a number of Strategic Programmes.

Overview of the annual budgeting and programming process

As shown in Figure 5.7, the annual budgeting and programming process starts in the fourth quarter of the year t-2 (year minus two) with the submission by ministries of their informal and broad priorities for the year after next (in two years). Based on these inputs, the STI Office provides guidance on the year t-1 (year minus one) for the next year's programmes and ministries' budget requests (called the "R&D investment directions"). The R&D investment directions are also used to inform the overall budgetary indications. After R&D budget ceilings for each ministry are set by the MOEF (usually at the end of April), based on these maximum budget allocations, all ministries develop their R&D programme proposals (until the end of May) in consultation with their own committees (for instance, the General Energy Committee that advises MOTIE) and networks of stakeholders for the next year. These proposals comprise the continuation of ongoing multi-annual programmes and some new programmes. All R&D programmes are submitted for review to the STI Office. Both the content and the budget requests of these programmes are reviewed before being approved by the Deliberative Council. The revised proposals are transmitted in the form of the National R&D Budget Allocation and Co-ordination Plan[29] to the MOEF for the final decision on the programmes and their respective budgets. Once aggregated, the MOEF transmits the government's annual R&D budget to the National Assembly, which approves it 30 days before the beginning of December of the year t-1.

Figure 5.7. Overview of Korea's annual budgeting and programming process



Source: OECD based on desk research and stakeholder interviews and KISTEP (2021[35]), *Government Research and Development (R&D) Budget: FY 2021 (2021년도 정부연구개발예산 현황분석)*, https://www.kistep.re.kr/board.es?mid=a10305080000&bid=0002&act=view&list_no=42194&tag=&nPage=1 and STEPI (2021[36]), *Background Paper for OECD Reviews of Innovation Policy: Korea 2021 (provided by STEPI to OECD)*.

The annual review of R&D programmes

A key milestone in the annual budgeting cycle presented above is the central review of all R&D strategic programmes from around 26 ministries and departments. This process applies to the major R&D programmes (i.e. mainly science, technology, engineering and mathematics [STEM]-related programmes),[30] which accounted for about 80% of the total R&D budget in 2022. Programmes related to social science and humanities (general R&D programmes) are managed directly by the MOEF. The extent to which this divide between two strands of co-ordination might limit the ability to better integrate natural sciences and social sciences and humanities is not known. One can surmise that it does not promote the launch of transdisciplinary research programmes, i.e. programmes that involve integrating knowledge from different hard and soft science disciplines and (non-academic) stakeholder communities. This issue is increasingly important as transdisciplinary research is considered crucial to dealing with complex societal challenges (OECD, 2020[37]). Such integration is to be realised primarily at the level of projects and programmes themselves by agencies and ministries. However, it should also be reflected at a higher level in the system and encouraged by mechanisms to identify co-operation opportunities.

The STI Office reviews the R&D-specific programmes with support from eight expert committees under the Management Committee. The PACST Deliberative Council reviews and approves the final results of this process. These expert committees comprise about 20 scientific and technological experts from the public and private sectors in specific areas (energy, ICT, and convergence technologies, among others). These experts assess the technical soundness and feasibility of the different programmes submitted by the ministries. These assessments are complemented by the STI Office's analysis of the coherence of the different programmes, both between themselves and with the priorities outlined in the Basic Plan. On this basis, the STI Office provides feedback to the ministries, which can then revise their proposals. If needed, there can be meetings between the STI Office and the relevant services of the ministries to discuss the details of the revisions to be made. In some cases, the STI Office can provide additional budgets to some programmes if deemed necessary, although such practice is relatively rare. In the end, once the decisions

regarding budgets of the different programmes for one ministry are aggregated, they can represent an increase or decrease in the ministry's R&D budget.

It is beyond the mandate of this OECD review to assess the level of resources required by this process in relation to its benefits. The STI Office contends that this process remains light and does not consume significant resources.[31] First, the review process is more detailed for new programmes than ongoing ones. The STI Office also focuses on key strategic programmes, i.e. those most relevant to the government's priorities and/or are the largest in allocated public funds.

However, one issue concerns the sustainability of this process in the future. The process is essentially the same as when the Framework Act established it in 2001. In 2003, the NSTC reviewed 234 R&D programmes submitted by 19 ministries and agencies, with 142 civilian experts joining the review process. In 2020, the STI Office and the Deliberative Council expert committees reviewed 949 programme proposals, including 253 new ones. In 2021, they reviewed 1 198 programme proposals, including 291 new ones, and 1 254 programme proposals in 2022 (196 new) (MSIT, 2020[38]; 2021[39]). The trend is expected to continue due to the R&D budget increase and ministries' inclination to divide large projects into smaller ones to avoid the pre-feasibility test (see below). The increase in the number of programmes to be reviewed may, in the future, require more resources and potentially lead to a procedural mechanism with reduced value. Therefore, it is essential to allocate resources to STI Office activities that operate at a more systemic and strategic level, in close co-operation with sectoral ministries. The new five-year R&D Investment Plan aims to enhance the strategic dimension of budgeting. Evaluating whether this new mechanism has achieved the intended outcome will be crucial.

Regarding the results of this process, the STI Office reports that the guidance it provided at the beginning of the cycle (see Figure 5.7) in 2022 allowed ministries to save KRW 1.3 trillion. Another KRW 1 trillion was saved by eliminating duplications between programmes. After identifying overlaps, the STI Office encouraged the ministries concerned to reorganise their programmes. The central co-ordination of R&D programmes therefore resulted in significant efficiency gains, representing about 9.3% of the overall 2023 R&D budget (KRW 24.7 trillion, about EUR 18.8 billion) (Government of Korea, 2022[40]). The funds saved are reinvested in R&D programmes. The STI Office can indeed offer budget top-ups to certain programmes that are deemed strategic.

One strength of the Korean system is that the sectoral ministries interact with STI-specific organisations (the STI Office and the Deliberative Council) with expertise in this policy field, while in most other countries, the finance authorities keep their main budgetary prerogatives. The need for specific R&I expertise was one of the main reasons for the delegation of the budget formation function to the STI Office and Deliberative Council in the first place.

Beyond the number of programmes being reviewed, the granularity of the review is a critical issue. Although in English, everything appears to be at the "programme" or "project" level,[32] the Korean language demonstrates a nested structure with distinct programme levels. There are five main levels, as shown in Annex Table 5.B.1. This configuration is based on the Programme Budgeting System that was put in place in 2008. The goal was to align the organisational structure of ministries with the classification of R&D programmes and projects, allowing for more strategic management of R&D support at a higher level in the administrative structure. Against this backdrop, the higher-level groupings of "1" and "2" were created to match the bureaucratic units of office and department[33] within ministries (KISTEP, 2019[41]).

The *ex ante* review of programmes is performed at the third level of Specific Programmes, which represent rather small administrative entities. However, this can vary significantly from one case to another. A survey conducted as part of a study in the bio-health area revealed that the budget review process is focused at a level that is too detailed, rather than at the programme (level 1) or programme unit (level 2) levels, which would be more appropriate for more holistically assessing the relevance of government actions in addressing overall national priorities (Lee et al., 2020[42]). It is, however, essential to link large strategic orientations and activities implemented in projects and other types of initiatives. While lower-order levels

are relevant to reduce overlaps and increase management efficiency, this should be embedded in strategic discussions about what to do for what impact, by whom and with whom. Such reflection is conducted as part of the development of the Basic Plan and the review of the mid-term plans of all relevant ministries, which both set the broad strategic orientations. However, the linkages between these overall strategic orientations and the budgetary review of programmes should be strengthened. The mid-term plans previously discussed partly provide this holistic and higher-level perspective, but it is important to complement these with continuous strategic steering and monitoring.

5.4.3. The stringent pre-feasibility test of large R&D programmes has been improved

The pre-feasibility test, which conditions the launch of large programmes, can potentially prevent the misuse of significant budgets. Such *ex ante* assessment of large programmes already existed, but it was administered by the MOEF, like for any other "big projects", such as those in construction. The STI Office now leads a dedicated test for R&D projects. Large programmes with total expenditures over KRW 50 billion (approximately EUR 36 million) and public support of more than KRW 30 billion must undergo this pre-feasibility test, which is a two-stage process divided into a pre-test and a main test in order to avoid a waste of administrative efforts (Ministry of Legislation, 2021[43]).

The first stage pre-test is based on four criteria: 1) necessity and urgency considering recent S&T developments; 2) appropriateness to be funded by the national R&D budget; 3) novelty, yet having foreseen linkages with the existing programme; and 4) specificity of the programme plan. These criteria are reviewed using ten sub-indicators (KISTEP, 2021[44]).

If the programme successfully passes the first stage, the main test is then carried out in about seven months. The assessment of the main test uses three high-level criteria with mid-level indicators:

- **S&T feasibility**: Three mid-level indicators evaluate the adequacy of the "context of the identified problem/issue", the "programme goal", and the "specific tasks and implementation strategies".
- **Policy relevanc**e: Two basic mid-level indicators examine the "consistency with existing policies (namely, high-level strategies)" and "risk factors (including financial and legal aspects)". If the programme concerns wider matters outside the conventional STI policy arena, such as balanced regional development, job creation or safety assessment, it may be selectively scrutinised with one additional "special" indicator.
- **Economic feasibilit**y: Cost-effectiveness analysis (E/C; if quantification is not possible but at least comparative alternatives exist) or cost-benefit analysis (B/C; if the programme's effect can be quantified) is performed, and the results of the analyses are presented along with the total project cost estimate.

The STI Office is entrusted with forming the General Committee for National R&D programme evaluation under MSIT. The experts of this committee perform the assessment. In 2018, this exercise was reduced from one year (on average) to six months. In the following years, the criteria for reviewing these large programmes, based on procedures already in place in other areas, were modified to be better suited for R&D projects (Table 5.3). Specific methodologies apply to programmes with which R&D correspond to three pre-defined profiles: challenging, growth and infrastructural. For instance, the challenging R&D programmes are reviewed using the cost-effectiveness analysis rather than the more traditional and narrower cost-benefit analysis. Furthermore, decisions now include explanations and rationales, which enables ministries to learn from the assessments and improve their programme designs accordingly.

The feasibility test is very stringent: only 15% of submitted large programmes pass the pre-test successfully, and 52% of the programmes that pass the pre-test succeed in passing the main test.[34] This leads ministries to reduce the size of their projects or split them into several programmes to not exceed the KRW 50 billion threshold. These avoidance strategies result in increased transaction and management costs and possibly in reduced effectiveness of sub-scale programmes.

Table 5.3. Modified evaluation criteria of Korea's pre-feasibility test (as of 2019)

High-level criteria	Mid-level indicator	Low-level indicator	Weighted value by programme type (%)		
			Challenging type	Growth type	Infrastructural type
S&T feasibility	Adequacy of the context of the identified problem/issue	-	55-65	40-50	40-50
	Adequacy of the programme goal	-			
	Adequacy of the specific tasks and implementation strategies	-			
Policy relevance	Consistency with existing policies	Compatibility with high-level national strategies	20-40	20-40	30-50
		Implementation structures and institutional will			
	Risk factors	Financial			
		Legal and institutional			
Economic feasibility	-	-	Less than 5	10-40	10-20

Source: Information provided by STEPI.

MSIT has recognised this issue and plans to raise the threshold to KRW 100 billion. This process should be reviewed in one year to assess the result of this change and, more generally, its overall added value and unintended effects.

5.5. Implementing and evaluating STI programmes and projects

This section describes and analyses how, at the end of the policy cycle, the governance arrangement allows strategic orientations and related programmes and plans to be put into action through various types of instruments and regulations and monitors and evaluates their effects. It does not cover the whole Korean policy mix. The components (policy instruments and initiatives) pertaining to business innovation and knowledge creation are analysed in Chapters 3 and 4, respectively.

The key criteria for assessing the satisfactory performance of implementing and evaluating STI programmes and projects are:

- Appropriate incentives and governance arrangements are set to ensure that agencies are steered towards desired goals through strategic orientations and action plans while maintaining autonomy in how they choose to realise them.
- The objectives and rationales of the different policy instruments are clearly linked to the high-level strategic frameworks and the different ensuing ministry and agency plans.
- These instruments realise their respective goals but also, when relevant, contribute to systemic objectives. In some cases, they can be articulated or even jointly managed and implemented.
- There are mechanisms, regulations and "safe spaces" in place to allow for the experimentation of new approaches.
- Monitoring and evaluation results feed into decision-making processes.

5.5.1. There have been significant efforts to improve and harmonise the key role of agencies in implementing R&D programmes

STI policies are mainly implemented in the form of R&D programmes by around 15-17 dedicated R&D agencies.[35] These agencies can be mandated to allocate funding and manage projects (R&D management

agencies), while others perform a range of other actions to support R&D and innovation (R&D promotion agencies). In some cases, the difference between the agency roles is unclear, with some agencies playing both. Furthermore, some agencies have the title of institutes, such as the Institute of Information and Communications Technology Planning and Evaluation (IITP), which promotes technology transfer in the IT sector and manages national R&D projects/programmes funded by MSIT.

Through the years, management agencies have established a set of elaborate programme management procedures throughout the whole project cycle. As in other advanced countries, these agencies are tasked with defining the precise programmes under the purview of their line ministries. Once approved and funded through the annual process described above, they develop roadmaps and calls for proposals, involving various experts and stakeholders (notably through the use of surveys and expert committees) to organise the project selection process. The projects are then funded, managed, monitored and evaluated. They have well-established processes for performing these tasks. Within agencies, the programme directors are important actors, responsible for consultation with stakeholders and managing the portfolio of projects in their respective areas.

The programmes and the projects within are multi-annual. At MOLIT, for instance, projects are funded for three to seven years, depending on their objectives, with a majority being funded for five years. Moreover, as previously mentioned, respective R&D agencies are subject to different mandates that are formalised in a number of laws and decrees accumulated over time. In this regard, enacting the 2021 Innovation Act helped streamline the overall process in that the act applies to all national R&D programmes and projects and takes precedence over other laws and regulations of sectoral ministries (MSIT, 2022[45]).[36]

As previously mentioned, the Innovation Act includes new provisions for regular reviews of agencies by their respective “principals”. Research institutes and project investigators are required to submit annual, mid-term and final progress reports, as well as performance reports upon request from the heads of central government bodies (e.g. ministries). The Innovation Act specifically outlines the content to be contained in these reports, along with the timing. For instance, the final report should be submitted within 60 days from the termination of projects and should provide information on: the performance level; the level of goal achievement; the contribution of the project to related fields of research; and future plans to manage and utilise the outputs (MSIT, 2022[45]). Furthermore, the Innovation Act clarified the regulations for performance evaluation. The most notable change is that both the process and achievements of the R&D projects are evaluated simultaneously, whereas, before the reform, the assessment of results preceded the review of the process. This reform applies to both the mid-term and final evaluations.

5.5.2. There are no effective governance arrangements to link agencies’ funding to their performance and strategic goals

Although their scope, status, functions and even name (agency, council, foundation or institute) vary among countries, the term “agency” generally refers to semi-autonomous organisations that programme, select and fund research and/or innovation activities under the ministry that has authority in their policy area and has a budget to fulfil this mandate. In most countries, agencies allocate specifically project-based funding through competitive mechanisms that respond to well-accepted international norms regarding project selection and evaluation (while ministries often retain the function of allocating institutional funding to higher education institutions and/or research institutes) (Borowiecki and Paunov, 2018[46]).

R&D management agencies in Korea are essentially execution agencies that plan, manage and evaluate projects in line with the strategic orientations set by their ministry. The type of governance arrangement established between the “principal” and its agency is therefore essential to ensuring effective bi-directional information channels:

- Incentives set by the ministry should convey clear messages on priorities and objectives, guide agencies in performing according to these objectives, and hold them accountable for their performance.
- Information feedback loops from the agency to the ministry ensure that the latter sets relevant objectives based on data collected by agencies as part of their management activities (notably results from the monitoring and evaluation, but also the information retrieved and the expertise formed in the numerous consultations conducted during programme planning and diverse road-mapping exercises).

In many countries, these governance arrangements have evolved toward ministries defining objectives while giving agencies increased autonomy to devise the best ways to meet these objectives. Normally, therefore, ministries do not make decisions about individual projects.

In Korea, although the proximity to the principal is always a matter of balance, agencies appear very close to their relevant ministries. They interact frequently, for instance, during consultations with R&I-performing organisations (brainstorming and road-mapping workshops, etc.). This proximity provides better information to the agencies, which is essential as policy implementation often extends beyond the usual scope of authority of the R&D agency, especially when addressing systemic societal challenges involving issues such as regulations or market incentives. However, this proximity should not reduce the operational autonomy of the agency, and it should have the freedom to implement what it considers to be the best mechanisms to meet the set objectives.

More importantly, the governance arrangements in place do not connect the agency's strategic orientations and performance to the funding allocated by the relevant ministry each year. Although evaluations of the agencies by MOEF use the mid-term plans submitted by the heads of agencies when taking office as a basis, conducting the evaluations annually hinders the inclusion of more strategic considerations about mid-term impacts. Furthermore, the results of these evaluations are only linked to the salary of the agency head and not to the agency's budget itself (Hwang, Park and Kim, 2021[47]). Implementing a clear performance framework to allocate funding offers several benefits:

- The performance framework set by the ministry trickles down within the agency and, therefore, also incentivises different agency departments.
- Rather than a multitude of daily interactions, it sets conducive conditions for strategic discussions between the ministry and its agency on the agency's objectives and the means needed to fulfil them.

Internationally, most research funding and performing agencies are separated organisationally from their line ministry (operating "at arms' length") and may be governed via multi-year performance agreements. For example, in France, the National Research Agency (ANR) is governed by four-year performance contracts negotiated with the Ministry of Higher Education and Research. The contract defines the objectives, actions (with a timeline) and monitoring indicators for the agency. The current contract, covering 2021-25, includes 19 indicators and 37 milestones describing the key actions to implement to realise the agency's 6 overarching objectives. Based on this contract, the ANR develops three-year action plans spanning two contracts (ANR, 2021[48]).[37] This ensures continuity between two contracts while still allowing for changes. By way of another example, Austria implements a comprehensive approach to steering its agencies and other central institutions operating under the purview of ministries (see Box 5.4).

Box 5.4. Connecting a national strategy to agency priorities, activities and funding: Austria's Research, Technology and Innovation (RTI) Pact

Austria's ten-year government strategy, the Research, Technology and Innovation (RTI) Strategy 2030, adopted by the Austrian Council of Ministers, outlines the nation's top priorities. It is structured along three objectives and eight interlinked and interdependent "fields of activity" (each field of activity is assigned to one objective but can contribute to several of them). The strategy was significantly influenced by the conclusions of the *OECD Reviews of Innovation Policy* conducted in Austria in 2018. Its implementation is monitored by a cross-governmental RTI Task Force under the chair of the Federal Chancellery, involving authorities in charge of finance, education, science and research, digital and economic affairs, as well as the Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK).

To connect the overarching national strategy to concrete activities on the ground, the Austrian government decided in 2020 to negotiate priorities every three years based on the Research Financing Act between the three ministries with the highest R&I budgets (the Federal Ministry of Education, Science and Research [BMBWF], the BMK and the Federal Ministry for Digital and Economic Affairs [BMDW]). In a cross-ministerial setting, the 2021-23 RTI Pact (hereafter, the "Pact") operationalises the targets and fields of activity set out in the RTI Strategy 2030 and defines the corresponding priorities and concrete measures to be implemented for the coming three-year period. The Pact also establishes a multi-annual stable funding framework (amounting to EUR 3.9 billion) and reduces duplications between the three ministries.

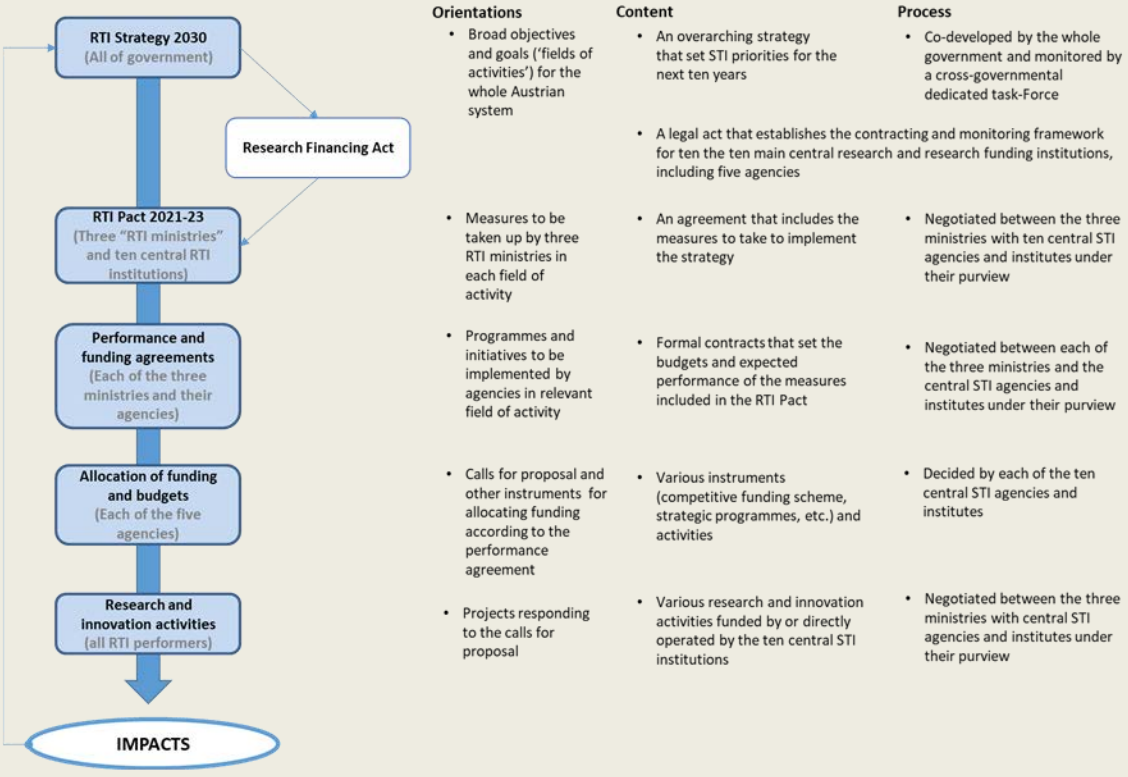
Concretely, the Pact is a 20-page document structured along the RTI Strategy 2030's field of activities. For each field of activity, the Pact presents a list of measures to be implemented. The precision of these measures enables the communication of the expectations for the desired results while leaving room for agencies to determine the best way to implement them. For instance, the field of activity "Promote excellence in basic research" (assigned primarily to Objective 2, "Focus on effectiveness and excellence") includes four measures, including the establishment of performance agreements with universities and the central institutions for basic research specified in the Research Financing Act with a focus on excellence and appropriate competitive mechanisms for the internal allocation of funds. Another measure calls for developing and testing new, innovative types of instruments and measures for funding excellent research that may also be high-risk and targeted use of open innovation and citizen science methods to identify research questions of relevance to society. In the same objective, the field of activity "RTI for achievement of the climate targets" includes a measure that calls for the adoption of mission-oriented funding programmes, which can make a significant contribution by pursuing a co-ordinated, cross-sector approach, keeping regulatory frameworks in mind and responding to the needs of stakeholders.

Another important component of this governance structure is the Research Financing Act passed in July 2020, which establishes a specific legal basis for financing the ten non-university central research and research funding institutions, including the five agencies active in the R&I area. The objective is to allow multi-year strategic funding of these institutions through the negotiation of performance and funding agreements between them and their ministry of reference, in line with their mandate and scope. For instance, the funding agreement (Finanzierungsvereinbarung) between BMBWF and the Austrian Science Fund (FWF) for 2021-23 refers formally to the measures included in the Pact that the agency's programmes will contribute to. In accordance with the legally assigned tasks according to the Research and Technology Promotion Act (FTFG), it includes a description of the different programmes, the budget assigned to these programmes for the three years, as well as monitoring and governance arrangements.

The Research Financing Act also sets out a framework for the annual monitoring of the use and effect of their allocated budgets. An annual report provides a systemic overview of these ten institutions based on eight standardised indicators. At the end of the term of the performance and funding agreements, a report will present a comparative analysis of these institutions' budgets and actual outcomes.

The Pact is, therefore, a new element added in 2020 to the Austrian governance structure that enables a clear and formal strategic continuity between the ten-year STI strategy and the activities of research-performing organisations funded by agencies (see Figure 5.8).

Figure 5.8. Overview of the strategic continuum across the different layers of Austria's STI system



Note: The five agencies are the Austria Wirtschaftsservice Gesellschaft mbH (AWS), the Christian Doppler Research Association (CDG), the Austrian Science Fund (FWF), the Agency for Education and Internationalisation (OeAD) and the Austrian Research Promotion Agency (FFG).

Source: Based on Austrian Federal Government (2021[49]), *Austrian Research and Technology Report 2021*, https://www.bmbwf.gv.at/dam/jcr:c4eae98b-17ac-4af2-92ea-340ebe9a1c72/FTB_2021_engl_bf.pdf; Austrian Federal Government (2020[50]), *RTI Strategy 2030*, https://www.bundeskanzleramt.gv.at/dam/jcr:90b413e2-ce1b-4326-9c4a-dfbb3e67d4c9/RTI_Strategy_2030.pdf; Austrian Federal Government (2020[51]), *RTI Pact 2021–2023*, https://www.bundeskanzleramt.gv.at/dam/jcr:a07cc716-1032-4ffe-a568-57d15be53c2c/RTI_Pact_2021%E2%80%932023.pdf; BMBWF and FWF (2021[52]), *Auszug Finanzierungsvereinbarung (FV) 2021–2023*, https://www.bmbwf.gv.at/dam/jcr:1e0a6c58-0299-4925-8385-b826b946fabd/FWF-FV%20barrierefrei.pdf.

5.5.3. Co-operation between policy-making bodies is limited

A number of broad and complex ("wicked") issues require resources and capabilities that go beyond the portfolio of any single ministry or agency. In this case, co-operation between different ministries and

agencies pertaining to different policy fields can prove beneficial either to cover different stages of the innovation cycle (from research to deployment), different areas of competencies (for instance, support to technological development and support to skills development) and/or different thematic areas (for instance, energy and transport). Large programmes are one of the main mechanisms for collaboration among ministries and agencies across policy silos.

In Korea, since 2011, ministries have joined up on specific occasions to implement co-operative programmes. The "ministry-led inter-ministerial programmes"[38] (hereafter, "ministry-led type") tend to be longer-term and have a larger scale and scope, and therefore subject to pre-feasibility tests (KISTEP, 2019[53]). These programmes are generally initiated bottom-up based on the demands identified by participating ministries, meaning there may be overlaps with existing programmes (KISTEP, 2019[54]). The mismatch between the operational guidelines of ministries and the limited use of inter-ministerial consultative bodies set up to promote their voluntary co-operation are other limitations of this programme type.

The government established the Multi-ministerial R&D Programme Promotion Plan in 2013 to overcome the issues affecting the ministry-led type and to facilitate a new type of joint undertaking that would be centrally managed rather than initiated by the ministries themselves. According to the plan, these joint undertakings (hereafter, the "multi-ministerial R&D programmes") are different from the ministry-led type in that they are co-ordinated earlier in the policy cycle, from the planning stage (rather than after budget allocation to sectoral ministries) and require inter-ministerial co-operation throughout the whole programme cycle (rather than opportunistically, when needs emerge during the course of the programme). Most importantly, multi-ministerial R&D programmes are managed by the Multi-ministerial programme promotion committee (hereafter, the "Multi-ministerial Programme Committee"),[39] a permanent co-ordination structure under the PACST Deliberative Council, which reviews and selects the R&D co-operative programmes, and more generally deliberates on all issues regarding inter-ministerial co-operation. The Multi-ministerial Programme Committee is chaired by the Head of the STI Office and comprises 11 high-level government officials and 13 private experts (PACST, 2022[55]). These programmes are subject to a common set of operational guidelines, in contrast with the ministry-led type where individual regulations of sectoral ministries apply (MSIP, 2013[56]; Ministry of Legislation, 2022[57]).

The planning of multi-ministerial R&D programmes follows four steps. First, MSIT and KISTEP conduct two surveys to identify the needs for co-operation: the first is a bottom-up process in the form of calls for expression of interest to industry, academia and GRIs; and the second is a top-down process based on the demands from sectoral ministries. Second, MSIT supports the pre-selection of the candidate programmes, later to be approved by the Multi-ministerial Programme Committee. Third, once selected, the lead ministry assigned to each co-operative programme, in consultation with other ministries, develops a detailed programme plan that includes the division of labour among ministries. Finally, the developed plans are again submitted to the Multi-ministerial Programme Committee, which gives final approval (KISTEP, 2021[58]).

An example of these multi-ministerial R&D programmes is the national programme in the biomedical sector in which several ministries, such as MSIT, MOTIE, the Ministry of Health and Welfare (MOHW) and the Ministry of Food and Drug Safety (MFDS), participate. This programme aims to support the R&D and innovation activities from the ideation stage to the approval by MFDS and beyond.

While in practice, these multi-ministerial R&D programmes have a wider scale and scope in other countries, they are undertaken at the Specific Programme level in Korea (see Table 5.B.1, Annex 5.B). The number of Specific Programmes selected has been constant, at around five per year from 2013 to 2020. It recently rose to 12 in 2021. These numbers are very low compared to the overall number of Specific Programmes per year (above 1 000). These programmes are far less frequent than the ministry-led type mentioned above. In 2017, multi-ministerial R&D programmes accounted for only 10.4%, whereas the ministry-led type was 89.6% of total multi-ministerial programmes (KISTEP, 2019[53]). There is currently no formal

incentive for ministries to launch multi-ministerial R&D programmes, but budget officers tend to prioritise them. An option is to reserve a dedicated central budget for these programmes in order to offer a financial "top-up" that would reduce the costs for participating ministries.

Furthermore, multi-ministerial R&D programmes often take the form of "umbrellas" to host the Internal Programmes of different ministries, managed by their own implementation agencies (see Annex Table 5.B.1..A.1, Annex 5.A) (KISTEP, 2021[59]). These programmes often replicate the vertically segmented structure between policy fields, with exclusive relationships between ministries and their respective agencies in each silo. The added value of these programmes, therefore, lies in the *ex ante* division of tasks among the participating ministries, which avoids unnecessary overlaps, and some integrated monitoring of the programme. While this undoubtedly raises the efficiency of these programmes, it falls short of more co-operative practices where integrated teams belonging to different agencies collaborate to select, manage and evaluate projects.

Different schemes exist to promote and enable this type of co-operative endeavour at the ministry or agency level in practice. In large cross-ministerial programmes, such as those in Korea, different ministries launch a common umbrella programme and delegate some components to their respective agencies. Other co-operation is implemented directly between agencies in joint programmes. These can be limited to ad hoc joint calls for proposals. They can also be more ambitious and structural, such as in cross-agency challenge-led programmes like Pilot-E in Norway, where three agencies create a one-stop-shop funding scheme to jointly fund and monitor ambitious large-scale consortia from research to deployment (see Box 5.5).

Box 5.5. An example of cross-agency STI co-operation across the innovation cycle: Pilot-E in Norway

Norway has set up several cross-agency challenge-led programmes, starting in 2016 with Pilot-E. This scheme aims to be a one-stop-shop that provides seamless support from idea to market to various climate, emission-free and energy-saving solutions. Within Pilot-E, three agencies systematically co-ordinate their actions to provide tailored and seamless support to industry-led consortia along the entire pathway from research to market deployment. The scheme is governed by a dedicated structure of governance involving representatives of the three agencies. They also collectively hire and share the cost of a secretary supporting the implementation of the scheme.

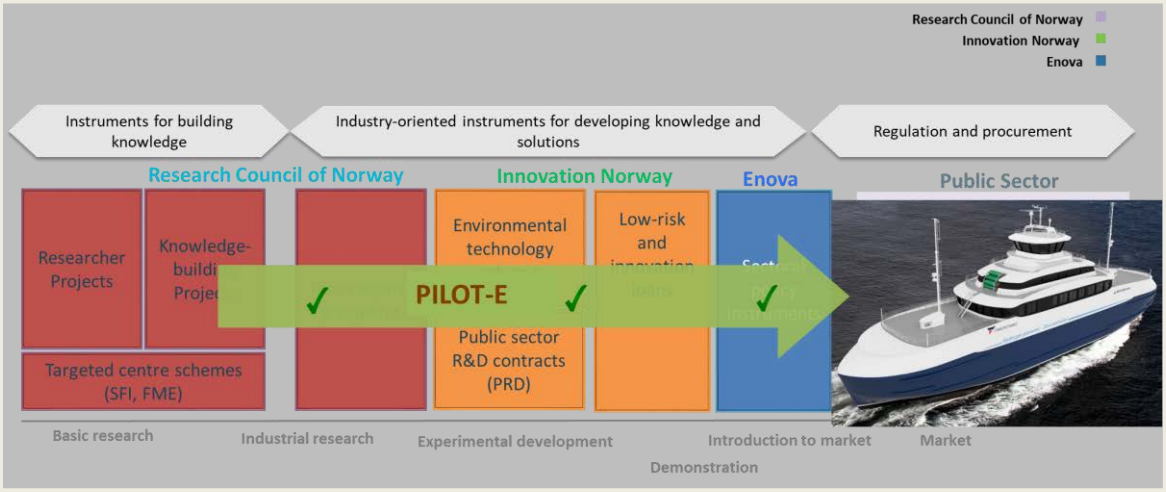
Pilot-E is a joint funding instrument, gathering technology push and market pull funding instruments of the three agencies to provide comprehensive support along the innovation chain. The Research Council of Norway supports research and research-based innovation; Innovation Norway supports innovation; and Enova provides financial incentives for the uptake of new solutions among end-users, including public procurement for innovation (see Figure 5.9). Moreover, regulatory authorities are active in removing legal barriers to technology implementation.

Through joined-up action of the agencies and close monitoring of projects, Pilot-E is suited for larger consortia that address more complex challenges than traditional projects that are supported by any of the partner agencies individually. Pilot-E was positively evaluated in 2020.

This scheme is now also applied in other areas, such as transport and digitalisation (Pilot-T), health (Pilot-H) or bio-economy (Pilot-B, focusing on aquaculture and timber) areas. More recently, leveraging the Pilot-E positive experience, the Green Platform Initiative is a scheme launched in 2020 to support large-scale R&D and innovation projects that co-ordinate joint actions along the whole innovation chain from upstream research to business development, commercialisation and scaling of green transition

processes, products and services. Five ministries participate in the Green Platform Initiative, which is operated by three agencies (RCN, Innovation Norway and Siva).

Figure 5.9. The funnel approach in Norway's Pilot-E: Packaging together the instruments of three agencies



Source: (Volla, 2019[60]).

Source: Larrue (2021[61]), "Mission-oriented innovation policy in Norway: Challenges, opportunities and future options", https://doi.org/10.1787/2e7c30ff-en; Larrue (2021[62]), *The design and implementation of mission-oriented innovation policies: A new systemic policy approach to address societal challenges*, https://doi.org/10.1787/3f6c76a4-en.

5.5.4. The monitoring and evaluation of programmes and projects has significantly changed, but it is too early to assess the impact

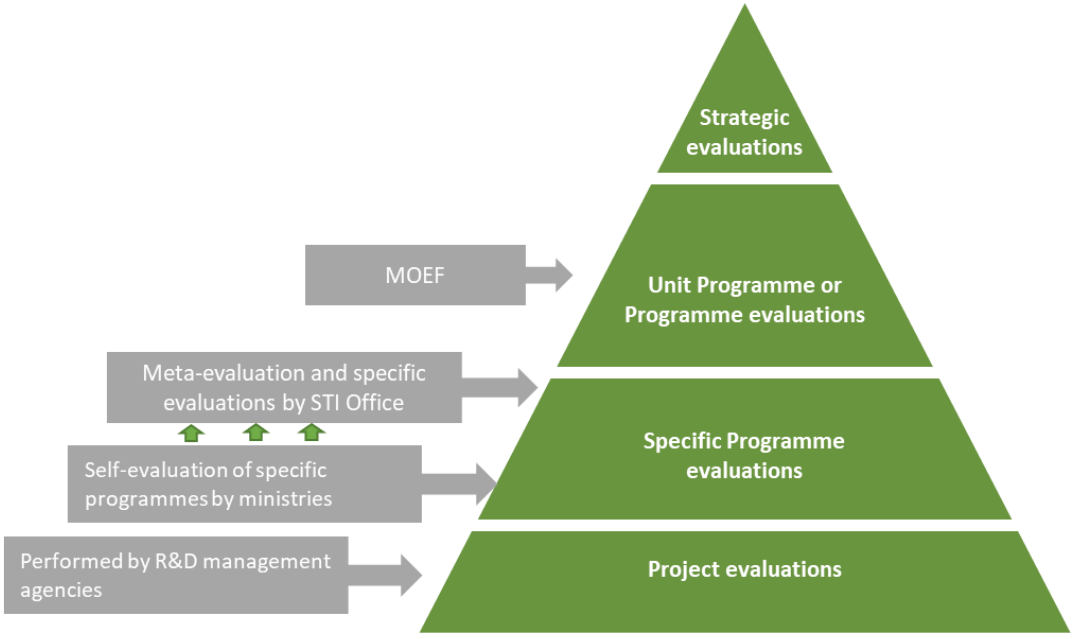
A system of laws, guidelines and procedures frames the monitoring and evaluation of programmes and projects. Many reforms have been enacted in the past. For instance, in 2012-13, a reform was enacted to allow for more and better reflexivity (so that, for instance, *in itinere* evaluations can lead to corrective actions, or even discontinuation, earlier in the project cycle); better structuration for greater evaluability of projects (through the strengthening of the *ex ante* review system discussed earlier); and stronger linkages between the outcomes of funded projects and future decisions regarding future programmes and projects (the results of the previous project evaluation is one of the criteria for new project proposals).

Until 2021, ministries were required to perform self-evaluations of their programmes at different stages of the programme cycle: 1) an evaluation of performance indicators (at the planning stage); 2) interim and/or specific evaluations (throughout programme implementation); 3) a final evaluation (after programme finalisation); and 4) a follow-up evaluation (within five years of programme finalisation). All these evaluations were subject to meta-evaluation by the STI Office to monitor the adequacy of the evaluation process (MSIT, 2020[63]). Ministries could be asked to reperform their self-evaluations. Furthermore, an additional step of specific evaluation was reserved for certain programmes that were longer-term, larger-scale and of high national importance, therefore requiring central co-ordination by the STI Office.[40]

In 2021, the 2005 Research Performance Evaluation Act was significantly revised. Importantly, the autonomy and responsibility of sectoral ministries for programme evaluation were strengthened, while the role of the STI Office focused on monitoring rather than evaluation. For transparency, ministries were asked to develop an evaluation strategy plan for each programme and monitor its implementation. Also,

the meta-evaluation process by the STI Office was simplified (KISTEP, 2021[64]).[41] Continuing the previous reforms, another change was made to promote research quality rather than focusing solely on indicators based on the quantity of outputs. This approach helps to better capture the socio-economic impacts of research. Finally, the "follow-up evaluations" changed name to "R&D programme impact-chasing" evaluations and are now carried out by the ministries themselves. Before the reform, follow-up evaluations of Specific Programmes were performed by KISTEP.

Figure 5.10. Korea's different types of evaluation by programme



Source: Based on desk research and stakeholder interviews and OECD (2016[65]), *Evaluation Systems in Development Co-operation: 2016 Review*, https://doi.org/10.1787/9789264262065-en.

It is too early to assess the effect of such a recent reform. One can only emphasise that several reforms in the past addressing the same issues had limited effects, hence providing the rationale for a new wave of reforms. Efforts should also be dedicated to better understanding why past reforms have not yielded the expected results, including through an analysis of how the new evaluation rules and procedures are applied. Several interviewees mentioned that the issue does not lie in the formal framework, which appears to include the latest international good practices on paper (and sometimes even innovates),[42] but rather in the behaviours of actors within that framework.

5.6. Governance of the Korean sustainability transition

This section examines Korea's efforts to develop and implement cross-cutting strategic and policy frameworks to support its transition to a more sustainable model and, in particular, achieve its commitment to a net-zero economy.

5.6.1. Orienting funding towards addressing societal challenges

Korea has demonstrated a growing awareness of the importance and urgency of societal challenges and started reforming its governance and policy framework accordingly. In 2013, MSIT prepared the first Comprehensive Plan on S&T-based solutions for social problems[43] as an inter-ministerial plan. In 2018, the second Comprehensive Plan aimed to improve living standards through STI. It included three main

strategic thrusts aiming to: 1) build an inter-ministerial co-operation structure to invest public R&D in areas of public demand; 2) form an ecosystem for social problem-solving R&D; and 3) strengthen the social contribution of STI. To that end, the Comprehensive Plan identified 41 society-related problems in 10 fields.[44] Also in 2018, as mandated by the plan, the first public-private consultative meeting was formed, including with high-level government officials (both central and local) and private experts (firms, academia and GRIs). Such meetings are organised each quarter of the year by the Head of the STI Office.

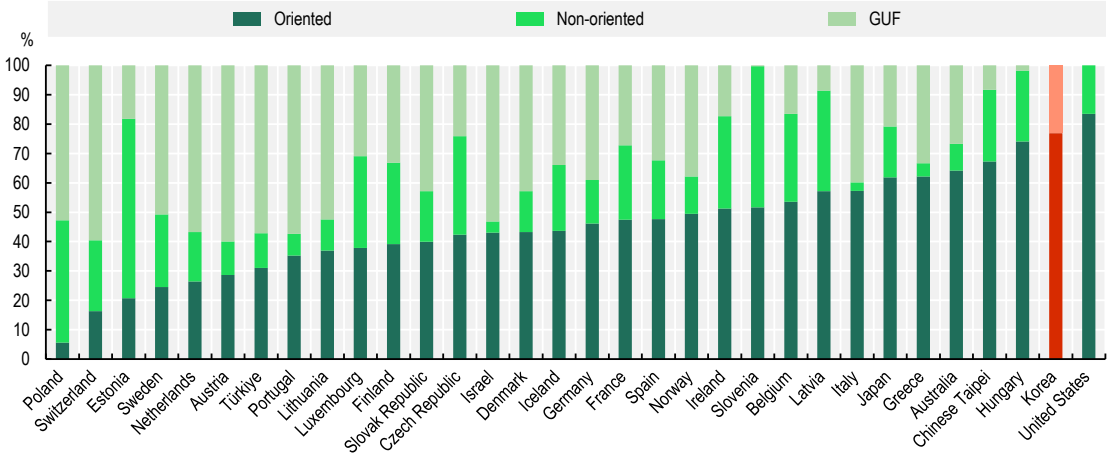
Furthermore, in 2021, MSIT developed the Social Problem-solving R&D Guidelines for ministries in order to increase the contribution of R&D to public well-being (MSIT, 2021[66]). The guidelines define the three core features of such programmes: establishing objectives that reflect high social demands; being supported by a governance structure that includes relevant stakeholders; and generating increased impact in response to identified problems. The guidelines are intended to be used by ministries across the programme cycle of their R&D programmes, from planning and budgeting to performance management.

International experience suggests that there is often a comprehensive gap between plans and concrete actions when it comes to societal challenges. One way to assess whether Korea has moved beyond intentions is to try to analyse funding trends of "social problem-solving" R&D. A first element to consider is the capacity of the government to allocate funding to specific issues (i.e. oriented or "directional" funding), thus not only providing neutral support, e.g. through an R&D tax credit.

A large portion of Korea's government appropriations dedicated to R&D is thematically oriented (Figure 5.11). Non-oriented research includes both research for the general advancement of knowledge and institutional funding. Oriented research includes research reported by national authorities as contributing to specific socio-economic objectives. In Korea, public funds for oriented research accounted for 75% of the total (direct) fund for R&D in 2020 (85% in the United States, 68% in Japan, and 46% in Germany). The general university fund (GUF), which mainly includes institutional funding to universities, is null in Korea since institutional funding of universities only covers the educational mission of universities (see Chapter 4).

Figure 5.11. Oriented and non-oriented government budget allocations for R&D (GBARD) in Korea and selected economies, 2021

As a percentage of civil GBARD

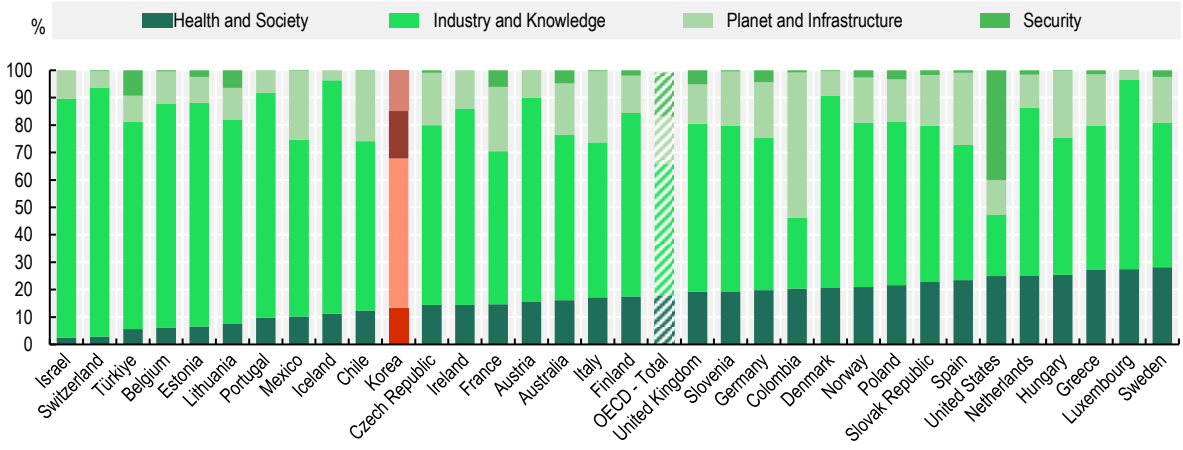


Note: Non-oriented research for Korea includes GUF. Differences in methodology for Australia, Austria, Israel and Japan. Estimated values for Denmark, France and Sweden.
Source: Authors' calculations based on OECD (2021[67]), "Research and Development Statistics: Government budget appropriations or outlays for R&D", https://doi.org/10.1787/620bbce8-en (accessed on 20 June 2023).

The allocation of public funds for R&D in Korea reveals that the country dedicates a relatively small proportion of its government R&D budget to projects and activities related to health and society issues. In 2019, only 14% of R&D funds were allocated to these areas, compared to 32% in Sweden and 21% in Germany (Figure 5.12). As in most countries, it is experiencing an upward trend (it was 9% in 2012). A higher share in international comparison is allocated to security-related R&D (15%, second to the United States in Figure 5.12. As in almost all countries, most of Korea's R&D resources are directed towards industry and knowledge (53%).

Figure 5.12. Government R&D budgets by Sustainable Development Goal-related category, Korea and selected OECD countries, 2020 or latest available

As a percentage of total GBARD



Note: Data for Chile, Germany, Iceland, Spain and the United States correspond to 2019.
Source: OECD, Research and Development Statistics Database, http://oe.cd/rds (accessed on 21 June 2023).

According to research by KISTEP, the share of the Korean R&D budget dedicated to societal issues is rising (a 10% increase in 2021) but remains low, representing only 5.8% of the total R&D budget (KISTEP, 2021[68]). The main contributors to this budget were MSIT, the Ministry of Welfare and MOTIE.

For example, in the energy sector, which accounts for most of the greenhouse gas (GHG) emissions in Korea, funding for fossil fuel research, development and demonstration (RD&D) (and nuclear RD&D) significantly decreased between 2013 and 2019. However, funding for renewable energy, hydrogen and fuel cells, and other power and storage technologies has not significantly increased or at all.

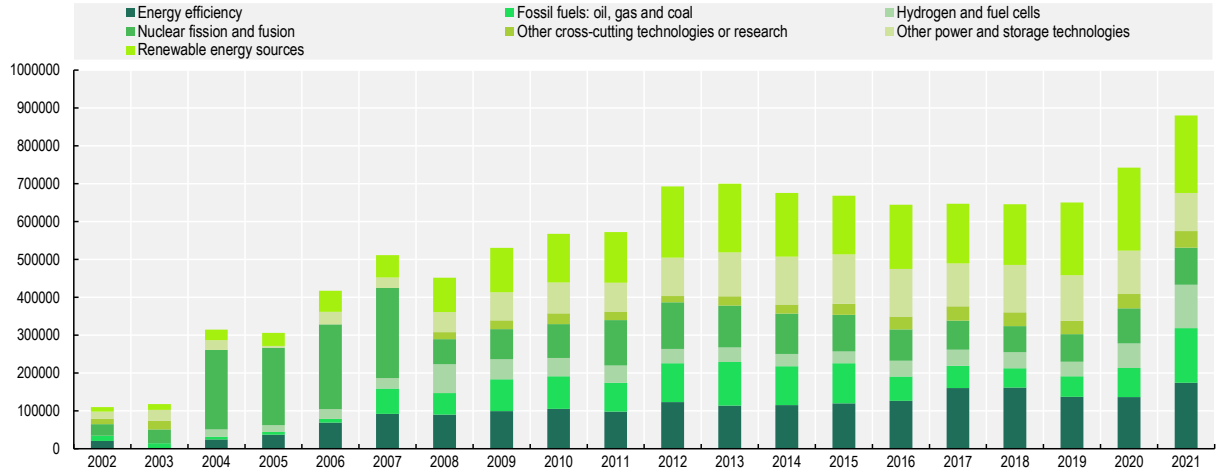
As a result of the Green New Deal (see below), Korean energy RD&D increased significantly in 2020 and even more so in 2021 (see Figure 5.13). However, despite this increase, Korea ranked 8th in terms of RD&D budgets dedicated to energy among International Energy Agency (IEA) member countries in 2021 and 13th when normalised by level of gross domestic product (GDP).[45] The Korean energy RD&D budget (EUR 659 million) was about half of Germany's (EUR 1 354 million) in 2021, which is consistent with their GDP difference. However, German public investment in energy RD&D has increased far more steadily since the beginning of the 2000s (with a drastic increase in 2022 due to the national Recovery and Resilience Plan) than Korea's.

The allocation of the energy RD&D budget among the different technologies is also enlightening. While Korea invests mainly in renewables (23%) and energy efficiency (20%), Germany focuses on hydrogen and fuel cell technologies (29%) and renewables (16%). Korea still invests a significant share of its energy

RD&D budget in fossil fuels technologies (16%), compared with less than 2% in Germany, 3% in France and 5% in Japan despite their large automobile industries (IEA, 2022[69]).

Figure 5.13. Korea's energy RD&D budget by technology, 2002-21

In KRW millions (2019 prices)



Source: IEA (2022[69]), *Energy Technology RD&D Budgets* (database), https://www.iea.org/reports/energy-technology-rdd-budgets-overview/data-explorer#abstract (accessed on 21 July 2022).

5.6.2. Governance of the net-zero agenda remains fragmented

As shown in Chapter 2, Korea is one of the few advanced countries where GHG emissions continue to rise, and the national CO_2 intensity of GDP remains one of the highest among OECD countries (see Chapter 2, Figure 2.28, Panel B). Korea's GHG emission intensity per capita is still above the OECD average (third-highest intensity after Canada and Australia) and has increased since 2000. The power sector is the main source of emissions, and its emissions have increased by 42% since 2008 (an increase of 21% in the transport sector and other energy sectors by 23%) (IEA, 2020[70]).

However, achieving net-zero commitments is a considerable challenge for all countries regardless of their recent results in terms of emission mitigation. In response to this imperative, countries are implementing an increasing range of STI policy experiments to support their sustainability transitions. A growing body of literature in environmental and science policy studies exists to guide and learn from these experiments. Although there is still much uncertainty regarding the most effective types of design to address ambitious societal challenges, including climate change and rapid ageing, and bring about needed systemic change, a consensus prevails on some overall principles.

The urgency, complexity and systemic scope of the most pressing societal challenges call for proactive policies where the state has a strong role to play in initiating and steering relevant initiatives. The needed government intervention goes far beyond issuing a list of national priorities or key technologies or even developing an overall STI strategy or plan. Public authorities play the role of orchestrators of large strategic and policy frameworks dedicated to solving specific challenges or objectives, with the strong involvement of a wide range of policy actors and other public and private stakeholders.

The cross-cutting and systemic nature of the societal challenges requires an unprecedented level of holistic co-ordination of a wide-ranging policy mix. In order to reduce GHG emissions, for instance, supporting the R&D of novel solutions cannot be disconnected from the skills needed to produce and maintain these technologies, the new needed infrastructure, the supply of new materials, the regulatory changes required

to experiment and diffuse the technologies or even the behavioural and social changes associated with the use of the new technologies. The electric vehicle illustrates this point. Even more, these efforts should also be linked to the activities on many other complementary or competing technologies that will be necessary to trigger the necessary system transition, often belonging to different industries and based on different scientific disciplines and bodies of knowledge. In short, societal challenges that are systemic in nature require system innovations, which calls for systemic policies (OECD, 2015[71]).

In Korea, following the President's commitment to combat climate change, the government proposed in October 2020 to achieve carbon neutrality by 2050. The Framework Act on Carbon Neutrality and Green Growth for Climate Change[46] entered into force in 2022. It includes a goal to cut GHG emissions by 40% by 2030 (compared to 2018) and reach net-zero emissions by 2050. This Act demonstrates that Korean society at large is now firmly committed to achieving the sustainability transition and is ready to engage in bold actions, such as replacing fossil fuel power generation with renewable energy and green hydrogen, using carbon capture, usage and storage (CCUS) technology and, for instance, shifting towards zero-emission vehicles. This evolution is recent and remains to be confirmed in years to come, as difficult trade-offs, with potentially significant economic and social consequences, will have to be made. The challenge is considerable, given Korea's high level of emissions.

The government has launched comprehensive policy plans and programmes to implement these commitments. As already mentioned, the 2050 Carbon Neutrality and Green Growth Commission is a specific body established in May 2021 to serve as the "control tower" of all carbon neutrality policies in the country (the Net-Zero Policy framework) and as a platform for citizen consultation and engagement (2050 Carbon Neutrality and Green Growth Commission, 2022[72]). The commission is headed by the Prime Minister and has four sub-committees composed of public and private stakeholders.[47] In 2021, the commission released two policy roadmaps for carbon neutrality (corresponding to two scenarios)[48] and is mandated to approve and monitor Korea's net-zero policy agenda.

The National Green Growth Strategy for Carbon Neutrality was launched in October 2022. It includes four main policy orientations: 1) responsible carbon neutrality through concrete and efficient solutions; 2) innovative carbon neutrality and green growth led by the private sector; 3) carbon neutrality led by the co-operation of all members of society; and active participation to carbon neutrality leading the global market and the international community. Based on these four orientations, twelve key projects were defined, and specific policy directions and responsible departments were specified. Furthermore, the Commission also launched the Strategy for Green Growth Technology Innovation during the same period. It includes three main orientations: technological innovation toward carbon neutrality mainly through private-sector-led missions; enhanced investment in rapid and flexible carbon-neutral R&D; and pre-emptive building of infrastructure for innovative technology development. With innovation being an important factor in the achievement of these strategies and roadmaps,[49] it is important to ensure a formal connection between PACST and the Net Zero and Green Growth Commission.

One option would be that all committees with significant prerogatives in reducing GHG emissions meet in a specific format about twice a year, possibly with a dedicated monitoring report.

5.6.3. An ambitious yet traditional policy framework for the transition to net-zero

One of the components of the policy framework is the Korean New Deal. This overarching plan was announced in April 2020 as a new stimulus package to lessen the impact of the COVID-19 crisis and pave the way towards the "post-coronavirus era". Geared to support the "twin transitions", it was composed of two main pillars, the Digital New Deal (DND) and the Green New Deal (GND). The Safety Net programme complemented these two pillars. In 2021, the GND budget was KRW 8.1 trillion, mainly focused on infrastructure, energy supply and industry (Government of Korea, 2021[73]). It set precise targets to be achieved at key milestones, including the overarching goal of creating 1 901 000 jobs by 2025.[50] The

initiative is structured along nine policy areas (four on DND, three on GND and two on the Safety Net component) and ten "major tasks".

In 2021, upon reassessing the recent changes in both domestic and external environments and their impact on Korean society, the government rebranded the initiative to Korean New Deal 2.0 (hereafter, "KND 2.0"). While the timeline (2020-25) has remained unchanged, the national budget increased from KRW 160 trillion to KRW 220 trillion to create 2.5 million jobs (compared to 1.9 million) (Government of Korea, 2021[74]). The biggest change is that the social safety net measures that were previously regarded as foundational, but rather supplementary policies, to facilitate the digital and green transition under the pillars of DND and GND were regrouped into the "Human New Deal" (HND) programme. KND 2.0 is, therefore, now composed of three programmes (DND, GND and HND). The policy areas were redefined and expanded from 9 to 12. Furthermore, an additional programme, the Regional Balance New Deal, is planned with a dedicated budget to help regions – particularly the least developed ones – benefit from KND 2.0. For instance, some funds will be used to incentivise local governments that participate in KND 2.0 projects. There are also plans to reduce the bureaucratic burden (including the feasibility tests) to launch new green development projects in local areas.

Dedicated governance structures are set to co-ordinate and monitor the overarching plan and its three components. At the highest level is the Strategy Meeting on the Korean New Deal convened by the President. This meeting is supported by the Government-Party Headquarters for the Korean New Deal (hereafter, "HQ"). The HQ is headed jointly by the Minister of Economy and Finance (Vice Prime Minister) and the General Manager of the Office of KND within the major political party. The members, by design, include both ministers of MSIT, MOE, MOTIE and the Ministry of Employment and Labour (MOEL),[51] representing the government and leading the three components of KND, and the corresponding three heads of divisions from the political party (Korean New Deal, 2022[75]).

The fiscal investment in GND planned until 2025 is KRW 97 trillion, of which KRW 61 trillion comes from the national budget. In 2022, KRW 13.3 trillion of government investment is planned, which is the largest sum of all three pillars (Government of Korea, 2021[74]). The four tasks defined are: 1) building policy for carbon neutrality (newly introduced under KND 2.0); 2) exploring green transition options for city infrastructures and lifestyle; 3) diffusion of low-carbon energy sources; and 4) establishing an innovative ecosystem for green industries.

While the budgets and scope of these new initiatives are considerable, it is unclear whether they represent a qualitative shift from traditional strategy and modes of intervention. It appears to focus more on inputs – allocating money into the system – than impact. It is essentially an umbrella for ten large programmes with rather short-term objectives, implemented by different ministries. Furthermore, the GND's prime objective seems to concentrate on achieving economic recovery through new green business activities.

Since starting from an umbrella recovery programme in 2010, France has continuously strengthened the integration of its Investments for the Future programme (PIA). The latest edition, launched in 2021, includes a "directed logic" component, where large and ambitious challenges are tackled through inter-ministerial Acceleration Strategies (see Box 5.6).

Box 5.6. France's STI framework to support its sustainability transition

The French government launched the Investments for the Future programme (PIA) in 2010 to promote investments and innovation in key sectors to stimulate employment, boost productivity and increase the competitiveness of French businesses. The PIA is characterised by centralised inter-ministerial steering led by the General Secretariat for Investment (SGPI), which, under the authority of the Prime Minister, is responsible for ensuring the general consistency and monitoring of the state's investment in PIA. PIA's implementation is decentralised in funding agencies.

Three PIAs have been launched since PIA1 in 2010 (PIA2 in 2013, PIA3 in 2017 and PIA4 in 2021, covering 2021-25) with an overall investment of about EUR 67 billion. Priorities have evolved with each new PIA, with a growing focus on R&I activities that can contribute to the ecological transition. PIA4 has set a target of at least one-third of investments supporting the ecological transition. The evaluation of the first ten years of PIA (i.e. covering PIA1 and PIA2) in 2019 highlighted a need to renew the original PIA strategic investment priorities and streamline the intervention tools to better integrate the support for R&I in the upstream and downstream phases and be more impactful.

PIA4 (integrated into France Relance 2030 since 2022), launched in 2021, responds to this call for a renewal of the programme. It has a EUR 20 billion budget and is structured in two main "intervention logics". The "structural logic" provides long-term sustainable funding to key R&I institutions. The "directed logic" promotes a more directional approach to support exceptional investments to meet five "grand challenges": 1) securing, certification and reliability of AI; 2) improving medical diagnostics through AI; 3) cybersecurity – making France's systems sustainable and resilient to cyber-attacks; 4) producing high value-added proteins biologically and at a reduced cost; 5) development of high-density energy storage for sustainable mobility. These challenges were selected by the Innovation Council, which was created in 2018 to define the main priority orientations of French innovation policy, define cross-cutting actions and simplify the French R&I policy landscape.

The main instruments of the "directed logic" component are the Acceleration Strategies. In specific challenge areas, these large initiatives aim to identify the main socio-economic transition challenges and to invest in tackling these challenges using a global and systemic approach combining various modes of intervention (research, training, financing, standards and norms, taxation, etc.). The expected added value of Acceleration Strategies is not primarily in the novelty of the supported activities but in their stronger strategic steering and integration across the entire innovation cycle. While the objectives of the first PIA were politically determined in 2010 in the context of the 2008 financial crisis, the PIA4's Acceleration Strategies are co-constructed by all relevant partners.

The Carbon-free Hydrogen Acceleration Strategy has set targets for 2030, including the installation of a carbon-free hydrogen production capacity of 6.5 GW (gigawatt) by electrolysis, the saving of more than 6 Mt (metric tonnes) of CO_2 and the creation of 50 000-150 000 direct and indirect jobs in France. Each strategy has its own governance structure, with a dedicated inter-ministerial co-ordinator who reports to the Innovation Council. The task of the co-ordinator is to lead the inter-ministerial co-ordination and monitoring of all the actions implemented. The Carbon-free Hydrogen Acceleration Strategy has a budget of EUR 3.4 billion during the period 2020-23, and EUR 7 billion is planned until 2030. The strategy covers all aspects related to establishing a hydrogen value chain (*filière*) from research to production, pipelines, skills and markets. The strategy also aims to develop key technologies and components through pilot projects for different types of usages and markets.

One essential added value of each Acceleration Strategy is integrating all instruments, from exploratory research programmes to price-based mechanisms, in a common institutional space with a dedicated governance structure gathering various ministries and stakeholders.

Source: Various sources, notably the SGPI website, https://www.gouvernement.fr/secretariat-general-pour-l-investissement-sgpi.

5.6.4. Korea has launched mission-oriented policy experiments, but these remain too narrowly focused on technologies

The OECD defines mission-oriented innovation policies (MOIPs) as a co-ordinated package of policy and regulatory measures tailored specifically to mobilise STI in order to address well-defined objectives related to a societal challenge in a defined timeframe. These measures possibly span different stages of the

innovation cycle from research to demonstration and market deployment, mix supply-push and demand-pull instruments, and cut across various policy fields, sectors and disciplines (Larrue, 2021[62]). The specificity of this approach is to integrate into the same institutional space the three key functions of an innovation system as presented earlier: 1) strategic orientation; 2) co-ordination/programming; and 3) policy implementation. Mission-oriented policies are therefore not limited to a strategy, a cross-ministerial committee or a new plan including various policy measures but integrate these three elements. A mission-oriented policy should include: 1) concrete objectives to be achieved linked to a challenge to be met; 2) a dedicated governance structure (inter-ministerial, possibly multi-level, with public and private actors); 3) a tailor-made policy mix (including financial tools to encourage research and support demand; qualitative support measures, regulations, etc.) to achieve goals; and 4) a "reserved" budget.

Korea has demonstrated a strong interest in MOIPs in the last three to four years. It has launched two main initiatives to pursue ambitious goals, with projects financed for up to nine years. They pertain to the challenge-led schemes designed after the US Defense Advanced Research Projects Agency (DARPA) model. These can be effective in accelerating technical changes in some targeted areas but fall short of supporting more systemic innovation that links technological, behavioural, regulatory, social and market innovation. Other countries, such as Germany, Japan and the Netherlands, have set up broad systemic frameworks to realise long-term "national missions". The characteristics of the Korean programmes are consistent with their main objective, which is to strengthen national competitiveness. The mobilisation of this policy approach to support the green transition will require a different type of design and governance. Some recent announcements propose to follow this route but have not yet been enacted.

Korea implements "DARPA-like" challenge-led schemes

There are two main types of MOIPs:

1. **Overarching mission-oriented policy frameworks** aim to realise wide and ambitious national missions (e.g. reducing GHG emissions, fighting cancer). They are systemic in nature and link various types of alternative or complementary solutions (mixing technological, social, behavioural and regulatory changes). For instance, Germany set 12 national missions in its High-Tech Strategy 2025; Japan has 9 Moonshot Goals; and the Netherlands has 25 missions as part of its Mission-driven Top Sectors Policy.
2. **Challenge-led schemes** are focused on a narrower objective (e.g. developing green ships or a system for automatic textile recycling). These are often of a more scientific or technological nature and put the emphasis on R&D activities. To various degrees, these initiatives emulate some of the characteristics of the high-risk, high-reward model implemented by the United States (DARPA).

In the last three to four years, Korea has demonstrated a strong interest in MOIPs, actively engaging in the work of OECD on this policy approach and experimenting with different schemes, all pertaining to the Type 2 presented above. The National Plan for Strengthening Innovative and Challenge-led R&D[52] was adopted in 2019 to prepare the foundation for "mission-oriented problem-solving R&D" programmes.

Currently, three types of national programmes fall under the wide definition of challenge-led missions in Korea:

- the Korea Advanced Research Programme (KARPA) by MSIT
- the Alchemist by MOTIE
- the Future Challenge Technology Development Programme by the Ministry of Defence.[53]

KARPA was created under the leadership of MSIT in 2020 to run from 2020 to 2024.[54] It aims to, first, generate innovative outcomes that can bring about socio-economic transformations and, second, to encourage more ambitious and efficient research. KARPA establishes three research areas (i.e. happy and healthy ageing; safe and pleasant society; sustainable growth of Korea's economy) and five criteria

(i.e. clarity, challenge-orientation, innovativeness, originality, impact) based on which "research themes" are selected. The research themes fall into two types. First, the "exploratory" type funds projects for about four years from ideation until the proof-of-concept phase (therefore, short term). Second, the "package" type funds the whole cycle from R&D to demonstration phases for a maximum of nine years (longer term). The appointed KARPA director selects five themes annually in consultation with the Innovative and Challenge-led Project Programme Committee (see below) and develops detailed plans for some of them, to be implemented by ministries and their agencies.[55] The annual budget for KARPA operation was around KRW 1.4-1.8 billion for 2020-22. While each ministry has to follow the normal budget request process for their KARPA programmes, the STI Office recognises the specificity of these programmes. They are, therefore, treated with more attention and flexibility to adapt to their specificities.

A specific regulation, the Operation and Management Regulation for Innovative and Challenge-led Projects, provides the legal basis for KARPA. Within this programme, private programme directors manage cross-ministerial national projects with an aim to generate a large social and economic impact despite the risk of failure (Ministry of Legislation, 2020[76]). A private-public joint committee including 12 ministries, the Innovative and Challenge-led Project Programme Committee, was established under MSIT to review the plans developed by the programme directors and take charge of the inter-ministerial co-ordination.

The Alchemist is a high-risk, high-reward R&D programme owned by MOTIE. The programme aims to promote disruptive and breakthrough technologies for future generations with the help of R&D. It also seeks to tackle some of the weaknesses of the Korean R&D system, in particular, relatively low performance compared to large and annually growing R&D investment (input-oriented) and a low appetite for conceptually new and risky projects. MOTIE launched the programme in 2019 with the Korea Evaluation Institute of Industrial Technology (KEIT). The pilot programme ran from 2019 to 2021; in 2021, the programme passed the pre-feasibility test with a budget of KRW 414.2 billion earmarked for 2022-27 (of which KRW 374.2 billion comes from the national budget and the rest from the private sector). The Alchemist programme adopts a stage-gate and competition approach, where six projects are selected for the concept phase (funded for one year), three for the pilot phase (one year) and one for the main research phase (five years).

The government has ambitious plans for the future of mission-oriented policies in Korea

The government has identified inefficiencies in the current governance and budgeting of the Korean STI system that hamper cross-ministerial challenge-led R&D programmes (MSIT/STEPI, 2021[77]) (MSIT/STEPI, 2021[77]). The areas for improvement identified by this exercise included: 1) lack of co-ordination between ministries, which hinders a clear identification of their respective roles in implementing such programmes; 2) insufficient scale of the budgets for these programmes, defined within the budget ceilings set by MOEF, which tend to demotivate ministries' participation (according to the results of this exercise); 3) time needed (on average, two to three years) to reflect for the budgets of these programmes in the respective ministries' budget portfolios, which compromises their timely implementation.

In order to overcome these problems, the government foresees a two-step – short-term and mid- to long-term – promotion plan to set up a sound institutional setting for the challenge-led scheme. The short-term reform plan (until 2024) involves establishing cross-ministerial government and R&D regulations more conducive to implementing challenge-led R&D programmes. This includes a dedicated budget, a revision of the pre-feasibility test regulation and changes to the management and leadership of these programmes. On a longer-term horizon (from 2025 onwards), a bill submitted to the parliament contains a clause that stipulates that the government can designate organisations for planning, evaluation and management of challenge-led missions.

So far, Korea has mainly implemented 'challenge-led missions' as defined previously. However, there has been an increasing interest in 'overarching mission-oriented policy frameworks' in recent years, which has

led to new policy developments. This could have important positive impacts since this policy approach provides a crucial complement to the more focused type in that it can bring about more systemic changes necessary for sustainability transitions to succeed. According to Kuttinen, Polt and Weber's (2019[78]) mission typology, challenge-based mission schemes can achieve "acceleration missions", whereas broader national mission frameworks, such as the Danish Green Missions, as well as the German High-Tech Strategy 2025 and the Dutch Mission-Driven Top Sectors, are considered transformative missions (Kuttinen, Polt and Weber, 2019[78]).

Box 5.7. An example of national missions: Innovation Fund Denmark's Green Missions

The objective of Innovation Fund Denmark's Green Missions is to make a significant contribution to the green transformation of society and the development of sustainable climate technologies. Concretely, the missions should contribute to the country's net-zero commitments. Four missions have been launched: 1) capture and storage or use of CO_2; 2) green fuels for transport and industry (Power-to-X, etc.); 3) climate- and environment-friendly agriculture and food production; and 4) recycling and reduction of plastic waste.

Each mission has its own overarching objectives and specific objectives. For instance, the green fuels mission aims, among others, to harness the potential to capture, store or use to the order of 4-9 million tonnes of Danish CO_2 emissions.

The missions were selected according to the following criteria: the green potential of the area (to contribute to net-zero objectives); national professional strength (of the Danish business community); potential (of the market of the related green solutions); research strengths (expertise of Danish researchers and ability to enter into international collaborations and partnerships); and partnership potential (scope to support R&I partnerships where there is a clear basis for co-operation between universities, companies, public authorities, etc.).

In the agreement on the Research Reserve 2021, a total of DKK 700 million (Danish krone) (approximately EUR 94 million) was set aside to establish Green Research and Innovation Partnerships that meet specific missions. Each mission has a dedicated minimum budget.

The missions are implemented through the Innovation Fund Denmark in two stages.

1. Call for roadmaps. All relevant stakeholders across the Danish R&I system are encouraged to come together to contribute their expertise and propose a realistic and robust path toward developing or accelerating cutting-edge solutions to achieve the mission's objectives. The roadmaps need to describe challenges and gaps within the mission, strongholds and potential and sketch key activities and relevant workstream themes for future partnerships. Roadmaps are expected to cover the entire value chain and collect all driving forces from all types of organisations (from researchers to investors, education and talent, legislators, authorities, users, etc.) and include descriptions of technical, implementation/regulatory, and business/financial pathways to the vision. They should outline how it will range from strategic research to commercialisation, with a focus on short-, mid- and long-term impact. All types of stakeholders can put forward a roadmap.
2. Call for partnerships to implement selected roadmaps. Selected roadmaps proceed to the partnership phase. This decision is based on an evaluation undertaken by the Innovation Fund Denmark's Board. The overall call process is identical across the missions, but each mission can be treated differently in terms of the number of partnerships, structure and level of ambition according to the maturity and key challenges in each mission.

   Investments in partnerships are split into two steps. The first step focuses on the foundation of the partnership, including management, governance, capacity building, infrastructure,

communications, relations and the primary research work streams (activities within the first year). The second step describes specific R&D activities and efforts aligned with the overall vision and goals of the partnership. There is the expectation that the broad, strong and agile partnerships comprise the whole value chain, a short- or mid-term result focus, a five-year partnership period, and a partnership centred around fulfilling the mission goals.

There is a two-step process for selecting partnerships. First, there is an initial assessment of the proposal. Second, there is an interview with a panel of national and/or international experts and possibly board members and other relevant stakeholders. Finally, there is a request for an investment proposal, on which a decision to move forward is made.

The partnerships are structured as a consortium. Governance of the partnership entails a General Assembly, a Partnership Board of Directors, and a project management group, including five scientific leads and project leads, and the project management group, are aided by a secretariat. These bodies get inspiration from an international advisory board and a national stakeholder sounding board.

Source: OECD.

PACST made recommendations in 2020 to set up national missions with clear and ambitious goals related to societal challenges (PACST, 2021[79]). According to the draft plan, the STI Office must designate a lead ministry and agency to take charge of the national missions. The ministry would set a specific but ambitious goal within a defined timeframe, which would have to include the R&D roadmap, later to be submitted to and approved by PACST. In order to monitor the implementation process, the R&D monitoring committees would be established under PACST for each challenge. They would bring together different relevant ministries, experts (industry, academia, GRIs) and the public.

While these recommendations were not taken on board as such, the Deliberative Council R&D Budget Allocation and Co-ordination Plan for 2023 (see Figure 5.7) took up the issue of mission-oriented policies (PACST, 2022[80]). It pledges to strengthen investments in mission-oriented R&D[56] to solve socio-economic challenges that necessitate whole-of-government interventions. Examples of these missions include climate change and securing national strategic technologies. In particular, they proposed to set up a specific funding framework for national missions that aim to solve societal problems (PACST, 2022[80]). Within these missions, the funding across the whole innovation cycle would be integrated, from basic research to market deployment. This could represent a significant way forward to reduce the fragmentation of the policy mix. However, no information is yet provided on how this integration will be achieved in practice.

More generally, the plan proposes to experiment with more strategic and integrated platform-based funding between ministries to fund R&I initiatives dealing with societal challenges. The investment priorities would be reviewed by the existing expert committees under the Management Committee of the PACST Deliberative Council. The soon-to-be-established National Centre for Technology Strategy (NCTS) could support the STI Office by analysing the portfolio and strategic investment of the relevant areas.

These options are still at an early stage, and little information was available at the time of writing. Despite governance arrangements, the funding of the missions is particularly crucial. As previously mentioned, the fierce competition between ministries for budgets limits co-operation opportunities in Korea. Against this backdrop, whether missions will be financed – at least partly – by some specific, centrally operated fund will be crucial to incentivising joint endeavours. In the absence of such “budget top-ups” for ministries contributing to missions, the same barriers that hinder large-scale cross-ministerial programmes will also affect the missions.

To respond to the growing need for a mission-oriented policy framework, PACST approved MSIT’s mission-oriented policy strategy in October 2022. (PACST, 2022[81]). The strategy calls for “solving national

socio-economic challenges through mission-oriented R&D innovation" and identifies eight projects to be implemented in three areas: R&D investment based on clear missions; strategic investment to overcome fiscal limitations; and innovative and flexible R&D implementation. The framework will be first implemented in two major areas where S&T can bring about significant changes and produce tangible results: carbon neutrality by 2050 and fostering national strategic technologies. Based on the expected outcome, the scope of the mission-oriented R&D will be expanded to other areas, such as ageing society and epidemics.

The mission-oriented approach will consist of three main components:

1. First, the government will focus on establishing necessary roadmaps and leading bodies in order to implement effective mission-oriented R&D. Furthermore, a public-private council in five technology areas will be created in order to actively collect opinions from private actors. The five areas include: carbon neutrality; renewable energy; future biotechnology; future mobility; and digital transition.
2. Second, the current rigidity in budget allocation will be reduced so projects can adapt quickly to changes in technology and the environment. The pre-feasibility test process will be shortened and reformed where necessary to secure the timeliness of mission-oriented R&D projects. Furthermore, various funding allocation processes will be promoted as needed.
3. Third, the accountability and flexibility of project management will be improved for mission-oriented R&D projects. A project manager with powerful authority will be appointed. The projects will be permitted to change their mission and goals to adapt to the changing environment. Lastly, the mission-oriented R&D project will be closely monitored at each step and evaluated based on clear and specific performance indicators.

5.7. Synthesis

Table 5.4 sets out the main achievements and challenges of the Korean STI governance system.

Table 5.4. Korea's main achievements and challenges related to its STI governance system

Achievements	Challenges
Strategic orientation • Korea's strong foresight system systematically informs whole-of-government and sectoral strategies and plans. • Korea has a comprehensive framework to link the long-term, mid-term and annual plans across the government structure.	Strategic orientation • There is a potential disruption in the long-term strategy due to the presidential cycle in Korea. • Despite progress in Korea's 6th Foresight exercise, foresight remains too technology-focused and expert-based and falls short of more systemic and inclusive foresight exercises.
Co-ordination and programming • Korea has a central STI co-ordination unit ("control tower") with a powerful mandate to co-ordinate STI-related budgets, plans and activities of more than 20 ministries that intervene in this area. • There is a systematic reduction of programme overlaps between ministries, allowing for significant efficiency gains in Korea.	Co-ordination and programming • Despite a unique governance structure, cross-ministerial co-ordination is still considered a significant issue in the Korean STI system, according to surveys and interviews. • Emphasis of central organisations on annual monitoring of sectoral ministries' compliance happens to the detriment of higher-level and more holistic co-ordination.
Policy implementation • Korea is implementing reforms to improve agencies' activities and provide more autonomy to research organisations. • There is growing interest in mission-oriented policies and the implementation of two DARPA-type challenge-led schemes in Korea.	Policy implementation • Cross-ministerial and cross-agency co-operation often perform as large umbrella programmes in Korea and are limited in number. • Governance of agencies by their "principal" is not sufficiently linked to their plans and performance in Korea. • Korea's mission-oriented policies remain confined to technological and engineering projects with limited systemic scope.

Annex 5.A. Korea's main centralised governance arrangements and associated processes

Annex Table 5.A.1. Korea's main centralised governance arrangements and associated processes

	Governance arrangements	Associated processes	Objectives
1. Strategic orientation	**S&T long-term vision** Latest: Innovate KOREA 2045, launched in 2020	• Developed by the STI Office, in consultation with other ministries • Validated by PACST Deliberative Council	• Provide long-term guidelines for S&T mid-term strategies and plans • Lay out the long-term desired orientations for Korean society and S&T challenges to be tackled
	Five-year Basic S&T Plan Latest: Basic Plan 2018-22; in preparation Basic Plan 2023-27	• Developed by an ad hoc planning committee (and several sectoral sub-committees and working groups) under the STI Office • Ministries and various actors consulted on draft versions • Process orchestrated and co-ordinated by the STI Office • Validated by PACST Deliberative Council	• Provide the orientations for the whole STI innovation system • Most authoritative STI strategic document. By law (Framework Act), the Basic Plan must be implemented by all ministries with relevant activities and local governments
	Ministries' S&T mid- to long-term plans About 90 plans. Example: National Strategy for Artificial Intelligence (2019-30)	• Developed by sectoral ministries • Reviewed by STI Office (consistency check) • Validated by PACST Deliberative Council	• Set the mid- to long-term STI orientations of all ministries in line with the S&T Basic Plan
	Five-Year S&T Investment Plan	• Developed by the STI Office, in consultation with other ministries	• Provide the orientations for the R&D investment for the implementation of the S&T Basic Plan • Will include budget figures
2. Co-ordination and programming	**Ministries' S&T annual action plans** About 80-90 plans	• Developed by sectoral ministries • Reviewed by the STI Office to avoid unnecessary overlaps, identify possible synergies and adjust ministries' S&T budgets. Interactions with sectoral ministries. • A selection of important action plans (as defined by law) is reviewed by PACST Deliberative Council	• Translate the S&T Basic Plan and ministries' priorities into actions to be implemented during the year, with corresponding budgets • These plans also include sectoral actions not covered in the S&T Basic Plan (not reviewed by STI Office)
	Integrated annual S&T action plan	• Developed by the STI Office based on the ministries' annual plans	• Present in one whole-of-government document the action plans of all relevant ministries • Include a synthesis of the monitoring of the previous year's action plan
	Ministerial S&T programmes About 1 000 per year, including about 200 new programmes	• Developed and implemented by sectoral ministries New programmes • Comprehensive review by STI Office (consistency with Basic Plan and coherence with other programmes and budget) • Comprehensive review by PACST Deliberative Council's expert committees (assessment of the scientific and technological quality of	• Implement ministries' mid-term plans • Based on expert committees' opinions, the STI Office approves, rejects or adjusts ministerial programmes' content and budget

	Governance arrangements	Associated processes	Objectives
		the programmes) – hearing of responsible ministries by expert committees Ongoing programmes • Light review by STI Office	
3. Policy implementation	**Multi-ministerial R&D programmes** About 5-10 per year	• Review and selection of cross-ministerial R&D programmes by the Multi-ministerial Programme Committee, a permanent co-ordination structure under the PACST Deliberative Council, chaired by the Head of the STI Office	• Promote, guide and monitor cross-ministerial co-operation across the whole R&D programme cycle
	Pre-feasibility test of large-scale S&T programmes Currently for programmes above KRW 50 billion	• Performed by sectoral committees (under MSIT) that are chaired by the Head of STI Office for those related to R&D	• *Ex ante* assessment of the technological soundness and strategic relevance of large projects
	***Ex post* evaluation of S&T programmes**	• Performed by each responsible sectoral ministry • STI Office performs *ex post* evaluation of Special Programmes (defined by law), i.e. programmes considered critical due, for instance, to their large budgets or relevance to national priorities • STI Office also performs meta-evaluation of ministries' evaluations	• *Ex post* evaluation of ministries' programmes when completed • Review by the STI Office of the soundness of ministries' evaluations and approve or reject them
	"Impact-chasing" evaluation	• Performed by each responsible sectoral ministry and submitted to the STI Office • STI Office monitors the adequacy of the results and provides feedback if needed	• *Ex post* assessment of ministerial programmes at most five years after their completion to assess their impact and learn from their success and limitations

Annex 5.B. The different levels of programmes in the Korean administrative system

Annex Table 5.B.1. The different levels of programmes in the Korean administrative system

Level (tentative English translation)	Original Korean term	Number of items in 2020 (or latest data available)	Example
1. Programmes	프로그램	158 (in 2019)	Future fundamental technology development
2. Unit Programmes	단위사업	336 (in 2019)	Nanomaterial technology development
3. Specific Programmes	세부사업	1 022	Future material discovery
4. Internal Programmes	내역사업	n.a.	Metal materials
5. Projects	세부과제	73 501	Graphene-metal composite material for mass production of ultralight and large-capacity power lines

Source: Lee et al. (2020[42]), *Government R&D System Review and Policy Recommendations: A Case Study of the Biohealth R&D programs*, https://stepi.re.kr/common/report/Download.do?reIdx=984&cateCont=A0201&streFileNm=ffeb3213-ac3c-4aa0-8e26-fb0a3647a41f.pdf&downCont=0.

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Notes

1. Arnold and Barker (2022[90]) defines first-generation governance as the one that after World War II delegated the governance of science to scientists. In the second generation, the focus was put on different means of knowledge transfer as society demanded a social return from science through innovation and economic growth. The third generation aims to focus R&I on major societal challenges characterised by their complex and systemic nature.

2. This section draws on several sources, including (UNESCO, 1985[83]); (Bartzokas, 2005[91]); (Seong, 2011[6]); (Jang, 2012[94]); (Oh and Lee, 2013[7]); and (Hong, 2005[8]).

3. It is estimated that about 190 Industrial Research Associations were created in Korea between 1982 and 1997 (Sakakibara and Cho, 2022[4]).

4. The HAN Project aimed to increase the technological competitiveness of Korea to the level of G7 countries (hence the name, G7 Project). The project ran for ten years from 1992 to 2001. Its budget was KRW 3.7 trillion (around USD 3.5 trillion), including KRW 1.6 trillion (around USD 1.48 trillion) from the government and KRW 2.2 trillion (around USD 2.03 trillion) from the private sector.

5. The private sector represented 2% of the GERD in 1961, 3% in 1970 and 75% in 1985. Private sector R&D expenditures have exceeded public expenditures since 1983.

6. In Korean, *과학기술처*.

7. Notably, following the merger between MOST and MOE into MEST in 2008, the former STI Office (within MOST at the time) was reduced to a small bureau.

8. A large portion of MKE became the MOTIE. Other parts fell in the current portfolio of MSIT.

9. These are the 26 ministries for which R&I activities are co-ordinated by the Innovation Office in 2022. This number might vary in the case of changes in the government structure and reallocation of ministries' portfolios.

10. International comparisons are hazardous in this regard as ministries have different scopes. In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Economy, Trade and Industry (METI) account respectively for about 65% and 16% of the total R&D budget in 2020. In Germany, the Federal Ministry of Education and Research (BMBF) accounted for 56% of planned budgets (EUR 13.27 billion) in 2021, the Federal Ministry of Economics and Technology (BMWK) for 21% (EUR 4.97 billion) and the Defence Ministry for 7.5% (EUR 1.79 billion). Since MEXT and BMBF include universities in their portfolio, their share of R&D state budgets should be compared in Korea with the combined shares of MSIT and MOE (41%) to be meaningful.

11. The Defence Ministry, which acts rather separately from the rest of the system, is not taken into account in the rest of the report.

12. “Specific Programmes” (세부사업) are one category in the five-level administrative scale of programmes that ranges from “Projects” (the more granular administrative unit of action) to “Programmes” (the largest unit). While the size of these entities vary from one case to another in different areas and contexts, their number gives an indication of the order of magnitude at stake. There were 1 022 Specific Programmes in 2020 (see Annex 5.B, Annex Table 5.B.1..B.1).

13. The S&T Review Committee (1973-1996) headed by the Prime Minister and the S&T Ministerial Meeting (1997-99) headed by the Deputy Prime Minister of Economy and Finance, then the Ministry of S&T.

14. These changes have been analysed in depth in the 2009 OECD Review (OECD, 2009[10]).

15. To date, PACST’s main national strategies and plans include: Measures to build an information society (1993); Measures to improve the efficiency of the science and technology administrative system (1996); STI Promotion Plan to overcome the economic crisis (1998); Measures to strengthen the technological competitiveness of private companies to transform into the advanced economy (1999); S&T technology strategy following the fast rise of China (2002); Plan to provide demand-oriented support for the industry through industry-science collaboration (2005); Measures to improve global competitiveness of graduate schools (2011); Measures to create new energy industries in response to climate change (2014); Basic roadmap for the reduction of national greenhouse gas emission by 2030 (2016); and Measures to innovate the national S&T system (2018).

16. A professor from POSTECH during the term of the previous government.

17. The National Science and Technology Advisory Council Act.

18. For instance, in Sweden, the National Innovation Council is chaired by the Prime Minister and composed of 4 ministers (Environment and Climate; Finance; Business, Industry and Innovation; Higher Education and Research) and 12 representatives of R&I communities in a broad sense. It meets six times a year, of which two meetings are regional. Under the last government, the mandate was focused on providing advice on how Swedish society can address complex social challenges through innovation and co-operation.

19. The former president met with PACST three times during his term.

20. About ten of them come from MSIT and the rest are researchers from GRIs and universities.

21. The Committee is divided into two sub-committees, the S&T Committee and Innovative Ecosystem Committee, which make key decisions for the Vision.

22. The 1st Basic Plan included 67 projects; the 2nd Basic Plan 50 projects; and the 3rd Basic Plan 78 projects.

23. A more manageable set of national strategic technologies than the 4th Basic Plan, which included 120 core technologies.

24. These plans are also based on significant consultation. For instance, the development of the Industry Technology Innovation Promotion Plan for 2019-23 drew on 8 thematic committees gathering a total and 113 experts, who met 34 times. In addition, 669 people were met during on-site consultation meetings.

25. The exercises were carried out respectively in 1994, 1999, 2004 (2008), 2011 and 2016. They used to take place every five years until 2004. Since 2008, the foresight exercise results provide inputs to the Basic Plans.

26. In Korean, 중장기계획 조사·분석 결과.

27. In Korean, 중장기투자전략.

28. About half of the 90 sectoral mid-term plans are implemented via specific annual plans.

29. In Korean, 국가연구개발사업 예산 배분·조정안.

30. Major R&D programmes include basic/applied research, operating costs of GRIs and costs related to research facilities and procurement of equipment.

31. The programmes are all reviewed in about one month. The eight expert committees under the management committee of the Deliberative Council spend one week per year for the in-person budget review meetings.

32. The situation is further complicated by the fact that “programmes” and “projects” are often used alternately in English translations.

33. In Korean, 실 and 국 respectively (Ministry of Legislation, 2021[85]).

34. In 2020, 28 programmes went through the test, 24 in 2019, 31 in 2018, 12 in 2017 and 12 in 2016 (KISTEP, 2021[86]).

35. In 2021, Hwang, Park and Kim identified 17 agencies falling under the definition of R&D management agencies as defined in the National R&D Innovation Act of 2021. They performed their activities of planning, evaluation, and management of R&D projects under 13 ministries (Hwang, Park and Kim, 2021[47]). In 2020, a study for KISTEP listed 15 agencies (Hwang, 2020[92]).

36. Examples of these laws and regulations are: the Act on the Promotion of Science and Technology for Land, Infrastructure and Transportation (MOLIT), the Health and Medical Service Technology Promotion Act (MOHW), and the Act on the Promotion of Technology Innovation of Small and Medium Enterprises (MSS).

37. The next ones are 2022-24 and 2025-27; ANR is the French Ministry of Research and the French National Research Agency.

38. In Korean, 부처주도 다부처사업. Examples include the GoldenSeed project (Ministry of Agriculture and Food, Ministry of Oceans and Fisheries, Rural Development Administration and Korea Forest Service) and the Nano-convergence 2020 project (MSIT and MOTIE).

39. Formerly the Special Committee on Multi-ministerial Programmes, renamed in 2022 (Ministry of Legislation, 2022[57]).

40. For instance, in 2020, 79 programmes underwent specific evaluation. Examples include the Promotion of industrial foundation for hydrogen industry (MOTIE), Technology innovation R&D for SMEs (MSS) and R&D support for future materials (MSIT) (NTIS, 2022[87]).

41. In 2022, 146 programmes (accounting for a total of KRW 6.7 trillion) from 19 ministries were submitted for meta evaluation (PACST, 2022[88]).

42. For instance, KETEP has set up the “online meta evaluation” system. This is a unique online review tool that allows evaluators, applicants and management agencies to evaluate each other and verify how professional and fair their review and evaluation process is (IEA, 2020[70]).

43. In Korean, 과학기술 기반 사회문제해결 종합계획.

44. Health, environment, leisure, public safety, disaster control, energy, buildings and transportation, family, education and social cohesion (KISTEP, 2018[89]).

45. In absolute amounts, Japan is second to the United States, Germany is third and France is fourth (IEA Public energy RD&D database). In 2021, Korea’s energy RD&D represented 3% of the total IEA energy RD&D public spending (Japan accounted for 11%, France for 8%, and Germany for 6%) (IEA, 2021[84]).

46. In Korean, 기후위기 대응을 위한 탄소중립·녹색성장기본법.

47. In total, the commission has 55 commissioners, including 22 from the government (ministers from all ministries) and 33 from the private sector.

48. Each roadmap includes the decommissioning of the oldest 24 coal-fired power plants by 2034 and the phasing-out of all coal-fired power generation by 2050.

49. While currently available technologies can achieve the needed emission reductions targets of the 2030 commitments (45% reduction from 2010 levels), the net-zero objective for 2050 will require significant new advances and scale-up of technologies that are still in laboratories or at prototypeor demonstration stage (IEA, 2022[93]).

50. Another 600 000 jobs are expected in the new Korean New Deal 2.0, amounting to a total of about 2.5 million jobs by 2025 (the employed population in Korea was about 27 million in 2021).

51. Minister of Science and ICT leads DND, the Minister of Environment and Minister of Trade, Industry and Energy leads GND, and the Ministry of Employment and Labour leads HND.

52. In Korean, 국가 R&D 혁신·도전성 강화방안.

53. This initiative is not included in the scope of this review.

54. The programme is expected to be renewed for another period.

55. Three “theme-based programmes” were launched in 2022.

56. In Korean, 임무지향 R&D.